CO-DEVELOPING STEM ACTIVITIES THROUGH DESIGN THINKING APPROACH FOR FIFTH GRADERS

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ABSTRACT

CO-DEVELOPING STEM ACTIVITIES THROUGH DESIGN THINKING APPROACH FOR FIFTH GRADERS

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STEM (Science, Technology, Engineering and Math) education aims to integrate diverse disciplines by making interdisciplinary collaboration in K-12 education. When we review the STEM training and course materials given to teachers in Turkey, it is observed that they mainly focus on science and mathematics, and remain insufficient for disciplines such as social sciences, Turkish, English or visual arts. This situation implies that teachers from diverse disciplines need to work collaboratively among themselves. Creative processes that prioritize the effective participation of students and the design methods that support these processes have been increasingly used for different purposes in education. From this perspective, design is one of the most significant areas that would contribute to interdisciplinary education.

This study uses the “design thinking” (DT) approach for the development and implementation of STEM activities by secondary school teachers from various disciplines. The aim of the study is to investigate the effects of the DT approach on STEM education. To test the proposed DT approach developed within the scope of this study, one pilot and two main studies were carried out with teachers in 2017 and 2018. In the main studies, co-design workshops were organized with five 5th-grade teachers and one researcher-designer. In these workshops, teachers designed STEM activities and lessons for 5th-grade students by using the proposed DT approach. Then, STEM activities and lessons were implemented in the 5th-grade class of 16 students. The study documents the analysis and evaluation of data from co-design workshops, focus group, group interviews, individual interviews, mobile instant messaging, and observation.

Findings from the study indicate that the implementation of the DT approach in STEM education presents solutions to the challenges of STEM education, including collaboration among teachers, integration of disciplines, and developing and implementing STEM activities appropriate to the learner level. This study also provides the proposed DT approach as a teachers' guide for developing and implementing STEM activities.

Keywords: STEM Education, STEAM Education, Design Thinking for Educators, Design Thinking in K-12 Education, Co-developing STEM Activities

ÖZ

TASARIM ODAKLI DÜŞÜNME YAKLAŞIMI İLE BEŞİNCİ SINIFLAR İÇİN ORTAKLAŞA STEM ETKİNLİKLERİ GELİŞTİRME

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STEM (Fen, Teknoloji, Mühendislik ve Matematik) eğitimi, ortaöğretim düzeyinde disiplinlerarası iş birliği yaparak çeşitli derslerin harmanlamasını amaçlamaktadır. Türkiye'de öğretmenlere verilen STEM eğitimlerine ve ders materyallerine bakıldığında, bunların fen bilgisi ve matematik branşlarına odaklandıkları, sosyal bilgiler, Türkçe, İngilizce veya görsel sanatlar gibi branşlar için yetersiz kaldıkları gözlenmektedir. Bu durum, farklı branşlardan öğretmenlerin kendi aralarında daha fazla iş birliği yapmaları gerektiğine işaret etmektedir. Öğrencilerin etkin katılımını önceleyen yaratıcı süreçlerin ve bu süreçleri destekleyen tasarım metotlarının eğitimde farklı amaçlar için kullanımı giderek artmaktadır; bu açıdan bakıldığında tasarım, disiplinlerarası eğitime katkı sağlayacak en önemli alanlardan bir tanesidir.

Bu çalışma, farklı disiplinlerden ortaokul öğretmenlerinin STEM etkinliği geliştirmeleri ve uygulamaları için "tasarım odaklı düşünme" (TOD) yaklaşımını kullanmaktadır. Araştırmanın amacı, TOD yaklaşımının STEM eğitimi üzerindeki etkilerini araştırmaktır. Araştırma kapsamında geliştirilen tasarım odaklı düşünme yöntemini test etmek amacıyla 2017 ve 2018 yıllarında bir pilot ve iki ana çalışma gerçekleştirilmiştir. Ana çalışmalarda, 5. sınıf öğretmenlerinden oluşan beş kişi ve

bir araştırmacı-tasarımcı ile ortak-tasarım çalıştayları düzenlenmiş ve bu çalıştaylarda öğretmenler, geliştirilen yöntemi kullanarak 5. sınıf öğrencileri için STEM etkinlikleri ve dersler tasarlamışlardır. Sonrasında bu etkinlikler ve dersler, 16 kişilik bir 5. sınıfta uygulanmıştır. Bu çalışma, ortak-tasarım çalıştayları, odak grup, grup görüşmeleri, bireysel görüşmeler, mobil cihazla anlık mesajlaşmalar ve gözlemlerden elde edilen verilerin analizini ve değerlendirmesini ele almaktadır.

Araştırmadan elde edilen bulgular, TOD yaklaşımının STEM eğitiminde uygulanmasının, öğretmenlerin iş birliği yapması, disiplinlerin harmanlanması ve öğrencilerin seviyesine uygun STEM etkinliği geliştirilmesi ve uygulanması gibi STEM eğitiminin zorlu yanlarına çözümler sunduğunu göstermektedir. Bu çalışma, ortaokul seviyesine uygun STEM etkinliği tasarlamak ve uygulamak için geliştirilen TOD yaklaşımını öğretmenler için bir kılavuz olarak da sunmaktadır.

Anahtar Kelimeler: STEM (FeTeMM) eğitimi, STEAM Eğitimi, Eğitimciler için Tasarım Odaklı Düşünme, Ortaöğretim Eğitiminde Tasarım Odaklı Düşünme, Ortaklaşa STEM Etkinlikleri Geliştirme

To my parents

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LIST OF ABBREVIATIONS

ABBREVIATIONS

5-E: **E**ngage, **E**xplore, **E**xplain, **E**laborate/**E**xtend, **E**valuate

5W1H questions: **W**ho, **W**hat, **W**here, **W**hen, **W**hy and **H**ow questions

DBL: **D**esign-**B**ased **L**earning

DBS: Advanced **D**esign-**B**ased **S**cience

DT: **D**esign **T**hinking

ESTEM: **E**ntrepreneurship, **S**cience, **T**echnology, **E**ngineering, and **M**athematics

EU: **E**uropean **U**nion

HPI: **H**asso **P**lattner **I**nstitute

IDEO: Name of the global design company

LBD: **L**earning **b**y **D**esign

MİS: National Monitoring Exam

MoNE: **M**inistry **o**f **N**ational **E**ducation

MOOC: **M**assive **O**pen **O**nline **C**ourses

STEAM: **S**cience, **T**echnology, **E**ngineering, **A**rt and **M**athematics

STEM: **S**cience, **T**echnology, **E**ngineering, and **M**athematics

STEM-A: **S**cience, **T**echnology, **E**ngineering, and **M**athematics and **A**rt

CHAPTER 1

INTRODUCTION

Designers have started to design societies, environments, services, and systems; besides, they are expected to solve problems with other disciplines in an interdisciplinary, collaborative environment by acting as conciliators or facilitators. One of the fields to which designers have contributed is education. In education, the design thinking approach has been used in many areas, such as curriculum design, instruction design, and classroom design (IDEO, 2012; K12 lab network, n.d.; REDlab, n.d.; Carroll, 2014; Teacher Guild, n.d.; Cisneros, 2013). In education, teachers' activities have also started to be perceived as design activities (Brown & Edelson, 2003), and designers have been accepted as guides for educators (McFadden, 2015).

There have been some attempts to introduce integrated education that includes approaches like STEM and STEAM in K-12 education. The acronym "STEM" stands for the first letters of science, technology, engineering, and mathematics, while the 'A' in "STEAM" represents the arts. Moore et al. (2014) define the integrated STEM education as a "combination of four STEM disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (p. 4). According to this, instead of teaching these four disciplines separately, STEM integrates them in an interdisciplinary manner (Akgündüz et al., 2015). However, in the international literature, there is a tendency to include all disciplines into STEM education (Plaza, 2004; Daugherty, 2013). The literature also mentions the types of integrations such as interdisciplinary, multidisciplinary (Drake & Burns, 2004), and curricular and instructional design strategies for the STEM education

(Roberts, 2013; Bruce-Davis et al., 2014); however, the literature does not propose a guide for integrating disciplines. Besides, STEM education suffers from STEM activities that are not aligned with the learner level (Carter, 2013). The literature also highlights the need for teachers' collaboration, administrative support (Margot & Kettler, 2019), and constructing parents' understanding of STEM (Carter, 2013) for the implementation of STEM education.

In Turkey, STEM (called FeTeMM in Turkish) activities have mainly been organized in some private schools, and STEM research centers organized some workshops. Turkish Ministry of National Education (MoNE) has prepared a STEM education report in 2016 to show the importance of STEM education and the urgent need for the adaptation of the national curriculum to STEM. In this report, all disciplines are proposed to be included in STEM education to make students gain "an interdisciplinary perspective on Science, Technology, Engineering, Art and Mathematics" (Ministry of National Education, 2016, p.30). Currently, there is no extended national curriculum for STEM education. Ministry of National Education made changes for the integration of STEM education only in the science education curriculum from 4th to 8th classes (MEB Science education curriculum, 2018) and in the technology and design course's curriculum in 7th and 8th classes (MEB Technology and design course curriculum, 2018). However, there has been no change in other disciplines. Akgündüz et al. (2015) discuss the reasons for inadequate STEM education at the K-12 and higher education levels and indicate that the most critical deficiencies are curriculum integration, interdisciplinary cooperation, inadequate implementation, instructor qualification, 21st-century skills, and the lack of STEM courses. Concerning the STEM programs in K-12 education, Akgündüz et al. (2015) propose interdisciplinary collaboration among faculties and departments, and among teachers from diverse disciplines and higher and K-12 education. According to Uştu (2019), a ready-made activity prepared for a particular class level cannot be appropriate for a specific region, school facilities, students, or teachers' understanding of implementation. This further emphasizes the significance of preparing STEM activities considering the learners' academic and social levels and the school context. The review of the local and international literature indicates that a guide can support teachers for integrating disciplines and creating a STEM activity with an appropriate learner level to conduct the STEM education, and in return, facilitate the interdisciplinary collaboration among teachers.

Design Thinking (DT) approach has gained popularity with the efforts of IDEO (Brown, 2008). Although the DT is not a new term for designers and the use of the DT started with Simon in the late 1960s, the DT approach has been utilized in K-12 education in the last two decades. It has mostly been used to address a variety of challenges in education (Tran, 2017). Notably, it has multiple areas of application, such as curriculum design (IDEO, 2012), instructional design (Brown, & Edelson, 2001), learning environment design (Design Council, 2005), improvement in students' skills (d.loft STEM, n.d.), and organizational change in the educational institution (De Campos, 2014). According to the related literature, using the DT approach in education can provide numerous benefits to students in their learning and the teachers in their teaching (Tran, 2017).

In this study, it is proposed that the DT approach has the potential to answer the challenges of STEM education. In this respect, the DT approach can enable the integration of various disciplines into STEM education owing to being described as the integration point of business, design, engineering and social sciences (Leifer, & Steinert, 2014) and its relation to science, technology, and engineering (Catterall, 2013). Moreover, the DT approach can assist teachers in developing STEM activities in accordance with the students' needs because of its human-centered nature. This characteristic is also compatible with the student-centered characteristic of STEM education (Walker et al., 2018) as well as the "broader humanistic purpose" (p. 277) of education in general (Foshay, 1991). DT approach can also be used to facilitate collaboration among teachers from diverse disciplines owing to its pedagogy involving collaboration, and reflection (Catterall, 2013). Keane and Keane (2016) note that science looks for 'which is' while design investigates 'which could be' by looking at many possibilities to reach multiple solutions. The DT approach can function as a problem-solving method for solving the STEM challenges because of its creative problem-solving process (Catterall, 2013).

1.1 Goal of the study and research questions

This study investigates the impact of the DT approach on the development and implementation of STEM activities by secondary school teachers. The goal of the study is to understand the ways in which the DT approach can contribute to STEM education and support teachers' collaboration for developing and implementing STEM activities that meet the needs of target students. The study seeks answers to the following questions:

Research Question: How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities for 5th graders?

> **Sub-question 1:** How and to what extent does the design thinking approach support collaboration among teachers for developing and implementing STEM activities?
>
> **Sub-question 2:** How and to what extent does the design thinking approach support teachers' integrating various disciplines into the STEM activity design and implementation?
>
> **Sub-question 3:** How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities appropriate to the needs of a specific learner level?

The study employs qualitative research methods, including action research, case studies, co-design workshops, focus group interviews, individual interviews, and observation.

1.2 Scope of research

This study aims to develop a DT approach for STEM activity design and implementation. The research area of this thesis is comprised of STEM, DT for educators, DT in K-12 education, and co-developing STEM activities with teachers. The study stems from the initial observations that currently, STEM education is an evolving area in Turkey, and there are many challenges and uncertainties in its application in the absence of a comprehensive national STEM curriculum. In that account, it is believed that the DT approach can provide solutions to STEM challenges and teachers to conduct this education productively. It should be noted that this study focuses on developing and implementing STEM activities only for secondary school education since some changes have been applied in the national curriculum on the secondary school level.

The literature review conducted for this study covered STEM education, its framework, and implementation both from local and international perspectives. Additionally, exploratory research was conducted to understand the state of the art of STEM education in Turkey. The literature review was also conducted for the DT approach to investigate its origin, characteristics, and understanding in diverse fields. Mainly, this study focused on the various DT approaches and their areas of application. This way of exploration provided data concerning DT, its methods, tools, and ways of working. Besides, the literature review presented the connection between the STEM and DT approach in terms of having common benefits and characteristics.

The literature review and the exploratory research provided a point of departure for developing a DT approach for the STEM activity design. Following the development of an initial DT approach for the STEM activity design and implementation, it was first tested through a pilot study with teachers. After the testing and revisions, two main studies involving co-design workshops were carried out in a private school for designing and implementing STEM activities and lessons with 5th-grade teachers and students. The findings from the main studies were used to revise the DT approach for STEM activity design and implementation.

As an interdisciplinary topic, this study lies at the intersection of design and education studies. Consequently, the research findings target the secondary school pre-service or in-service teachers, specialists, educators, or researchers from the education or design fields, designers, and design students. This study is also directed towards the institutions providing DT training to teachers and educational institutions and the Ministry of National Education concerning the implementation of STEM education in Turkey.

1.3 Definition of terms

This section provides the definitions for the key terms used in this study. The literature offers alternative explanations for these terms; the presented ones have been adopted considering the aim of the study.

Design thinking: It means executing 'designerly thinking' (Johansson-Sköldberg et al., 2013) in the education field, mainly to design and implement STEM activities, by implementing situated actions (Laursen, & Haase, 2019).

K-12 education: "An international norm for pretertiary education, namely a kindergarten through grade 12" (Sarvi, Munger, & Pillay, 2015, p. 1).

STEM education: In the literature, STEM education is described to involve four disciplines only: science, technology, engineering, and mathematics (Moore et al. 2014). However, after reviewing the literature, it was discovered that there had been an inclination towards integrating all disciplines into STEM education (Plaza, 2004; Daugherty, 2013), which caused confusion about the description and the framework of STEM education. Similar to the international literature, the uncertainty about the interpretation of STEM education has been present in Turkey as well. For example, some emphasize the 'A' by adding it to the end of STEM as STEM+A (Çorlu, & Çallı, 2017), or some mention STEM with Computing as

STEM+C (Akgündüz et al., 2015). The disagreement about the interpretation of the letters ‘E’ and ‘S’ in STEM education has also been discussed in the report by the Ministry of National Education (2016). Considering the literature, I did not want to limit the study with four disciplines. Instead of emphasizing the particular disciplines in STEM education by naming it as STEAM or STEM-A, I used STEM as an umbrella term to refer to all disciplines.

21st-century skills: The 21st-century skills and knowledge include learning and innovation skills (critical thinking, problem-solving, communication, collaboration skills, creativity, innovation, and information), media and technology skills (information literacy, media literacy, and ICT) and lastly life and career skills (flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility) (P21, 2010).

1.4 Thesis structure

The first chapter introduces the research topic, research questions, the key terms, and the structure of the thesis. The second chapter covers the literature review about STEM education and the DT approach conducted to develop a DT approach for teachers’ designing and implementing STEM activities. The chapter starts with a literature review about STEM education and explores the definitions, challenges, benefits, characteristics, and the curriculum integration approaches involved. It also discusses the state of the art of STEM education in Turkey. The literature review also explores the definitions and origins of the DT approach in the discourses of design and management fields. It further discusses DT mindsets, various DT approaches, and mainly focuses on the ones used in the educational context. The literature review also covers the current execution of the DT approach in K-12 education. Lastly, it presents the DT approach developed for teachers to design and implement STEM activities.

The third chapter describes and justifies the methodological stance, research methods, data collection tools, and analysis. The chapter also presents an overview of the studies conducted within the scope of this study. The fourth chapter discusses the exploratory research (interviews with teachers and the school principals, and participating in a STEM education workshop) and its findings. The fifth chapter discusses the pilot study, a two-day workshop with teachers, and its findings. It also presents the revisions made to the DT approach.

The sixth chapter documents the Main Study I, which was about collaboratively designing and implementing a STEM activity and corresponding interdisciplinary lessons with 5th-grade teachers by using a DT approach in a private school. It further discusses the analysis and findings, and the revisions made to the DT approach developed. The seventh chapter documents the Main Study II, which was about collaboratively designing and implementing a STEM activity and corresponding lessons with 5th-grade teachers by using a DT approach in the same private school with the same teachers and students. The chapter discusses the analysis and findings and compares Main Study I with Main Study II. Lastly, it presents the final revisions made to the DT approach developed.

The last chapter presents the conclusions of the study concerning the research questions, discusses the potential areas for future research, the suggestions for integrating design education into teachers' education and K-12 education, and the limitations of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 STEM education

STEM has been proposed by the National Science Foundation (NSF) in the USA in the 1990s, to increase national competitiveness by enhancing the innovative abilities of the workforce (Bybee, 2010; Li, 2016). Thomasian (2011) indicates that there are two aims of STEM education. The first one is to increase the number of students who study STEM disciplines in higher education to support US innovation. The second one is to develop all students' STEM knowledge and skills for their practice in their daily lives.

Bybee (2010) interprets STEM as an integrated curriculum approach to challenge the big problems of the 21st century (Figure 2.1). Moore et al. (2014) define the integrated STEM education as a "combination of four STEM disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (p. 4). National STEM School Education Strategy of Australia (National STEM school education strategy, 2015) also defines STEM as a cross-disciplinary approach to teaching the four STEM disciplines collectively under its umbrella instead of teaching them as discrete subjects (Tim & Yin, 2015). It can be inferred from the definitions that, its theoretical framework is based on the curriculum integration of STEM disciplines without ignoring disciplines' characteristics (National Research Council, 2009).

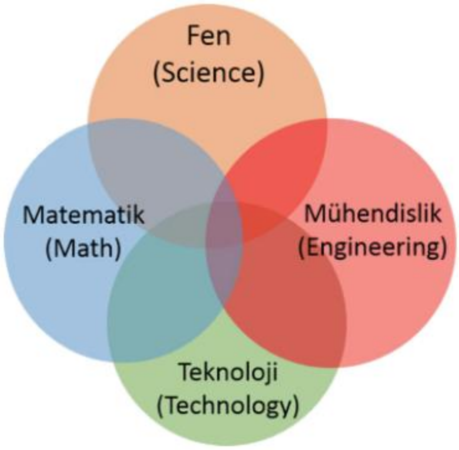


Figure 2.1. STEM Education (Akgündüz et al., 2015)

2.1.1 The characteristics and benefits of STEM education

According to Carter (2013), the characteristics of the integrated STEM education involve effective communication, students' presentation, project-based learning, skills development (such as logical reasoning, computer skills, and problem-solving) and real-world problem-solving. Moore et al. (2014) also find significant problem-based learning and cooperative learning, along with hands-on practices in integrated STEM education. Moreover, trying and failing is described as a part of the educational process (Connor, Karmokar & Whittington, 2015; Fredette, 2013) in problem-based learning. According to Walker III et al. (2018), the qualified integrated STEM curriculum also includes a motivating and engaging context, teamwork, student-centered instructional strategies, performance, and formative assessment, along with integrated science and math content into an engineering design challenge. Furthermore, Buckley et al. (2018) recommend choosing a subject that should attract children's interest and considering the age of children when creating an appropriate STEM activity. The Ireland STEM policy (STEM Education Policy Statement 2017–2026, 2017) also emphasizes two principles that promote the involvement of innovation, art, and design in STEM education (p. 9).

- STEM is interdisciplinary, enabling learners to build and apply knowledge, deepen their understanding, and develop creative and critical thinking skills within authentic contexts.
- STEM education embodies creativity, art, and design.

The reasons behind including these characteristics are explained by Reinking and Martin (2018) as follows:

- Hands-on learning to provide students' active participation.
- Service-learning to engage students in different community partners.
- Enabling student choice environment to make them choose and manage their learning.
- Encouraging student creativity for problem-solving activity.
- Empowering cooperative learning teams to enable students to learn from each other and teach each other.
- Creating inquiry-based classroom which changes teachers' role from direct teaching to facilitating and guiding.

Considering these characteristics, according to the Irish report about STEM education (STEM Education Policy Statement 2017–2026, 2017), students will deal with various activities such as collaboration with others, using their STEM knowledge to solve problems, engage with inquiry-based learning including questioning, researching, imagining, developing insights, designing, prototyping, creating innovative solution, testing and modifying the products.

Involving such richness in the content of education provides numerous benefits to the learners. Martin-Paez et al. (2019) divide these benefits into three categories based on their literature review: cognitive, procedural, and attitudinal benefits. For cognitive benefits, STEM education increases academic performance and the ability to apply STEM knowledge. It further fosters STEM disciplinary knowledge and enables making the connection between STEM disciplines. For procedural benefits, it increases creativity and technological skills and provides practical experience. For attitudinal benefits, it raises interest and develops positive attitudes towards STEM disciplines/subjects. Besides, it increases motivation for learning, enables higher-level thinking skills (Moore et al., 2014), develops students' 21st-century skills (Nathan & Pearson, 2014), and engagement to the course (Stohlmann, Moore & Roehrig, 2012). According to the literature, STEM education also provides benefits to educators: "changes in practice and increased STEM content knowledge and pedagogical content knowledge" (NAE & NRC, 2014, p. 39).

2.1.2 Challenges in STEM education

According to the literature, some barriers are reported for the integrated STEM education, such as pedagogical challenges, curriculum challenges, students' concern, structural challenges, teachers' concerns about assessments and time, teachers' inadequate STEM content knowledge, standardized testing, parents and the community and the inappropriate STEM activities to the needs of a specific learner level.

- Structural challenges: School structure barriers include inappropriate class, teachers' and students' scheduling (Margot & Kettler, 2019), the lack of necessary materials and equipment to implement the STEM education (Carter, 2013).

- Pedagogical challenges: These challenges are related to the change from teacher-centered education to student-centered education (Margot & Kettler, 2019). According to Reinking and Martin (2018), the integration of hands-on, authentic STEM curriculum change teachers' role into creator, observer, reflector, guide, and facilitator in a student-centered classroom.

They are expected to learn the facilitator role and to support students about risk-taking (Margot & Kettler, 2019).

- Curriculum challenges: Curriculum challenge is teachers' concern about creating STEM integrated curricula because of inflexible curricula and miscommunications between teachers about understanding each other's disciplines (Margot & Kettler, 2019).
- Students' concern: It is teachers' lack of belief about students' success in the STEM education and teachers' ignorance about the students' abilities for solving the STEM problems (Margot & Kettler, 2019).
- Teachers' inadequate STEM content knowledge (Margot & Kettler, 2019): Teachers should know other disciplines' practices and content to integrate STEM learning (Carter, 2013).
- Standardized testing: It is about the limitation of having state tests (Carter, 2013).
- Parents and the community: Parents and the community do not have a comprehensive understanding and expectation about integrated STEM education (Carter, 2013). Their understanding and expectations should be constructed about STEM since discovering their expectations regarding the integrated STEM education (Carter, 2013) and explaining the value of the STEM education and careers (STEM Education Policy Statement 2017–2026, 2017) is important.
- Assessments and time: Teachers' workload increase related to STEM education, and they need time for planning, collaborating with other disciplines, and preparing materials. The quality of assessment tools also isn't sufficient for STEM education (Margot & Kettler, 2019).
- Inappropriate STEM activities to the needs of a specific learner level: Many STEM programs have a limited educational focus that consists of cool

activities, some of which aren't appropriate for learner level (Carter, 2013). It was also discovered from the literature that teachers modify the existing STEM units or design new ones about specific subjects for high school students' level of knowledge and skills (Bruce-Davis et al., 2014). Thus, there is a need for designing and implementing STEM activities considering the students' abilities.

In the literature, some recommendations are proposed for integrated STEM education. For instance, the mentoring approach is suggested for in-service and pre-service STEM teachers (Allen, Webb & Matthews, 2016). Support via professional development is also recommended for teachers to develop their skills and knowledge (Carter, 2013; Moore et al., 2014). However, the majority of research on teachers' professional development in STEM disciplines has been conducted in science and mathematics (McDonald, 2016), and the other disciplines have been excluded. The literature also mentions the curricular and instructional design strategies for STEM education (Roberts, 2013; Bruce-Davis et al., 2014). According to the systematic literature review about STEM education (Margot & Kettler, 2019), teachers further need additional supports in three areas to implement STEM education: collaboration, administrative support, and prior experiences.

- Teachers point out the significance of collaboration with the other teachers or university staff to support STEM preparation. However, time and opportunity should be created for communication and collaboration between teachers for successful STEM education (Margot & Kettler, 2019). For instance, in Ireland's STEM education policy, the collaboration culture for professional learning is promoted between teachers to create effective STEM learning, teaching, and assessment. For continuous improvement, teachers and early years practitioners are expected to collaborate in or out of the school for sharing their experiences about STEM education and STEM learning, developing their skills about resiliency, creativity, and inquiry (STEM Education Policy Statement 2017–2026, 2017). Moore et al.

(2014) recommend that "teachers can also collaborate and share ideas with colleagues from other subjects to support content knowledge and learning in multiple disciplines" (p. 14).

- Teachers find significant administrative support for implementing STEM education (Margot & Kettler, 2019).
- According to teachers, having previous experience with similar STEM instructional methods, such as student-centered pedagogy, inquiry-based instruction, enables successful implementation in STEM education (Margot & Kettler, 2019).

Although the barriers and possible solutions were defined for the integrated STEM education in the literature, no ways are discussed how to implement these solutions.

2.1.3 The curriculum integration in STEM education

One of the main challenges in integrated STEM education is about how the disciplines can be integrated. When we review the literature, three approaches are prominent about integrated STEM education: interdisciplinary, multidisciplinary, and transdisciplinary integrations (Table 2.1).

According to Wang (2012), the multidisciplinary and interdisciplinary approaches are generally referred to in the literature for defining the curriculum integration. While in the multidisciplinary approach, the concepts are taught at the same time under the common theme in different disciplines or lessons (Wang, 2012), in the interdisciplinary approach, the main point is not the subjects, it is the skills that are wanted to be adopted by students.

Table 2.1 *Description of multidisciplinary, interdisciplinary and transdisciplinary integrations (Drake & Burns, 2004)*

Integration approaches	**Types of the integration approaches**	**Descriptions of the types of the integration approaches**
Multidisciplinary integration: Integration organized around a common theme; focus on the disciplinary standards and procedures.	Intradisciplinary Approach	"Integration of the sub-disciplines within a subject area, such as integration of reading, writing in language arts" (p. 8).
	Fusion	"Fusing skills, knowledge, or attitudes into the regular school curriculum, such as learning respect for the environment in every subject area" (p. 9).
	Service-learning	"Involving community projects that occur during class time" (p. 10).
	Learning Centers/Parallel Disciplines	"Addressing a topic or theme through the lenses of several different subject areas" (p. 10). For instance, in every learning center, students have an activity about the theme "patterns" from the perspective of one discipline. In higher classes, students work on a topic or theme in different lessons which form as parallel disciplines, such as "study a particular period of history and read literature from that period" (p. 11).
	Theme-Based Units	Planning a multidisciplinary unit collaboratively by integrating three or more subject areas in the study and ending it with an activity. For instance, working on a problem (Local Ecosystem) "from the different disciplinary lenses of science (earth sciences, biology, chemistry, and physics), English (genre readings, analyses, and communication skills), and math (data analysis tools and techniques)" (p. 12).
Interdisciplinary integration: Integration organized around around shared learning embedded in disciplinary standards to stress interdisciplinary concepts and skills.		
Transdisciplinary integration: Integration organized around students' concerns and questions.	Project-based learning	Dealing with a local problem; the selection of a topic based on the curriculum or students' interest, exploring the problem by students, and presenting the result to others for evaluation and reviewing (Chard, 1998).
	Negotiating the Curriculum	Questioning the basis for curriculum, teaching methods, and assessments.

For example, in the multidisciplinary approach (Figure 2.2), for the solar system theme, teaching the solar system in the science lesson, determining the distance of

“Moon” to sun, planets, and stars comparatively in the math lesson, discovering the roots of the name of the planets in the social science lesson, modeling the planets by using playdough in the visual arts lesson and reading the science fiction book in the English literature can be applied (Vasquez, Sneider & Comer, 2013).

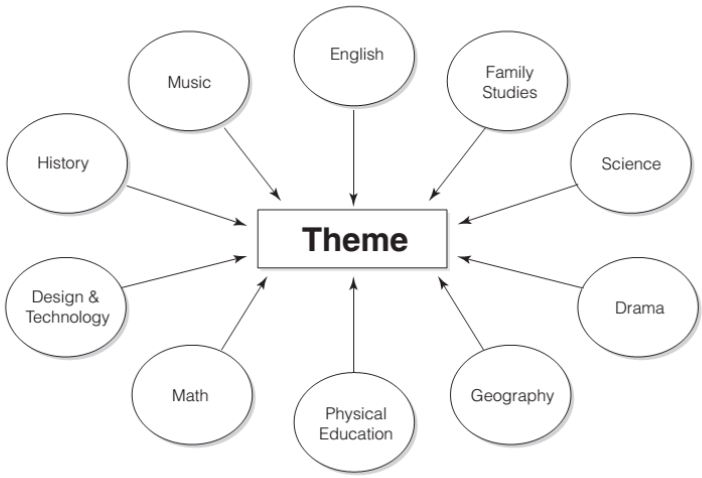


Figure 2.2. The multidisciplinary approach (Drake & Burns, 2004, p. 9)

However, in the interdisciplinary approach (Figure 2.3), “if students are asked to create a solar-powered boat, they will be expected to apply their knowledge from different subject areas, such as using science and math, to explore the concepts of sinking, floating, and stability to design their boat hulls” (Wang, 2012, p. 10). In a transdisciplinary approach, the border of the disciplines is removed, and the main aim is to solve a real-world problem by using interdisciplinary knowledge and skills (Vasquez, Sneider & Comer, 2013). In other words, the main focus is the real-life problems, not diverse subject areas.

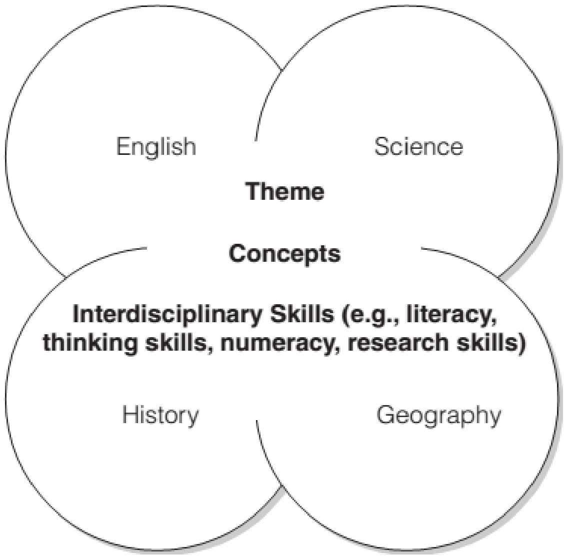


Figure 2.3. The interdisciplinary approach (Drake & Burns, 2004, p. 12)

Furthermore, in transdisciplinary integration (Figure 2.4), "students develop life skills as they apply interdisciplinary and disciplinary skills in a real-life context" (Drake & Burns, 2004, p. 13). For example, "with the topic of global warming, students are expected to connect this issue to many different factors, including social, political, economic, international, and environmental concerns" (Wang, 2012, p. 10).

Figure 2.4. The transdisciplinary approach (Drake & Burns, 2004, p. 14)

Between the three approaches, the degree of the separation among disciplines was the essential point (Figure 2.2). From this perspective, multidisciplinary integration differs from the others owing to the dominance of the disciplines. In the interdisciplinary approach, the disciplines have less importance compared to the multidisciplinary approach, but they are identifiable (Drake & Burns, 2004). Moreover, from the point of teachers' role, while they are expected to be a facilitator and specialist in the multidisciplinary and interdisciplinary approaches, they are expected to be co-planner and co-learner along with a specialist in the transdisciplinary approach (Drake & Burns, 2004).

Co-teaching in the integrated STEM education. In the literature, there is an application of co-teaching among pre-service and master teachers or mentors and new teachers to assist inexperienced teachers in the STEM implementations (Benuzzi et al., 2015). Stohlmann et al. (2012) further state that integrated STEM education can involve multiple teachers, lessons, or classes instead of one and does not always need to include all STEM disciplines.

Thousand, Villa, and Nevin (2006) define co-teaching as "collaboration in planning and teaching" (p.240) or sharing of teaching responsibility among two or more educators. They describe four types of co-teaching: supportive teaching, parallel teaching, complementary teaching, and team teaching (p. 242).

- Supportive teaching in which one teacher takes the lead and the others rotate among students to provide support.
- Parallel teaching in which co-teachers work with different student groups in different areas of the classroom.
- Complementary teaching in which co-teachers do something to enhance the instruction provided by another co-teacher.
- Team teaching in which co-teachers jointly plan, teach, assess, and assume responsibility for all of the students in the classroom.

Among co-teaching models, team teaching or teaching in teams is one of the teaching methods that are used in STEM education (Gardner, Glassmeyer & Worthy, 2019) and needs the effort to sustain teachers' collaboration before and during the lesson. In this method, the class responsibilities and management are shared by teachers, and both teachers teach lessons simultaneously by taking the lead or supporter roles (Thousand, Villa & Nevin, 2006). In team teaching, teachers can divide the lessons into meaningful parts to teach students their content. For instance, "for a lesson on inventions in science, one co-teacher whose interest is history will explain the impact on society. The other co-teachers strengths are more focused on the mechanisms involved and can explain how the particular inventions work" (Thousand, Villa & Nevin, 2006, p. 244). It is working as a learning model for students and focus on the learning process more than content knowledge (Shibley, Jr., 2006). In team teaching, turn-taking, which means "minute-to-minute exchange of leadership roles within the classroom" (p. 272), is significant. The collaboration among teachers can be unsuccessful owing to poor content integration and planning and unorganized turn-taking. Consequently, spending adequate time for a high degree of planning, strong collaboration among teachers based on the learners' needs, well-considered content integration, assessment, and turn-taking and considering the pedagogical differences are the key points for successful implementation of the team teaching. (Shibley, Jr., 2006). Although it requires sufficient time to do careful planning and execution, team teaching provides many benefits to teachers because of teachers' collaboration and sharing of experiences.

2.1.4 The tendency to include all disciplines in STEM education

In the literature, as previously stated, STEM education involves only four disciplines; Science, Technology, Engineering, and Mathematics. However, after reviewing the literature, it is discovered that there is an inclination to integrate all disciplines. That confuses minds about the description and the framework of STEM education.

For instance, Dyson (2010) criticizes STEM for not including D (design) inside. According to him, the design connects engineering to business. Thus, design and technology should have an equal value similar to science and math in K-12 and higher education. Kwack (2014) further argues that adding art and design thinking to STEM does not only mean bringing aesthetic quality, and it means offering students a different experience and builds a creative educational environment (Kwack, 2014). Root-Bernstein (2015) also proposes that STEM education needs art and craft integration because of their effect on stimulating creativity among gifted and talented STEM students. Besides, Irish STEM policy accepts the connection between Arts and STEM education. Consequently, one of their action plans involves supporting STEM education practice by partnering with Arts education to encourage universal design, creativity, and design thinking approach in STEM education practice (STEM Education Policy Statement 2017– 2026, 2017). Daugherty (2013) also opposes the separation of art from STEM disciplines, and he suggests integrating art into STEM disciplines to benefit from its way of expression and reflection. However, he does not have a clear idea about whether fully incorporating art into STEM to create a STEAM approach or using art barely for informing STEM education.

There are also advocators about adding liberal arts into STEM education. Bevins (2012) and Plaza (2004) promote the integration of liberal arts and STEM to show their different perspectives and to create opportunities for students' success. The inclusion of English language arts into science instruction and science texts into English language arts instruction is proposed by many educators owing to the need of "being proficient in reading the complex informational text independently in a variety of content areas" in both work and college environments (DeBoer, Carman & Lazzaro 2019). Additionally, Casey et al. (2018) suggest that adding art and literacy standards into science lessons may increase "students' academic success, engagement, and interest to the lesson and vocabulary acquisition" (p. 64). It can be concluded that the integration of all disciplines into STEM education has been supported owing to providing many benefits to the learners; however, it also generates new questions about how to make the integration of these disciplines into STEM education (Plaza, 2004; Daugherty, 2013).

STEAM education. In the literature, there are many supporters of the integration of art into STEM education. One of the most popular integration models includes the full integration of the 'A' component into STEM as STEAM education (Sousa & Pilecki, 2013; Korea Ministry of education & KOFAC, 2016). Yakman (2008, p.18) describes STEAM as "science and technology interpreted through engineering and the arts, all based in mathematical elements" (Figure 2.5). According to the literature, by adding 'A' to STEM, STEAM education emphasizes arts, humanities, sports, computer science, or innovation, which is needed in the 21st century (Li, 2016).

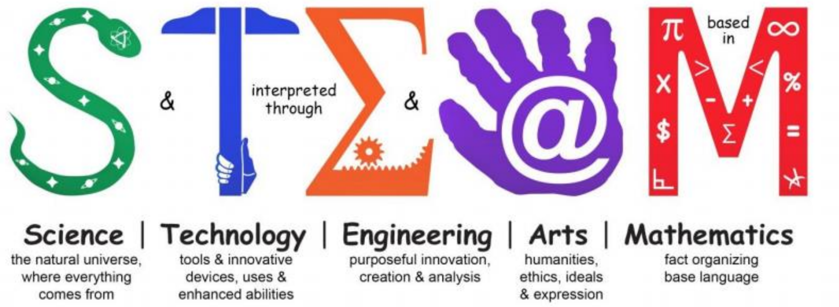


Figure 2.5. STEAM framework of Yakman (Chen, & Xiaoting, 2016)

Ghanbari (2015) argues that although STEAM seems like a new term, art and STEM have been integrated before without naming that approach STEAM. On the contrary, Gettings (2016) opposes that idea by seeing the application of STEAM not as a coincidence, instead of an intentional act. Moreover, owing to the scarcity of the literature on STEAM (Quigley & Herro, 2016), there is confusion regarding what 'A' corresponds. Consequently, in the literature, we see different interpretations of 'A.' For example, according to Delaney (2014), 'A' means arts (fine arts, language, and musical arts) and design. While it also means agriculture for the National Research Council (2009), in the report prepared for the

European Union (European Commission, 2015), the ‘A’ includes ALL other than STEM disciplines. It can be concluded that while there is confusion about what STEM means in the literature, there is also no joint agreement on what ‘A’ implies in STEAM.

2.1.5 STEM education in Turkey

In Turkey, there have been STEM (called FeTeMM in Turkish) activities mainly in some of the private schools, such as Bahçeşehir College, Uğur College, and STEM research centers organized some workshops. There are also some EU-funded collaborative projects on STEM education in which Turkey takes place as a partner, such as S-TEAM, MASCIL, and SAILS (Akgündüz et al., 2015). Although “Turkey does not have a direct STEM action plan prepared by the Ministry of National Education, some strategic goals appropriate for strengthening the STEM education took place in the 2015-2019 Strategic Plan of Turkey” (Ministry of National Education, 2016, p. 24). We have also seen the implementation of STEM education in public schools in Kayseri since 2013 (Ministry of National Education, 2016a) because Kayseri has been selected as a pilot region for STEM.

Furthermore, the Ministry of National Education has prepared a STEM education report (Ministry of National Education, 2016) to show the importance of STEM education and the urgent need for the adaptation of the national curriculum to STEM. In the report, it has been suggested to make students gain “an interdisciplinary perspective on Science, Technology, Engineering, Art and Mathematics” (Ministry of National Education, 2016, p.30). Besides, according to the opinions of teachers who have participated in the MEB’s survey, the visual arts education should be involved in STEM and not only Science and Mathematics teachers but also the other teachers should be informed about STEM education (Ministry of National Education, 2016). Therefore, in the report, the integration of all disciplines is proposed to be included in STEM education. Currently, there is no extended national curriculum for STEM education. Besides, the Ministry of

National Education made changes for the integration of STEM education only in science education curriculum from 4th to 8th classes (MEB Science education curriculum, 2018) and in the technology and design course's curriculum in 7th and 8th classes (MEB Technology and design course curriculum, 2018). However, there has been no change in the other disciplines. Additionally, for the integration of STEM education, the Ministry of National Education has proposed an action plan, which involves conducting STEM research in newly established STEM education centers, training teachers about STEM education, updating curriculum, and creating course materials (Ministry of National Education, 2016). According to the STEM education report, how STEM education is integrated into the curriculum (whether it should be integrated into the content of other courses or provided separately) should be carefully decided. Thus, step-by-step changes, including creating activities for raising the awareness of the students about scientific inquiry, are suggested for making the transition to STEM education in Turkey (Ministry of National Education, 2016).

Similar to the international literature, we further have discovered the confusion about the interpretation of STEM education in Turkey. For example, some of the scholars include only four disciplines in STEM (İstanbul Aydın University STEM School, n.d.), some emphasize the 'A' by adding it to the end of STEM as STEM+A (Çorlu & Çallı, 2017). According to the exploratory research, some of them think that 'S' in STEM means not only science but includes all disciplines (See section 4.2). The interpretation of STEM education has also been discussed in the report of the Ministry of National Education (2016) as follows:

> According to the interview with Özdemir (2016), there are two disagreements in the literature about the meaning of the letter 'E' and 'S' in STEM. According to this, while "the letter 'E' in STEM does not only mean 'engineering' but also means "design and production" and the letter 'S' indicating 'science' also includes 'humanity and social sciences'" (p. 15). Furthermore, we have seen abbreviations in the literature which are based on the STEM approach, such as ESTEM, S-TEAM, and STEAM. "The letter 'A' in these abbreviations means 'art', which covers aesthetics as well. 'E' letter in ESTEM implies entrepreneurship" (p. 15). All of this discussion presents the fact that STEM is a field still improving (as cited in Ministry of National Education, 2016).

In the last decade, İstanbul Aydın University founded a STEM School and a STEM lab in the Faculty of Education. Hacettepe University (H-STEM Lab), Bahçeşehir University (BAUSTEM), Middle East Technical University (BİLTEMM) and Recep Tayyip Erdoğan University (RTEU STEM) also have STEM research centers. They are organizing workshops, certificate programs, or seminars to teach teachers STEM education or to make students involved in STEM activities. However, the research centers are giving a STEM education only for science, mathematics, computer education, and instructional technology education teachers.

Existing STEM studies in Turkey have generally been conducted in secondary schools (Yamak, Bulut & Dündar, 2014; Baran et al., 2016; Ayar & Yalvaç, 2016). While generally science and engineering have been studied together (Çınar & Çiftçi, 2016), several studies are conducted mostly about science education (Yılmaz et al., 2018). Moreover, it is mainly the engineering design process and knowledge that have been used for STEM implementation in Turkey (Akgündüz et al. 2015). Additionally, among articles between 2010-2017, while the studies are mostly conducted with K-12 or higher education students, fewer studies are carried out with in-service teachers (Yılmaz et al., 2018).

Among graduate thesis, in-service and pre-service teachers' professional development researches include teachers from the math, science, primary school, and the computer education and instructional technology education fields (Table 2.2). Therefore, the focuses of the researches exclude the fine arts and liberal arts education and in-service and pre-service teachers from these areas. Besides, in some of the thesis, courses are implemented for the pre-service science teachers that serve to develop a STEM course or activity plan. However, these courses are discipline-based, and a guide isn't provided to design STEM lessons/activities. In these theses, student teachers also do not test the designed activities on the real students to understand their productivity and suitability for students' level (Gül, 2019; Türk, 2019). Only in Uştu's thesis (2019), there are strategies for planning and implementing STEM/STEAM activities, and they are meant for in-service primary school teachers. In his thesis, the primary school teachers also recommend instructional, curricular, and implementation strategies for adapting the ready-made activities for students' level. However, they state that they can do this because of being familiar with their students for four years and getting feedback from the researcher and other teachers for their activities.

Most of the graduate theses in STEM education on secondary schools (Ceylan, 2014; Yıldırım, 2016; Şentürk, 2017; Alıcı, 2018; Çalışıcı, 2018; Dedetürk, 2018; Nağaç, 2018; Topsakal, 2018; Okulu, 2019) are based on the implementation and the evaluation of STEM activities either developed by the researchers or previously integrated into the institutions. Thus, the preparation of the STEM activities or curriculum with in-service teachers is unexplored in these theses.

Table 2.2. *The research areas about in-service and pre-service teachers in graduate theses*

In-service teacher professional development research	**Literature**
The math and science teachers	Özacar, 2018; Tabar, 2018
The primary school teachers	Uştu, 2019
The physics and computer education and instructional technology education teachers	Tabar, 2018
Pre-service teacher education research	**Literature**
The science teachers	Belek; 2018; Duygu, 2018; Türk, 2019; Gül, 2019
The math, the chemistry, the biology, the physics and the computer education and instructional technology education teachers	Tabar, 2018
The primary school teachers	Altaş, 2018; Tabar, 2018

Additionally, research on these theses focuses on designing STEM training programs or STEM clubs to find out STEM effects on students such as academic achievement on STEM fields, motivation, design skills, creativity, engagement, computer skills, cognitive skills, handcraft skills, the group working and 21st-century skills or attitudes towards STEM fields as follows: (Table 2.3)

Table 2.3 *The focus of STEM training programs and clubs*

The focus of STEM training programs or clubs	Literature
Attitudes towards STEM fields	Yamak, Bulut & Dündar, 2014; Baran et al., 2016; Yıldırım, 2016
Academic achievements on STEM fields	Ceylan, 2014; Yamak, Bulut & Dündar, 2014
Creativity	Ceylan, 2014
Engagement	Baran et al., 2016
Computer skills	Baran et al., 2016
Motivation	Yıldırım, 2016
Cognitive skills	Baran et al, 2016; Yıldırım, 2016; Ceylan, 2014
Handcraft skills	Baran et al., 2016
Design skills	Baran et al., 2016
Group working and 21st-century skills	Yıldırım, 2016

In the report of Akgündüz et al. (2015), the reasons for inadequate STEM education at the K-12 level and higher education levels are discussed. Accordingly, the most critical deficiencies are curriculum integration, interdisciplinary cooperation, inadequate implementation, instructor qualification, 21st-century skills, and the lack of STEM courses. Mainly, they point out that teachers who graduated from the Faculty of Education or other faculties in Turkey have their disciplinary knowledge instead of the needed qualification for the integration of the disciplines or interdisciplinary cooperation (Akgündüz et al., 2015). There are also researches about conducting STEM courses in pre-service science teachers' education; however, in these researches, there was collaboration among students from the same disciplines, not different ones in higher education (Gül, 2019; Türk, 2019). The interdisciplinary cooperation among faculties and departments among teachers from diverse disciplines, and among higher and K-12 education levels, is further suggested to conduct project-based or inquiry-based activities or to create, revise or/and implement the STEM programs in K-12 education (Akgündüz et al., 2015). The limited-time is further considered as a barrier against the teachers' collaboration owing to the teachers' workload in the school (Okka, 2019). Teachers also have to perform new roles in STEM education since they are expected to be mentors and guide in STEM activities and reflect on students' ideas (Akgündüz et al., 2015).

2.1.6 Discussion on STEM education

STEM literacy involves understanding scientific, technological, engineering, and mathematical knowledge and figuring out how to use this knowledge in the physical world (Bybee, 2010). Problem-solving and modeling skills, developing an understanding and argumentation and making an investigation for a challenge are the most significant developments of STEM education (Howes et al., 2013). The U.S.A. is implementing STEM education to guarantee talents in the four fields of science (S), technology (T), engineering (E), and mathematics (M), and to focus on each of the four fields individually in many cases. However, both in the international and national literature, the confusion about the interpretation of the STEM education are discovered (Ghanbari, 2015; Ministry of National Education, 2016). Related to this issue, according to Wynn and Harris (2012), science and math have disconnected from real-world situations owing to becoming more quantitative, and that has made the learners who use their right brains and have an interest in art, less concerned about these disciplines. That is why; making connections between what is learned and real-life can bring success and enjoyment to learning.

Moreover, all disciplines generally have different understandings. For instance, while engineers have a clear goal at the beginning of their studies to minimize the uncertainty, artists have a general-purpose, and they use different approaches to explore it. Then, they develop a deeper understanding of the project, contrary to engineers (Fantauzzacoffin, Rogers & Bolter, 2012). Although there is confusion about the interpretation of STEM education, both in the local and international literature, the integration of all disciplines into STEM education has been supported (Ministry of National Education, 2016; Plaza, 2004; Daugherty, 2013).

In the literature, in both areas, the lack of teachers' qualifications (teachers' inadequate STEM content knowledge), interdisciplinary collaboration, and the problems in curriculum integration are the barriers that are forwarded in front of the application of STEM education. The international literature further points out the limitation originated from the standardized national tests, school structural challenges, pedagogical challenges, curriculum challenges, students’ concerns, teachers’ concerns about assessments and time, and the inappropriate STEM activities to the needs of a specific learner level. Additionally, the significance of administrative support for implementing STEM education and constructing parents’ understanding of STEM education is discovered.

In Turkey, only changes were executed in the national curriculum of science education and technology and design education for the implementation of STEM education. The focus of the researches (articles, thesis, etc.) excludes the fine arts, humanity, and social science education and their in-service and pre-service teachers from STEM education. Therefore, there is a need for the preparation of the STEM activities/curriculum for all disciplines. STEM education also suffers from STEM activities that are not aligned with the learner level (Carter, 2013). According to Uştu (2019), a ready-made activity that is prepared for a specific class level cannot be appropriate for certain regions, school facilities, students, or teachers’ implementation understanding. This claim further emphasizes the significance of preparing STEM activity considering the learners’ academic and social levels and the school context. Teachers’ roles are also changed from teaching to facilitating and mentoring. Both literature highlight the importance of interdisciplinary collaboration among teachers. It also says that there is a time barrier in front of this. Besides, no ways are proposed for enabling teachers’ collaboration. The literature further mentions the type of the discipline integrations (such as interdisciplinary, multidisciplinary (Drake & Burns, 2004) and curricular and instructional design strategies for the STEM education (Roberts, 2013; Bruce-Davis et al., 2014) and does not propose a guide for the ways of discipline integrations.

2.2 Introduction to design thinking approach

DT approach or using design methods has gained popularity with IDEO’s efforts (Brown, 2008). Many institutions have started to offer DT programs, such as the

Hasso Plattner Institute of Design (HPI) at Stanford (USA) and in Potsdam (Germany) or the Rotman School of Management in Toronto (Canada). They create a collaborative learning environment among students from different universities and disciplines, companies, or government, and educators from design and management departments taught these programs (Wrigley & Straker, 2015).

While the DT approach is not a new term for designers, “the explicit use of the term design thinking as used to describe the process of enabling innovation and solving broad problems within a business context is relatively new” (Figure 2.6) (Sobel & Groeger, 2012, p.5). Accordingly, in the design context, the use of the DT approach started with Simon in the late 1960s and continued with Lawson, Rowe, Buchanon, and Cross until the 2000s to build its structure. It is also discovered that the opinions about how the DT approach can be applied are developed around the 1970s. On the other side, Kelley was the first one who used this term in the management context at the beginning of the 2000s, and this continued with Dunne, Martin, and Brown until recently.

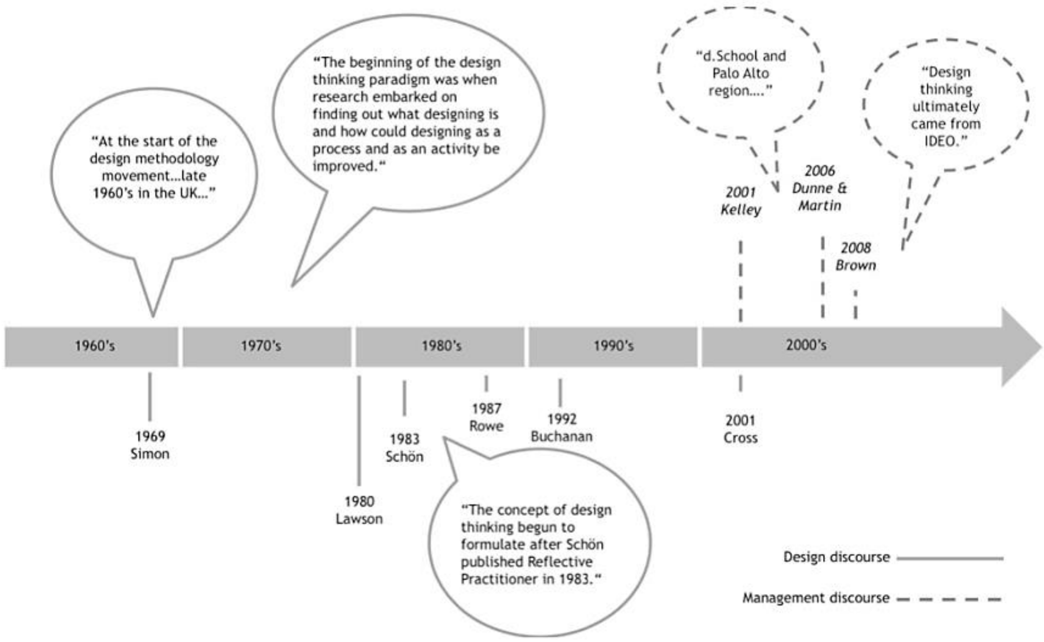


Figure 2.6. The views from the design discourse and management discourse (Hassi & Laakso, 2011)

Johansson-Sköldberg et al. (2013) mention two discourses of design thinking: ‘designerly thinking’ and ‘design thinking’. The ‘designerly thinking’, which is the academic field of designer’s professional practice have five sub-discourses and has been discussed for 40 years in the design context. The five sub-discourses of ‘designerly thinking’ (Table 2.4) are as follows (p.124):

- “Design and designerly thinking as the creation of artifacts” (Simon, 1969). Design means creating something new; it does not concern with what already exists as other sciences do.
- “Design and designerly thinking as a reflexive practice” (Schön, 1983). The relationship between reflection and creation is the core of the design practice.
- “Design and designerly thinking as a problem-solving activity” (Buchanan, 1992, based on Rittel & Webber, 1973). Design deals with the ‘wicked problems’ “as a conception of reality” (Laursen, & Haase 2019, p. 819) and includes problem definition and problem-solving sequence.
- “Design and designerly thinking as a way of abductive reasoning/making sense of things” (Lawson, 2006 [1980]; Cross, 2006, 2011). Cross deals with the designers’ activity of designing, and Lawson investigates the creative design processes’ psychology to offer a process model for design.
- “Design and designerly thinking as the creation of meaning” (Krippendorff, 2006)”. Contextual meaning-making as the main value or “truth criterion” (Laursen & Haase 2019, p. 819) is the focus of the design process.

Table 2.4 *Comparison of five discourses of designerly thinking (Johansson-Sköldberg et al., 2013, p.126)*

Founder	**Background**	**Epistemology**	**Core Concept**
Simon	Economics & political science	Rationalism	The science of the artificial
Schön	Philosophy & music	Pragmatism	Reflection in action
Buchanon	Art history	Postmodernism	Wicked problems
Lawson & Cross	Design & architecture	Practice perspective	Designerly ways of knowing
Krippendorf	Philosophy & semantics	Hermeneutics	Creating meaning

Considering Johansson-Sköldberg et al. (2013), Laursen and Haase (2019) define six methodological approaches that are significant in ‘designerly thinking’:

- Reflective practice (reflecting while doing and about the process of acting)
- Framing (defining or redefining the problem or situation)
- Modal shift (changing the focus between the diverse type of activities and tasks, if needed)
- Dialogue with the situation (the creation of prototypes, models or systems and interacting with them)
- Solution-led goal analysis (aiming to meet context or users’ needs with right solution)
- Co-development of problem and solution (dealing within an iterative process of proposing, testing and evaluating ideas)

‘Design thinking’ is mostly used in the management context and has developed over the last decade (Johansson-Sköldberg et al., 2013). ‘Design thinking’ has three sub-discourses (Table 2.5) which are (p.128);

- “Design thinking as design company IDEO’s way of working with design and innovation” (Kelley, 2001, 2005; Brown, 2008, 2009).

Design thinking is a process, including specific steps. Brown proposes that everybody can deal with the design thinking approach by following its problem-solving process.

- “Design thinking as a way to approach indeterminate organizational problems, and a necessary skill for practicing managers” (Dunne & Martin, 2006; Martin, 2009).

It is about teaching the design thinking approach to management students for making them deal with organizational management problems.

- “Design thinking as part of management theory” (Boland & Collopy, 2004a).

It emphasizes the cognitive characteristics of design instead of the working process since Boland finds similar both design and management disciplines’ general characteristics.

Table 2.5 *Comparison of the three management discourses of design thinking (Johansson-Sköldberg et al., 2013, p.130)*

Originator	**Audience**	**Discourse Character**	**Academic Connections**	**Relation to Practice**
IDEO design company (Tom Kelley & Tim Brown)	Company managers (potential customers)	IDEO success cases (written for managers)	Grounded in experience rather than research. Connections to innovation research.	Kelley: How ‘we’ (IDEO) do design thinking. Brown: How anyone can use design thinking.
Roger Martin	Educators (academics & consultants) Company managers	Success cases from production companies used to illustrate theory development (managerial thinking).	Grounded in cognitive science & management science. Builds on planning theories (‘wicked problems’).	How successful production companies do design thinking. How ‘any’ company (manager/individual) can do design thinking.
Richard Boland & Fred Collopy	Academic researchers & educators	Short essays where established (management) scholars apply their theoretical perspective to the design area.	Grounded in individual researchers’ own theoretical perspectives. Inspired by Gehry’s architectural practice or contact with design.	Design thinking as analogy & alternative.

Chon and Sim (2019) make a comparison between the two discourses. Accordingly, while ‘design thinking’ demonstrates the practice of design to non-designers in a simple way, ‘designerly thinking’ clearly presents the connection between theory and practice about professional design practice in the academic context and affects the development of ‘design thinking’ among non-designers. They argue that ‘design thinking’ focuses on finding innovative solutions and strategies in the management context by improving creative skills and emphasizing practical usage of the approach and its implications (Chon & Sim, 2019). Di Russo (2016) further argues that the term ‘design’ is associated with the ‘design thinking’ approach with more emphasis on the process, methods, and attitudes rather than practices. On the contrary, Chesson (2017) claims that ‘design thinking’ isn’t only a process or method to be used for organizations’ problems; it also changes the way to approach problem-solving. On the contrary, in ‘designerly thinking,’ “design practice requires skills and competencies beyond creative ability” (p. 190). It also focuses on improving designers’ ability to defining problems, analyzing needs, limitations. It challenges to develop insights by reflecting upon the obtained knowledge, to reach and implement the solutions (Chon & Sim, 2019). In this respect, Johansson-Sköldberg et al. (2013) argue that ‘design thinking’ leaves the creativity side of the designer, his skills and knowledge outside the management discourse, which on the contrary, have a place in the academic discourse of ‘designerly thinking.’

‘Designerly thinking’ deals with design paradigm and methodological approaches that are defined as being adaptive in different contexts by implementing situated actions (Laursen & Haase, 2019). On the contrary, ‘design thinking’ mostly focuses on recommended techniques and tools that should be applied in certain stages by imitating designer’s way of doing for non-designers and is defined by the authors as “‘suggested actions’ described in a ‘cookbook’” (ibid, p. 826). According to the authors, if a non-designer applies suggested tools and techniques of ‘design thinking’ approach for certain situations without making situated actions, he will probably use his methodological approach based on his expertise because of knowing one methodological approach. In that circumstance, reaching success is questionable (Laursen & Haase, 2019). In the light of the brief history discussed in this review, it can be concluded that the ‘design thinking’ isn’t a new practice in the design discipline and it provides a fresh viewpoint about design practice to the other disciplines as being perceived as an innovative problem-solving method. However, the application of ‘design thinking’ to non-designers and its success is questionable.

2.2.1 What is design thinking?

In the literature, there are no definite principles presented for the DT approach or how it can be taught (Kimbell, 2011). According to Richardson (2013) and Chesson (2017), there is also no accepted common theory that describes the DT approach, its way of working, and its result. Carlgren (2013) further states that in the literature, the descriptions of the DT include areas of application, a prescriptive process, design methods, and practice and a specific mindset. For instance, in the education context, the DT approach is defined as a human-centered and collaborative problem-solving approach that enables innovative solutions by fostering people's creative thinking skills (Aflatoony, Wakkary & Neustaedter, 2018). From the innovation management context, the DT approach is described as the integration point of business, design, engineering, and social sciences that enable problem definition, solving, and creating products, services, and systems (Leifer & Steinert, 2014). However, Brown describes (2008, p.85) DT approach as a "discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity."

The DT approach involves several steps, design practices or methods (Carlgren, 2013) to customize the innovation process in a variety of the fields (IDEO, 2012; d.school at Stanford University, n.d.) and to enable the stakeholders' and users' participation in the design process (Di Russo, 2016). For instance, IDEO has developed toolkits, particularly for educators (IDEO, 2012) and also for social innovation (The Field Guide to Human-Centered Design, 2015). Moreover, DT methods and processes are often utilized as representations of the mindset (Di Russo, 2016), which are also named as attitudes or sensibilities in the literature (Howard, 2015). The 'mindset' believers describe design thinkers as having innovative thinking, divergent and intuitive skills along with a human-centered and creative perspective (ibid.). Chesson (2017) asserts that these mindsets exist to some degree in all people, while some of them can use all of them to specific points, some of them can use the limited ones. But, according to him, they can be improved with practice. Considering the literature, having or developing an appropriate mindset is necessary to make the correct start for dealing with DT (Lor, 2017). However, Howard (2015) states that information is scarce in the literature about how these mindsets are developed or applied. When comparing the mindsets of the popular DT toolkits, it is discovered that there are common mindsets (Table 2.6).

Table 2.6 *Comparison of the mindsets among the toolkit for social innovation, the toolkit for educators, the d.school playbook for K-12 schools and HPI's DT approach for K-12 schools*

IDEO		**d.school at Stanford University**	
Toolkit for social innovation (The Field Guide to Human-Centered Design, 2015)	**Toolkit for educators (IDEO, 2012)**	**d.school playbook for K-12 schools (Tran, 2017)**	**HPI's DT approach used in K-12 education (Carroll et al., 2010)**
Make it	Human-centered	Focus on human values	Human-centered
Creative confidence	Collaboration	Radical collaboration	Radical collaboration
Optimism	Optimistic	Be visual	Show do not tell
Learn from failure	Experimental	Crafting clarity embrace experimentation	Culture of prototyping
Embrace ambiguity		Bias towards action	Bias toward action
Empathy		Defer judgment yes and (Build on others' ideas)	Empathy
Iterate			Mindful of process

From this comparison, it is evident that human-centered, collaboration, experimentation, bias towards action, and show do not tell (be visual) are common and significant mindsets in the education context. These mindsets also seem aligned with 21st-century skills. Although there are many mindsets described in the literature, commonly cited ones are described in Table 2.7.

The DT mindsets can also be interpreted in the literature as DT characteristics, and according to Howard (2015), "how these characteristics are embodied or enacted are key aspects of design thinking in practice" (p. 51). Tschimmel (2012) defines the main characteristics of DT as follows: Abductive thinking, Perceptive cognition, Visualising, Prototyping, Developing understanding and acceptance about failure and mistakes, and Human-centered. Similarly, according to Howard

(2015), there are eight core DT characteristics, which are; Optimism and comfort with ambiguity, Abductive thinking, Creative thinking, Systems thinking, Empathy and human centeredness, Collaboration, Visualization & prototyping, and Iteration. Howard (2015) states that these characteristics can be presented individually in different disciplines. However, they are also used to describe the DT as an approach or the design thinkers' attributes (mindsets).

Table 2.7 *Description of design thinking mindsets*

Mindset	Description
Failing often and early (Resiliency, Experimental, or Learn from failure)	Based on experimentation of human learning, it means developing many ideas and testing them with the users to find out the working and failing sides. If it fails, developing new ones until it reaches a feasible solution (Brenner, Uebernickel & Abrell, 2016) by adopting a prototyping mindset. It can also be named as “resiliency” (Kolk, 2012), “Experimental” (IDEO, 2012) or “Learn from failure” (The Field Guide to Human-Centered Design, 2015).
Collaboration (Radical collaboration)	It is about working with or co-creating with users, clients, and/or stakeholders to figure out the problem and its context, perceive the potential barriers and challenges, people’s perspective, needs, and desire and develop solutions (Chesson, 2017). It can also be named as “radical collaboration” (Tran, 2017).
Human centeredness	It is developing empathy for others by investigating the people’s needs, challenges, and motivations related to the problem (IDEO, 2012).
Empathy	“Empathy is the ability to see a situation from multiple perspectives such as the point of view of clients, end-users, and colleagues” (Chesson, 2017, p. 43). In the literature, both human-centeredness and empathy can be used to refer to the same mindset.
Being comfortable with ambiguity (Embrace ambiguity)	It is about being comfortable when discovering the unknown, productive solutions that do not exist (Chesson, 2017). It can also be named as “Embrace Ambiguity” (The Field Guide to Human-Centered Design, 2015).
Having a systemic vision	In this mindset, the problems are accepted as system problems and required systemic solutions by involving the policies, procedures, organizational concepts or software, and many others (Owen, 2007).
Taking action deliberatively and overtly (Bias towards action)	It is also called as “Bias towards action” and emphasizes focusing on the experimentation or hands-on experiences instead of only discussion-based thinking owing to giving priority to solutions instead of problems (Tran, 2017).
Being open to Risk-taking	It is about leaving the comfort zone to explore new ideas by questioning the current situation or context (Chesson, 2017). It also implies taking a risk as a learner and accepting not succeeding in your first attempt by emphasizing the importance of process (Kolk, 2012).
Being Optimistic	Being optimistic means not losing faith in finding better ideas to change the current situation into a viable one (Chesson, 2017).
Engaging in prototyping (Culture of prototyping or Iterate)	It is about prototyping and testing out ideas in an iterative process until discovering a viable solution to meet the user’s needs (Chesson, 2017). It can also be called “Culture of prototyping” (Carroll et al., 2010) or “Iterate” (The Field Guide to Human-Centered Design, 2015) in the literature.
Being visual (Show do not tell)	It is about thinking visually to generate new ideas about potential solutions and make it concrete (Chesson, 2017). It can also be called “Show do not tell,” which means expressing ideas in a non-verbal way, including sketching, prototyping, or storytelling (Carroll et al., 2010).
Mindfulness of process	It means to “know where you are in the design process, what methods to use in that stage, and what your goals are” (d.school at Stanford University, n.d.).
Reflection	Reflection is “described as a process of looking back to understand what the design thinker knows from past experiences that can be applied to what is known about the current problem” (Chesson, 2017, p. 45).
Defer judgment yes and (Build on others’ ideas)	It is about trusting others without making judgment and their creativity for developing ideas (Tran, 2017).
Having creative confidence	“Creative confidence is the belief that everyone is creative, and that creativity isn’t the capacity to draw or compose or sculpt, but a way of understanding the world” (The Field Guide to Human-Centered Design, 2015).
Having abductive thinking	“It is thinking in different perspectives and about future possibilities, which do not fit into existing models. It is a way of thinking in which feelings and emotions are just as important as rationality” (Tschimmel, 2012).

2.2.2 Design thinking approaches

In the literature, there are various alternative DT approaches. Although there are some similarities in the number and the name of the process stages, the typical DT approach has between three to six stages, and they are based on human-centricity, interdisciplinarity, ideation, and experimentation (Efeoglu et al., 2013). According to Bequett & Bequett (2012), all processes generally have similar steps for problem-solving such as defining the problem, research, generating ideas, prototyping, testing, and evaluating the result. For instance, Brown (2008) divides the DT process into three primary stages. In Brown's method (2008, pp. 88-89), while the *inspiration* means making research on the problem to understand the problem or opportunity and defining the insights, the *ideation* means generating ideas, developing them by making prototypes, and testing the possible solutions. The last stage of *implementation* means developing an action plan to put the solution into the market.

Howard (2015) uses Brown's three-stage process to make a comparison among the DT processes that are used in multiple disciplines (health, management, engineering, education, industrial design, etc.) (Figure 2.7). In this comparison, she illustrates the other design thinking processes under the three stages of Brown's process to facilitate the comparison. According to Howard (2015), all DT approaches have similar stages based on Brown's method, and the main difference originates from whether having the *implementation* stage in the DT approaches since in some of them; the *implementation* stage is missing. Howard (2015) thinks this as a weakness. On the contrary, in my opinion, the reason for this can be originated from the situatedness of the context. Its impact can cause variations during the implementations. Furthermore, except for the *implementation* stage, she finds uniformity in the design thinking processes with minor changes in the names and the number of the stages. In this circumstance, all DT processes follow a similar path starting with the problem definition and ending with the problem solution. Problem definition is the process of investigating and understanding the needs and analysis, while the problem solution is the process of generating ideas, prototyping, and testing (Howard, 2015).

In the literature, three DT approaches are mostly used in the education context: d.school at Stanford University, IDEO (Design thinking for Educators), and HPI's (Hasso Plattner Institut) design thinking approaches. In IDEO (Design thinking for Educators) (2012), the DT process includes five stages (*discovery, interpretation, ideation, experimentation,* and *evolution*) along with a zero-step called to *define a challenge*. (Figure 2.8) In the *discovery* stage, the challenge is creating a shared understanding about the problem within the team by sharing your knowledge, reviewing constraints, defining team members' role and the target group, creating the project plan, defining the sources for collecting data, making interviews and observations. The *interpretation* stage means transforming the data into insights by sharing them with others, documenting your findings, and making sense of them with defining themes, insights, and opportunities. In the *ideation* stage, many ideas are generated by brainstorming, and the promising one/ones are selected. The *experimentation* stage means making prototypes, sharing them with other people, and getting feedback about them. Lastly, the *evolution* stage deals with the development of the concept, including planning further steps, contacting other people to realize the solution, documenting the success criteria and the process.

Author	Perspective	Design thinking stages		
Brown (2008)	Industrial designer working as CEO of design and innovation consultancy IDEO	Inspiration	Ideation	Implementation
Fraser (2009)	Academic and consultant In management and business design	Deep user understanding	Concept visualisation	Strategic business design
Martin (2009)	Academic in management with a focus on competitive advantage in business.	Mystery	Heuristic	Algorithm
Duncan & Breslin (2009)	Practitioners in the health sector, Centre for Innovation at the Mayo Clinic.	Topic framing; Research	Design	Development
Clark & Smith (2008)	Practitioners working with the experience design process at technology company IBM.	Understand; Observe	Conceptualise; Validate	Implement
Liedtka & Ogilvie (2011)	Academics in management and consultants in business.	What is?	What if?; What wows?	What now?
IDEO (Bell, 2008)	Design and innovation consultancy working across numerous sectors	Understand; Observe	Visualise; Evaluate/ Refine	Implement
Beckman & Barry (2007)	Academics in business and mechanical engineering respectively. Model developed from empirical research with students.	Observation/ Problem finding; Framework/ Problems selecting; Imperatives/ Solution finding	Solution selecting	
Dym et. al. (2006)	Academics in engineering education developed from empirical research with students.	Observation; Inquiry	Learning	
Stanford University (2010)	Developed by the Stanford Design School for higher education and corporate education.	Empathise; Define	Ideate; Prototype; Test	
Holloway (2009)	Practitioner using design thinking at technology company SAP.	Problem definition	Idea generation; Visualisation; Prototyping	

Figure 2.7. Comparison of design thinking processes (Howard, 2015)

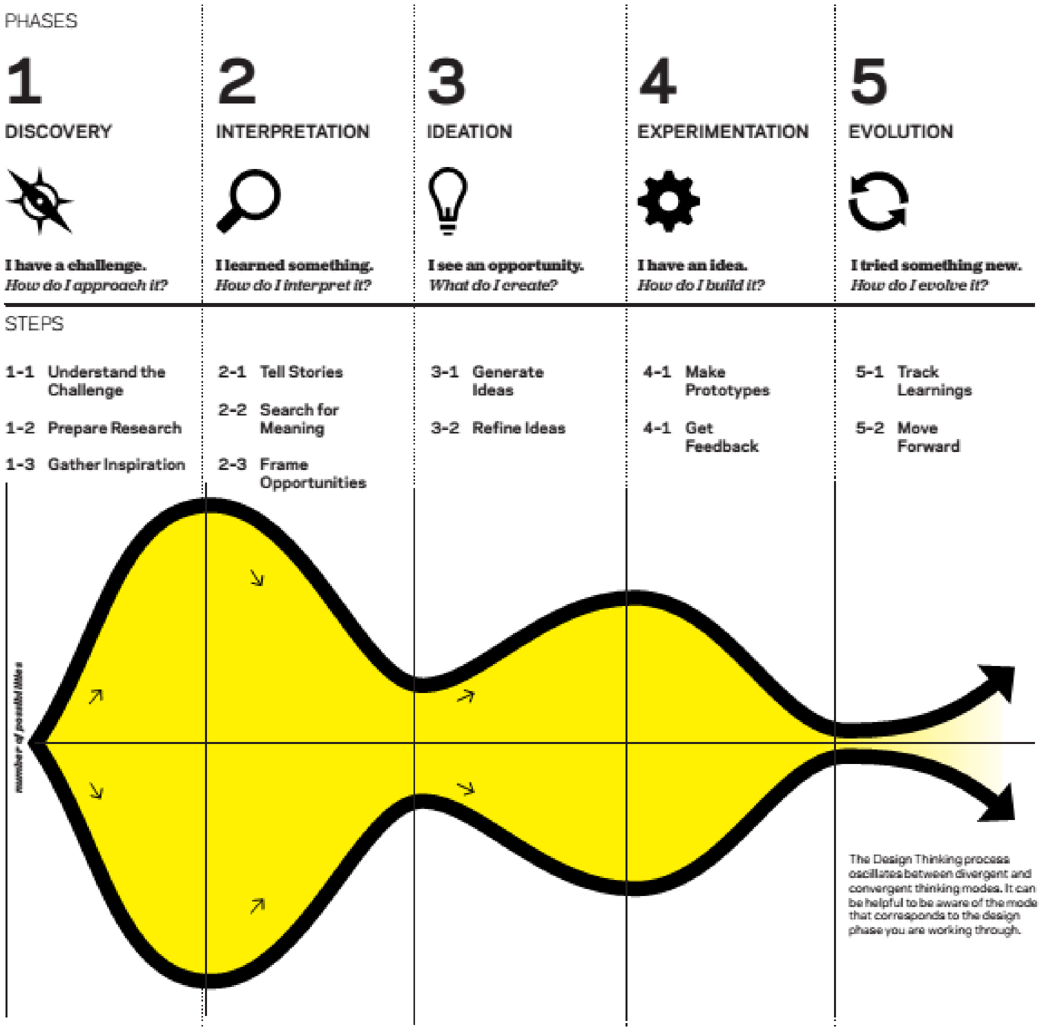


Figure 2.8. Five phases of the IDEO design thinking process for educators (IDEO, 2012, p. 15)

In d.school at Stanford University (n.d.) DT process includes five stages: *empathize, define, ideate, prototype*, and *test*. (Figure 2.9) *Empathy* stage means building empathy with people for whom you are designing and understanding what is crucial for them, how they interact with their environment by making interviews and observations. In the *define* stage, the collected data is synthesized into needs and insights to define the problem statement: point of view. The *ideate* stage means generating many ideas. The *prototype* stage deals with turning ideas into physical forms by making prototypes. The last stage is the *test*, which is an iterative phase and includes getting feedback from the users about the prototype and developing them to reach better solutions.

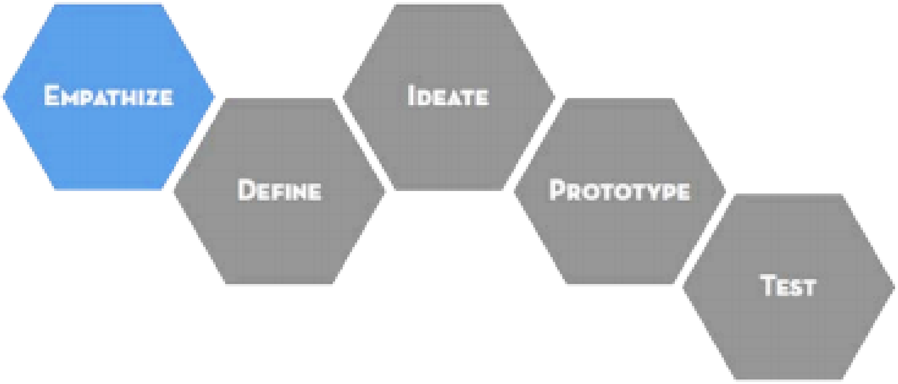


Figure 2.9. Five phases of d.school design thinking process (d.school at Stanford University, n.d., p.1)

In the HPI (Hasso Plattner Institut), the DT process has six stages (Thoring & Muller, 2011a), which are: *Understand, Observe, Point of View, Ideate, Prototype*, and *Test* (Figure 2.10). In this approach, if necessary, you can go back to previous stages or even to the beginning. According to Thoring and Mueller (2011b), while the *understand* stage aims to collect data related to the subject through research, the *observe* stage deals with developing an understanding of the problem and users by doing qualitative research. The *point of view* (POV) stage means sharing the knowledge collected in the previous stages, combining them to define needs and insights, and finally reaching a problem statement by developing a point of view. The *ideate* stage intends to brainstorm the question described in the *POV* stage and to select the best ideas based on the collective agreement of the team. In the *prototype* stage, it aims to build the concept chosen by using a variety of prototyping methods. The last stage is the *test*, which is an iterative process and intends to take feedback from the user concerning the prototype and, if needed, to make the necessary corrections by revising the prototype or the whole concept by going back to the previous stages.

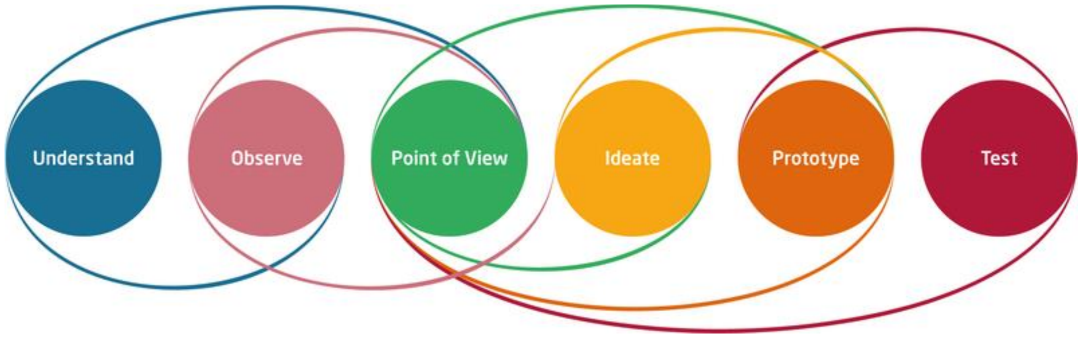


Figure 2.10. HPI design thinking process (HPI, n.d.)

Similar to Howard's (2015) comparison in Figure 9, I want to illustrate all three DT approaches executed in the education context under the Brown (2008) three-stage process (Table 2.8). Accordingly, all DT approaches have similar stages based on Brown's method, and the main difference is based on whether having the *implementation* stage in the DT approaches. For example, the d.school (n.d.) at Stanford has a five-stage design thinking process without the implementation stage. While *empathy* and *define* are placed under the *inspiration* stage, *ideate, prototype,* and *test* stages are placed under the *ideation* stage of Brown's approach. Moreover, HPI has a six-stage design thinking process (Thoring & Mueller, 2011b) in which three steps are the same as the d.school process. While *understand, observe,* and *point of view* are placed under the *inspiration* stage, *ideate*, *prototype,* and *test* stages are placed under the *ideation* stage of Brown's approach. Additionally, IDEO (2012) has a five-stage DT process with different names. It has almost the same function until the fifth stage with d.school. However, the change is apparent in the last stage by having the *implementation* stage. In this process, while *discovery* and *interpretation* are placed under the *inspiration* stage, *ideation* and *experimentation* are placed under the *ideation* stage of Brown's approach. Lastly, the *evolution* stage of the IDEO was set under the *implementation* stage of Brown's approach. Only IDEO (2012) has the *implementation* stage, while others have only *inspiration* and *ideation* stages.

Moreover, in three DT approaches that are implemented in the education field, it is evident that the functions of the stages are the same. However, they had different names, and some of them are separated into two parts. For instance, the *empathy* in d.school and *discovery* in IDEO have nearly the same function, but, in the HPI process, the role of these stages is divided into two as *understand* and *observe* stages. The same thing happened in the IDEO *experimentation* stage, and its function is divided into two both in HPI and d.school processes as being a *prototype* and *test* stages. It can be concluded that, if Brown's approach can be considered as the core of the design thinking process, DT approaches executed in the education field have similarities with each other except having changes about the names and the number of the stages. Compared to Brown's approach, having more stages makes the DT processes more tangible for people with a non-design background owing to the division of functions.

Table 2.8 *Comparison of HPI, d.school and IDEO design thinking approaches considering the Brown design thinking approach*

<table>
<tr><th>DT Approach</th><th colspan="7">Stages of Design Thinking</th></tr>
<tr><td>Brown's (2008) DT approach</td><td colspan="3">Inspiration</td><td colspan="3">Ideation</td><td>Implementation</td></tr>
<tr><td></td><td colspan="3">Making research on the problem to understand the problem or opportunity and defining the insights</td><td colspan="3">Generating ideas, developing them by making prototypes and testing possible solutions</td><td>Developing an action plan to put the solution into the market</td></tr>
<tr><td>HPI's DT approach (Thoring & Mueller, 2011b)</td><td>Understand</td><td>Observe</td><td>Point of View</td><td>Ideate</td><td>Prototype</td><td>Test</td><td rowspan="4"></td></tr>
<tr><td></td><td>Collecting data related to the subject through research</td><td>Developing an understanding of the problem and users by doing qualitative research (interviews, observation, etc.)</td><td>Sharing of the knowledge collected in the previous stages, combining them to define needs and insights and finally reaching a problem statement by developing a point of view</td><td>Brainstorming the question found in the POV stage and selecting the best ideas considering the collective agreement of the team</td><td>Building the selected idea by using a variety of prototyping methods</td><td>Taking feedback from the user for the prototype, if needed, making the necessary corrections by revising the prototype or the whole concept</td></tr>
<tr><td>d.school's DT approach (d.school at Stanford University, n.d.)</td><td colspan="2">Empathy</td><td>Define</td><td>Ideate</td><td>Prototype</td><td>Test</td></tr>
<tr><td></td><td colspan="2">Building empathy with people for whom you are designing and to understand what is crucial for them, how they interact with their environment</td><td>Synthesizing the collected data into needs and insights to define problem statement: point of view</td><td>Generating multiple ideas</td><td>Turning ideas into physical forms by making prototypes</td><td>Getting feedback from the users about the solution and developing them to reach better solutions</td></tr>
<tr><td>IDEO's (Design Thinking for Educators) DT approach (IDEO, 2012)</td><td colspan="2">Discovery</td><td>Interpretation</td><td>Ideation</td><td colspan="2">Experimentation</td><td>Evolution</td></tr>
<tr><td></td><td colspan="2">Creating a common understanding of the challenge or problem within the team by sharing your knowledge, reviewing constraints, defining the target group, creating the project plan, making interviews and observations for collecting data</td><td>Transforming the data into insights by sharing, documenting your findings and making sense of them with defining themes, insights, and opportunities</td><td>Generating ideas by brainstorming and selecting the promising one/ones</td><td colspan="2">Making prototypes, sharing them with other people and getting feedback about them</td><td>Planning further steps for production, contacting other people to realize the solution, and documenting the success criteria and the production process.</td></tr>
</table>

2.2.3 Using design thinking approach in K-12 education

Although the DT approach has been used since the 1960s in the design discipline, it has been utilized in K-12 education in the last two decades. However, a lot of effort has been made to utilize the design mindset in science learning before the application of the DT approach in K-12 education. For example, Kolodner et al. (1998) suggest an iterative *Learning by Design* (LBD) approach to solve problems. According to this approach, LBD gives children a reason to learn the science content, and solving a problem requires using both design and science skills (Kolodner, 2002). Fortus et al. (2004) also introduce an *Advanced Design-Based Science* approach (DBS) to teach 9th-grade students scientific knowledge and problem-solving skills and engage them in design. Strobel et al. (2013) further propose an approach of authenticity by presenting the impact and value of authenticity as a principle in *Design-Based Learning* (DBL).

In addition to the integration of design into K-12 education, the DT approach is applied to address various problems in education, such as students' low interest in school, the communication problems of students, the education inability about accommodating different learning styles and preparing kids for the real world, etc. (IDEO, 2012).

Since teachers are proposed to become the designer of their classroom, students' learning, and curriculum (IDEO, 2012) in some studies, the focus is on curriculum design and instructional design. For instance, Howard County Public School System in Maryland has been using DT approach to redesign their curriculum. Consequently, the design team tries to understand the teachers, students, administrators, and parents to develop new curriculum and resources (IDEO, 2012). Furthermore, in Design39 Campus, teachers have been using the DT approach to create a learning experience for students by working with stakeholders with adopting a collaboration culture. In these collaborations, teachers focus on students individually to create their own personalized learning experiences instead of thinking students in the same grade level as a whole (Power, 2019).

In Brown and Edelson’s (2001, 2003) studies, the researchers emphasize the curriculum development created by a collaboration among teachers and curriculum developers. According to the authors, teachers’ activities show the characteristics of design practice and teaching by design are found not to be a conscious activity but an inevitable one (Brown & Edelson, 2003). Similarly, McFadden (2015) perceives curriculum design as a design problem that involves a designer’s perspective, feelings, and evaluations and proposes coaching to teachers who are assigned to integrate STEM into their courses, while developing their curriculum. In his study, since pedagogical knowledge could not be enough for the STEM integrated curriculum design process, teachers also take the role of the designer. Consequently, in curriculum design, he proposes to work with designers who also teach as opposed to teachers who are asked to be designers.

De Campos (2014) further investigates the DT approach in education to implement 21st-Century Learning within a school district from the perspective of organizational change. Carroll et al. (2010) also recommend blending DT into the curriculum to assist classroom instruction and increase students’ learning by including a variety of interdisciplinary subjects. She also points out that teachers should understand what value the DT can contribute to education and how it can enhance the instruction. Many projects have been conducted by educational and public institutions to teach DT to students and teachers. Cooper Hewitt Museum (New York) is one of them, and it has tried to promote DT in K-12 for years. For example, in a *City of Neighborhoods* program, K-12 teachers are taught to use DT in their classrooms (Shelly, 2011). *Design in the Classroom* is a school-based, single-visit workshop and designed for introducing DT to K-12 students and helps teachers to integrate DT into their classroom (Cisneros, 2013).

d.school at Stanford University offers DT workshops to K-12 teachers and students and also carries out projects in the K12 lab network (n.d.). Some of their projects are:

- Shadow a Student (n.d.): Shadowing a student is to follow a student by observing, collecting evidence, and reflecting on them to develop empathy and insight into their experience.
- School Retool (n.d.): It is a professional development fellowship, including workshops, school visits, peer support, and coaching, for assisting school principals in recreating their school culture.

REDlab (n.d.) in d.school conducts research on the understanding of DT in K-12, undergraduate, and graduate-level education. They have some projects, such as *Taking Design Thinking to School I* and *II* and *d.loft STEM*.

- Taking Design Thinking to Schools: It is a collaboration of the Hasso Plattner Institute of Design (d.school), the School of Education (SUSE), and teachers in local schools and aims to bring DT to K-12 education. It mainly focuses on the adaptation of teachers and the development of the curriculum and the classroom space (Taking Design Thinking to Schools, n.d.).
- d.loft STEM: It is an education and research project which unites STEM with DT practices. They provide professional development and workshops to K-12 teachers and organize camps, afterschool events for middle schoolers (d.loft STEM, n.d.). For instance, in a three-year STEM-based project between Whitfield University and Diamond After School program, it is aimed to develop an understanding of STEM issues and mentoring relationships among the university students and middle schoolers. In this project, the prototyping mindset of DT is used by university students to improve their mentoring relationships with middle schoolers (Carroll, 2014).

In Turkey, ten graduate theses have been completed about the DT approach so far (Table 2.10). Of these, only three explore the DT approach from different perspectives in the context of education:

- The improvement of the 2nd, 3rd, 4th, 5th, and 6th-grade students' DT skills with the activities developed by the researcher by using creative writing, drawing and 3-dimensional design (Özekin, 2006)
- Providing solutions to the problems and needs of one of the 6th-grade social science units (Aydemir, 2019)
- Investigating the different integration methods to find out an appropriate approach for integrating the DT into business education (Çınar, 2018)

It can be concluded that in education, the focus of using DT is on curriculum design, organizational change in the educational institution, challenges of education, instructional design, learning environment design, improvement in students' skills, and solving students' problems (Table 2.9).

Table 2.9. *The areas using design thinking in the educational context*

Curriculum design	IDEO, 2012; McFadden, 2015; Power, 2019
Organizational change in the educational institution	De Campos, 2014
Challenges of education	Aydemir, 2019; The Teachers Guild, n.d.
Instructional design	Brown & Edelson, 2001
Learning environment design	Design Council, 2005; Taking Design Thinking to Schools, n.d.
Improvement in students' skills	d.loft STEM, n.d., Özekin, 2006
Solving students' problems	Shadow a student, n.d.

The DT approach is used in K-12 education to solve a variety of challenges related to curricula, learning spaces, and systems (Tran, 2017) and to enrich the learning and teaching experiences and the management in the school. Consequently, both the design mindsets and practices can present new modes of thinking and perspectives to the teachers and administrators in the instructional and learning environment design and on the students' learning in education.

Table 2.10. *Information about postgraduate theses including 'Design Thinking' in Turkey*

Author	**Year**	**Title of thesis**	**Field of thesis**	**Degree**	**University, Institute**
Thomas W. Vint	1996	Martin Heidegger's Structure of Existence as a Framework for Site Design Thinking	Architecture	PhD	Middle East Technical University, Graduate School of Natural and Applied Sciences
Münevver Özekin	2006	İlköğretim 2., 3., 4., 5. ve 6. Sınıf Öğrencilerinin Eğitiminde Tasarımcı Düşünce Eğitim Modelinin Değerlendirilmesi	Child Development	Master's	Hacettepe University, Graduate School of Health Sciences
Aykut Coşkun	2010	Post-Use Design Thinking for Product Design Process and Sustainability: A Study on an Educational Project in Glass Packaging	Industrial Design	Master's	Middle East Technical University, Graduate School of Natural and Applied Sciences
Pelin Koçkan	2012	Tasarım Araştırmaları Bağlamında Tasarımcı Düşünme ve Tasarım Süreci	Interior Architecture & Environment Design	Master's	Hacettepe University, Graduate School of Social Sciences
Ayşe Sine Serbes	2015	Bir Tasarımcı Girişiminde 'Design Thinking'in İçkin Olarak Kullanımı	Industrial Design	Master's	Istanbul Technical University, Graduate School of Science Engineering and Technology
Noman Aziz	2015	Research and Study of Developing an Integrated Entrepreneurial and Innovative Co-design Thinking Model and Toolkit	Innovation and Entrepreneurship	Master's	Fatih University, Graduate School of Sciences and Engineering
Ezgi Baştuğ	2015	Learning Design Thinking Through Pattern Generation: A computational framework	Informatics	Master's	Istanbul Technical University, Graduate School of Science Engineering and Technology
Çağdaş Özbaki	2016	Model Yapma Yoluyla Tasarım Düşünme Süreci: Analog ve Dijital Model Karşılaştırması	Informatics	PhD	Istanbul Technical University, Graduate School of Science Engineering and Technology
Gözde Çeviker Çınar	2018	Design Thinking in Business Education: A Case Study Perspective	Design Studies (Business Education)	Master's	Izmir University of Economics, Graduate School of Social Sciences
Arcan Aydemir	2019	Sosyal Bilgilerde Tasarım Odaklı Düşünme Yaklaşımı	Turkish and Social Sciences Education	PhD	Gazi University, Institute of Educational Sciences

2.2.4 Benefits of using a design thinking approach in K-12 education

DT approach differs from the project or problem-based learning since students define the problem by themselves (Kolk, 2012). It also allows students to express their ideas without borders or constraints while engaging in design activities. Thus, it is an essential tool for creativity and innovation (Carroll et al., 2010). According to Cook and Bush (2018), the DT approach fosters students' problem-solving skills, and it can further be used to reach multiple solutions (Bouchard, 2013). Razzouk and Shute (2012) also consider that the DT approach can affect education positively about improving the students' 21st-century skills. Additionally, a systematic literature review about DT studies in education reveals that the end purpose of teaching the DT approach is for "creativity and innovation, empathy and user-centeredness, prototyping and experimentation and multidisciplinary collaboration" (Lor, 2017, p. 59).

Teaching the DT approach can develop students' learning (Carroll et al., 2010), school satisfaction, engagement (Tran, 2017), and critical thinking in problem-solving. Besides, they can study interdisciplinary factors, such as social, economic situations related to design problems (Vande Zande, 2007). It also provides benefits to students in terms of building social skills, enabling authentic learning by providing ownership in their education, and increasing their motivation by giving students autonomy and an opportunity to learn from the failure (McGlynn & Kelly, 2019).

The nature of the design process also provides collaboration, teamwork, and communication (Kolodner, 2002). Mainly, collaboration is one of the crucial parts of the learning environment, and the collaboration in the classroom makes students listen to each other and share the knowledge between themselves (Carroll et al., 2010). Design-based activities can further enhance the self-confidence and the self-reflection of the students (Barron et al., 1998). Besides, with the help of the design process, students can develop their thought processes, and that can increase their interest in the lessons (Kwack, 2014).

According to Henriksen and Richardson (2017), using the DT approach in the educational context can solve complex problems of educational practice (such as students' and parents' engagement, classroom management) by "taking a strategic approach to problem-solving and treating the problem as a systematic process of analyzing" (p. 63). Using the DT approach in K12 setting provides numerous benefits to teachers, such as "having more creative confidence, better project management processes, stronger collaboration culture, strategic decision-making" (Tran, 2017, p. 4) and assisting classroom instruction (Carroll et al., 2010). There are also common benefits for teachers and students in terms of meeting teachers' and students' needs and providing productive teaching and learning (Tran, 2017). It can be concluded that using the DT approach in education can offer multiple benefits to students in their learning and the teachers in their profession.

2.2.5 Discussion of design thinking approach

One of the essentials for inadequate STEM education in Turkey is the 21st-century skills and knowledge (Akgündüz et al., 2015), and design thinking can be found in the 21st-century skills, which are the focus of Common Core Standards (Cooper-Hewitt, 2014). Carroll (2015) also indicates that the DT approach is essential for K-12 education since it has two mindsets: risk-taking and resiliency. Both of these mindsets are also important in STEM education (Carroll, 2015). Furthermore, considering the literature review, STEM and the DT approach have common characteristics and also benefits for the learners (Table 2.11 and Table 2.12).

DT approach is perceived as a thinking approach, and it is found significant in 21st-century education (Li et al., 2019). Moreover, it is stated that there has been an inclination of implementing the DT approach in the project-based STEM activities in K-12 schools to teach multidisciplinary collaboration, creativity, empathy, prototyping mindset, and innovation by emphasizing its iterative process

(Lor, 2017). The integration of the DT approach into STEM education is also proposed to facilitate students' learning owing to enabling diverse viewpoints and their way of approach to the problem definition and solution (Li et al., 2019). Consequently, similar to the engineering design process, the DT can take the role of facilitator and binder in STEM education to enhance students' STEM learning, abilities and skills because of having similar characteristics, mindsets, and benefits. This proposition is also compatible with the humanistic perspective of the general education (Walker et al., 2018; Foshay, 1991); in the STEAM literature, using the DT approach is considered more appropriate than the engineering design process because of its intentionally integrating empathy element into the problem-solving process (Cook & Bush, 2018).

Table 2.11. *Common characteristics of STEM education and the DT approach*

STEM Education	**DT Approach**
Interdisciplinarity (Carter, 2013)	Interdisciplinarity (Efeoglu et al., 2013)
Creativity (The Ireland STEM policy, 2017)	Creativity (McGlynn & Kelly, 2019)
Hands-on practice (Moore et al., 2013)	Hands-on practice (Hassi & Laakso, 2011)
Student-centered instructional strategies (Walker et al., 2018)	Student-centered approach (Cook & Bush, 2018)
Problem-based learning (Moore et al., 2013)	Inquiry (McGlynn & Kelly, 2019)
Cooperative learning (Moore et al., 2013)	Collaboration (McGlynn & Kelly, 2019)
Trying and failing (Fredette, 2013)	Failing often and early (resiliency) (Kolk, 2012)
Risk-taking (Carroll, 2015)	Risk-taking (Chesson, 2017) (Kolk, 2012)
Teamwork (Walker et al., 2018)	Reflective practice (Laursen & Haase, 2019)
Art and design involvement (The Ireland STEM policy, 2017)	Prototyping (Chesson, 2017)
Performance and formative assessment (Walker et al., 2018)	Problem-solving method (Kolk, 2012)
Motivating and engaging context (Walker et al., 2018)	Human-centeredness (Hassi & Laakso, 2011)
Effective communication (Carter, 2013)	Combining of divergent and convergent thinking (Brenner, Uebernickel & Abrell, 2016)
Students' presentation (Carter, 2013)	Empathy (Chesson, 2017)
Project-based learning (Carter, 2013)	Being comfortable with ambiguity (Chesson, 2017)
Real-world problem-solving (Carter, 2013)	Having a systemic vision (holistic thinking) (Owen, 2007)
Innovation (The Ireland STEM policy, 2017)	Addressing all students' learning needs (McGlynn & Kelly, 2019)

Table 2.12. *Common benefits of STEM education and the DT approach*

STEM Education	**DT Approach**
Increases academic performance (Martin-Paez et al., 2019)	Increases students’ learning (Carroll et al., 2010)
Increases students' motivation (Moore et al., 2013)	Increases students’ motivation (McGlynn & Kelly, 2019)
Develops students’ 21st-century skills (Nathan & Pearson, 2014)	Develops students’ 21st-century skills (Razzouk & Shute, 2012)
Increases students' engagement in the course (Stohlmann, Moore & Roehrig, 2012)	Increases students’ engagement in the course (Tran, 2017)
Develops team working skills (Yıldırım, 2016)	Develops team working skills (Kolodner, 2002)
Enables higher-level thinking skills such as critical thinking, problem-solving, decision-making, reflective thinking, creative thinking (Moore et al., 2013)	Increases self-reflection (Barron et al., 1998)
Develops students' problem-solving skills (Carter, 2013)	Develops students’ problem-solving skills (McGlynn & Kelly, 2019)
Increases interest in STEM disciplines (Martin-Paez et al., 2019)	Increases interest in the lessons (Kwack, 2014)
Improves hand-craft skills (Baran et al., 2016)	Increases self-confidence (Barron et al., 1998)
Develops logical reasoning (Carter, 2013)	Reaches multiple solutions (Bouchard, 2013)
Develops computer skills (Carter, 2013)	Develops students’ empathy skills (Carroll et al., 2010)
Increases technological skills (Martin-Paez et al., 2019)	Increases students’ school satisfaction (Tran, 2017)
Enables applying STEM knowledge (Martin-Paez et al., 2019)	Enables students’ ownership of their learning (McGlynn & Kelly, 2019)
Fosters STEM disciplinary knowledge (Martin-Paez et al., 2019)	
Enables making connections among STEM disciplines (Martin-Paez et al., 2019)	
Develops positive attitudes towards STEM disciplines (Martin-Paez et al., 2019)	

As previously stated, there has been an inclination to the integration of all disciplines into STEM education. Watson (2015) promotes the DT approach for art integration into STEM activities. The DT approach is also described as the integration point of business, design, engineering, and social sciences (Leifer & Steinert, 2014). Besides, it is taught as a concept with a group of interdisciplinary related subjects, such as Art & Design, STEM, and Business & Entrepreneurship, rather than an individual discipline in a single subject (Lor, 2017). In that circumstance, the DT approach can enable the integration of various disciplines into STEM education.

Furthermore, one of the important challenges of STEM education is about not having STEM activities that are appropriate for the learner level (Carter, 2013). In this respect, the DT approach can assist teachers in developing STEM programs considering their students’ needs because of its human-centered nature. The other challenges about STEM education are the need for teachers’ collaboration and administrative support (Margot & Kettler, 2019) for the implementation of STEM education. The DT approach can also be used to facilitate the collaboration of teachers from diverse disciplines owing to its characteristics based on collaboration and interdisciplinary.

Design thinking has been used in the curriculum and instructional design and in solving the challenges of education for the last decade. Consequently, the DT approach has the potential to be an intersection point for all disciplines’ integration in STEM education. It can also function as a problem-solving method for solving STEM challenges. With the help of design education, teachers can develop an innovative approach in their education by using their creativity (Keane & Keane, 2014), and according to this, the DT approach can assist teachers in developing and implementing STEM education at schools.

2.2.6 Summary of the literature review

According to the literature review, there is a tendency to include all disciplines into STEM education (Ministry of National Education, 2016; Plaza, 2004; Daugherty, 2013). STEM education suffers from STEM activities that are not aligned with the learner level (Carter, 2013; Uştu, 2019). The literature also highlights the need for teachers’ collaboration in STEM education (Margot & Kettler, 2019; Akgündüz et al., 2015). This study proposes that the DT approach has the potential to answer the challenges of STEM education as follows:

- DT approach is at the intersection of business, design, engineering and social sciences (Leifer, & Steinert, 2014). Therefore, it has the potential of integrating various disciplines into STEM education.
- DT approach is human-centered and can assist teachers' developing STEM activities taking the students' needs into consideration.
- DT approach's pedagogy involves collaboration and reflection (Catterall, 2013), and can be used to facilitate collaboration among teachers from diverse disciplines.

2.3 Developing a STEM activity design workshop process

Upon reviewing the literature about STEM education and the DT approach, a two-day STEM activity design workshop process for the pilot study was designed to make teachers understand STEM education and the DT approach efficiently.

For the workshop process, PowerPoint presentations were prepared to explain STEM education, the DT approach, and the aim of the workshop. For these presentations, I also included videos about the STEM education and DT approach from YouTube channel to help teachers figure them out in a short time (Sinop Üniversitesi, 2016; ideaport, 2016).

In the workshop, a quick exercise, called the "wallet design" exercise, was decided to be executed. This exercise is developed by d.school to introduce the DT approach with a hands-on activity to the participants in a short time. It emphasizes the main values of the d.school "-human-centered design, a bias towards action, and a culture of iteration and rapid prototyping- without attempting to communicate all of the methods and activities that the term "design thinking" encompasses" (An Introduction to Design Thinking "Wallet" Edition: Facilitators' guide, 2012). It follows the five-stage d.school at Stanford University (n.d.) DT process: *empathize, define, ideate, prototype*, and *test*.

For this exercise, I examined the d.school wallet design exercise worksheet (n.d.) and translated its template to Turkish. I further watched a video about the "design thinking workshop with Justin Ferrell from Stanford d. school at The Irish Times" (Johnny Ryan, 2013) to understand the process of conducting the wallet design exercise.

2.4 Developing a design thinking approach for the STEM activity design and implementation

In developing a DT approach tuned to the needs of STEM activity design and implementation, a thorough literature review was conducted about the DT approaches that are used particularly in the education field (d.school's, IDEO's, and HPI's DT approaches). Since all of them were similar to each other, in this study, I focused on finding out which approach could be appropriate for the STEM activity design and clearer to be followed by teachers, in other words, by non-designers. In that circumstance, I considered the HPI's DT approach's focus on embedding DT in education more broadly, since their practice and empirical research focuses on the integration of DT in K-12 education for the adaptation of teachers to DT approach, curriculum, and learning environment design and uniting STEM with DT practices (Taking Design Thinking to Schools, n.d.; d.loft STEM, n.d.). Consequently, HPI's DT approach (HPI, n.d.) was selected for the framework of the STEM activity design and implementation process. Although HPI's and d.school's approaches are similar to each other owing to sharing a common background, HPI's approach is more understandable to learn by non-designers (teachers) since the name of the six stages tells what it is expected to be done.

For developing a DT approach, while using the HPI's DT approach as a framework, I also focused on the methods that are used by the other DT approaches to find out the most appropriate ones for the STEM activity design. Besides, the Delft design guide (Van Boeijen & Daalhuizen, 2010) was explored to discover its design methods. Additionally, I have followed and examined two MOOCs about the DT approach to learn their ways of implementation.

- Design Thinking for Innovation: University of Virginia course in Coursera platform (Coursera MOOCs course, n.d.)
- Design Thinking for Leading and Learning: MIT course in edX platform (MIT MOOCs course, n.d.)

The first course in the Coursera platform takes DT from the management side and proposes a model including methods to use DT in problem-solving. On the other hand, the MOOCs course in the edX platform explores the DT from the education perspective for improving the school systems and learning.

As a result, some methods of other DT approaches, the Delft design guide, and MOOCs courses were selected to be used in my DT approach. For example, I took and adapted some of the d.school at Stanford University (n.d.) methods and exercise to be used in the STEM activity design, such as *extreme users*, *empathy map*, *journey map*, *How might we (HMW) questions*, brainstorming rules and *wallet design exercise*. Moreover, in the IDEO toolkit for educators (2012), there is a zero-step, called *define a challenge* to find out the opportunities or problems to solve. In my DT approach, I also created a zero-step. I named it “problem definition”, in which teachers select the appropriate subjects from their courses for creating a STEM activity. Besides, I utilized some of its methods in my DT approach such as brainstorming rules (Brainstorming rules, n.d.), *bundle ideas* (Bundle ideas, n.d.), *download your learnings* (Download your learnings, n.d.), *define your audience* (Define your audience, n.d.), and prototyping methods (IDEO, 2012). Furthermore, I used the MIT MOOCs course (n.d.) templates for brainstorming and interview by translating them into Turkish. Besides, its activity plan guided me to prepare my STEM activity plan. I also utilized MIT design process tips and assignments to explain some of the stages of my DT approach.

From the Delft design guide (Van Boeijen & Daalhuizen, 2010), I took some of their methods to use them in my approach: *WWWWWH (5W1H): Who, What,* *Where, When, Why and How questions*, *Mind map* and *Itemised Response and PMI (Plus, Minus, Interesting) method*. Besides, to adapt the *empathy map* and *Itemised Response and PMI method* to the STEM activity design, I made some changes and additions in their process. The other methods or directions taken from the other approaches were utilized separately or combined to explain the stages of my DT approach. As stated above, the "problem definition" stage was placed at the beginning of my DT approach as a zero-step to identify the subjects of the STEM activity design. Then the rest of the design thinking process was applied in the same order as followed in the HPI's approach. As a result, the first version of the DT approach that was used for the STEM activity design in the pilot study has the following stages: "Problem Definition, Understand, Observe, Point of View, Ideate, Prototype, and Test" (Table 2.13).

Table 2.13. *The first version of DT approach developed for the STEM activity design and implementation*

Stage	Methods	Content	Sources
Problem Definition (IDEO, 2012)	Brainstorming	Brainstorming rules and directions for brainstorming	(d.school at Stanford University, n.d.) (MIT MOOCs course, n.d.)
		Evaluation of ideas	(IDEO, 2012) (MIT MOOCs course, n.d.)
Understand (HPI, n.d.)	Brainstorming	Directions for defining the target group	(Define your audience, n.d.) (MIT MOOCs course, n.d.)
		Identifying extreme users	(d.school at Stanford University, n.d.)
	5W1H Questions	Directions for 5W1H Questions	(Van Boeijen & Daalhuizen, 2010) (IDEO, 2012)
Observe (HPI, n.d.)	Brainstorming	Preparing questions	(IDEO, 2012) (MIT MOOCs course, n.d.)
	Interview	Conducting interviews	
		Interview template	(MIT MOOCs course, n.d.)
	Observation	Directions for conducting observations	(MIT MOOCs course, n.d.)
Point of View (HPI, n.d.)	Bundle Ideas	Directions for compiling collected data	(Bundle ideas, n.d.)
	Empathy Map and Brainstorming	Directions for building an empathy map	(d.school at Stanford University, n.d.)
		Grouping the data	(Educator's Guide to Design Thinking, n.d.) (MIT MOOCs course, n.d.)
		Defining needs	(d.school at Stanford University, n.d.) (MIT MOOCs course, n.d.)
		Conducting analysis	(d.school at Stanford University, n.d.) (MIT MOOCs course, n.d.) (IDEO, 2012)
		Writing the problem statement	(MIT MOOCs course, n.d.)
		POV (point of view) template	(Wallet exercise worksheet, n.d.)
Ideate (HPI, n.d.)	Brainstorming	Brainstorming rules and directions for brainstorming	(Carroll, et al., 2010) (MIT MOOCs course, n.d.) (Brainstorming rules, n.d.)
		"How Might We" questions to assist brainstorming	(d.school at Stanford University, n.d.)
		Brainstorming template	(MIT MOOCs course, n.d.)
	Mind map	Brainstorming method	(Van Boeijen & Daalhuizen, 2010)
	Itemised Response & PMI	Evaluation of ideas	(Van Boeijen & Daalhuizen, 2010) (MIT MOOCs course, n.d.) (IDEO, 2012)
Prototype (HPI, n.d.)	Planning	STEM Activity Plan template	(Çorlu & Çallı, 2017) (MIT MOOCs course, n.d.)
	Journey Map	Prototyping with journey map	(d.school at Stanford University, n.d.)
	Diagram	Prototyping with Venn diagram	(IDEO, 2012)
		Prototyping with diagrams	(IDEO, 2012)
	Model Making	Prototyping with digital model making	(IDEO, 2012)
		Prototyping with physical model making (mock-ups)	(IDEO, 2012)
		Prototyping with paper	(MIT MOOCs course, n.d.)
Test (HPI, n.d.)	Peer review	Directions for evaluating ideas	(MIT MOOCs course, n.d.)

CHAPTER 3

RESEARCH METHODOLOGY

This thesis explores the effects of the design thinking (DT) approach on the development and implementation of STEM activities by secondary school teachers. The purpose of this study is to understand how the design thinking approach can contribute to STEM education and seeks answers to the following questions:

Research Question: How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities for 5th graders?

> **Sub-question 1:** How and to what extent does the design thinking approach support collaboration among teachers for developing and implementing STEM activities?
>
> **Sub-question 2:** How and to what extent does the design thinking approach support teachers' integrating various disciplines into the STEM activity design and implementation?
>
> **Sub-question 3:** How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities appropriate to the needs of a specific learner level?

This chapter describes an overview of the research design, general procedures for conducting the study, the description of data collection methods, and the analysis procedures.

3.1 Case study

In this study, a case study approach was adopted in which a pilot and two main studies were conducted. According to Creswell (2009), a case study explores an event, activity, process, a document or subjects in detail, and Yıldırım and Şimşek (2016) state that a case study design includes when, why and how questions in a situation to examine the case deeply. A case study can investigate a phenomenon over an extended period in one or more settings (Bhattacherjee, 2012) and also presents the sample of real people in the actual settings in a more clear understanding (Cohen, Manion & Morrison, 2007).

Case studies are comprehensively utilized in “organizational studies and the social sciences” (Hartley, 2012, p. 323). One of its advantages is having familiarity with the setting and observing the interactions or cause-effect relationships in the real context (Cohen, Manion & Morrison, 2007). The other advantage is that the research questions can be changed or modified during the investigation if the previous questions are considered irrelevant (Bhattacherjee, 2012). A case study can also be beneficial “when investigating new or emerging processes or behaviors” (Hartley, 2012, p. 325). In addition to its’ advantages, there are also weaknesses in a case study. The validity of the deduction can be weak since there is no control group, although this is mostly a problem for all other methods. A case study can also be questioned owing to having subjective evidence. Furthermore, there may not be generalization from a single setting to other cases originated from being contextual (Bhattacherjee, 2012).

In the case studies, multiple data collection methods can be utilized, such as observation, interview, and focus group. Many of the researchers use a combination of these methods to understand the setting (Hartley, 2012) and to triangulate among multiple sources and methods for validity and trustworthiness of evidence. When two different types of data present similar findings, the data can be considered accurate (Moore, Lapan & Quartaroli, 2012). Qualitative analysis and coding are also beneficial for case studies to develop and present (Creswell, 2009) "detailed descriptions" (ibid, p. 189). In a case study, data collection and analysis are ideally conducted simultaneously (Moore, Lapan & Quartaroli, 2012).

Authors (Moore, Lapan & Quartaroli, 2012) stated that considering the Stake's papers (1995, 2006), the case studies are separated into two in terms of their purposes; intrinsic and instrumental case studies.

> Intrinsic case studies deal with the case, which is "already being studied" (p. 246) to present the process to the involved stakeholders or others. Instrumental case studies utilize the results of the case to build new theories or support the existing one by triangulating, comparing, or questioning the findings. There are also two types of case studies; single and multiple. Single case studies are conducted in a single site by using one example or portion of the case. In multiple case studies, numerous examples of the case are explored in the same site or at multiple sites to make a comparison (Moore, Lapan & Quartaroli, 2012).

Most of the case studies can last six weeks to three months; however, some of them can be conducted from six months to over one year and named as longitudinal case studies (Moore, Lapan & Quartaroli, 2012). The researcher should decide whether to make a single case study or multiple cases. Spending weeks or years in one organization in a single case study can produce useful data about the research. This type of research can be strengthened by making another study since the researcher can have an opportunity to make a comparison within the case (Hartley, 2012).

In this study, it was considered appropriate to apply the case study approach in which the researcher was directly involved and had the opportunity to investigate the design and implementation of STEM education through the DT approach at school at a particular time by using multiple data collection tools and sources. Since case studies are appropriate for utilizing diverse methods and focusing on new processes intensely, according to this, three single case studies (CS) were conducted in this study, as follows:

Table 3.1. *The cases conducted in this study*

CS1 - Pilot Study	Testing and revising a DT approach.
CS2 - Main Study 1	Employing the DT approach for teachers' developing STEM activities and observing the teachers' implementing the activities in a classroom environment.
CS3 - Main Study 2	Further revising the DT approach, employing the revised version for teachers' developing and implementing new STEM activities.

To design the STEM activity by using the DT approach as a tool while a workshop was conducted in the pilot study, two co-design workshops were held in the main studies. Moreover, the cases in Main Study I and II included the implementation of the STEM activities and lessons on students to evaluate the success of the study. In this respect, the researcher spent more than six months in the same context to conduct the two successive cases in the main studies to strengthen the research; consequently, these two cases were evaluated under the longitudinal case studies.

3.2 Action research

O’leary (2004) describes action research as a “research strategy that pursues action and knowledge in an integrated fashion through a cyclical and participatory process” (p. 139). She also sees a connection between process, outcome, and application in the action research. According to McNiff and Whitehead (2002), action research can be called as practitioner research, practitioner-led research, practitioner-based research or self-reflective practice, since it is conducted by the practitioner herself/himself to research, act on, reflect and improve her/his practice. The action research aims to develop relevant solutions to identified problems by continuously evaluating and revising the data and the act considering the reflections based on earlier steps (O’leary, 2004). In education, among the research designs, “the action research is the most applied, practical design” (p. 576) and intends to improve the educational practice in a school or an educational setting (Creswell, 2012).

Similar to the DT approach, the action research is a collaborative, iterative and dynamic process, the researcher can go further or back about the problem, trying a solution, reflection on an action or developing a new action and data collection by following a new plan of action (Creswell, 2012). Therefore, the process of action research is flexible and continuous and can be changed as it proceeds within the research to solve a problem. University researchers, teachers, students or parents can also be coparticipants in the action research (Creswell, 2012). Furthermore, action and reflection are very important in action research, since “the learning influences the action and the action influences the learning” (McNiff & Whitehead, 2002, p.89). Therefore, doing the activity and learning with others is important to produce a report to show the process of learning (McNiff & Whitehead, 2002) and to develop a plan to solve an issue (Creswell, 2012).

In action research, mostly qualitative research methods are used. The practitioner can also be a tool for data collection by being objective and unprejudiced in the process (Yıldırım & Şimşek, 2016). However, for a high-quality action research study, it is advised to collect data from multiple sources (Creswell, 2012). In action research, the data can be gathered in different ways, such as by field notes, interviews, discussions or audiotaped interviews (McNiff & Whitehead, 2002). In addition, to evaluate the action, you can monitor your or other people’s action (McNiff & Whitehead, 2002). According to O’leary (2004), action research has the following cyclic process (Figure 3.1).

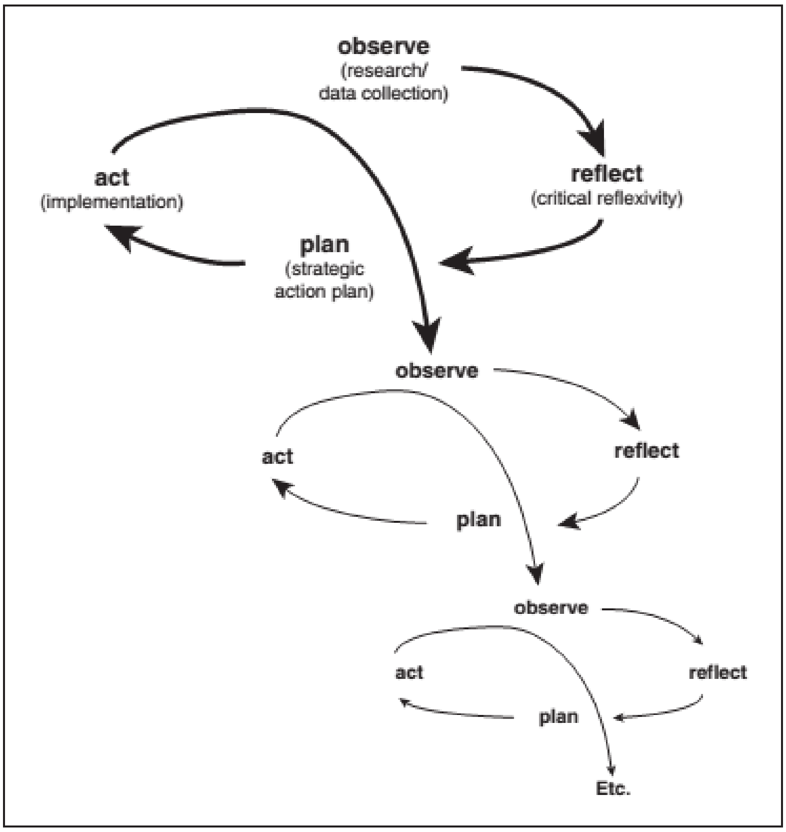


Figure 3.1. Action research cycles (O’leary, 2004, p. 141)

- In the “observe” step, you do research and collect data to understand a particular issue.
- This part can also include a literature review (Yıldırım & Şimşek, 2016).
- In the “reflect” step, you decide the topic or problem which you want to change or solve by analyzing and interpreting the data you obtained.
- In this part, you can define the problem and research questions (Yıldırım & Şimşek, 2016).
- In the “plan” step, you develop an action plan considering the analysis of the data.
- In the “act” step, you implement the action plan.
- After collecting all data, you analyze and critique your application to evaluate your action and to decide whether to continue with the developed plan or make a change on it (Dick, 1993 cited in O’leary, 2004) by going back to the first step.

In this study, it was considered appropriate to apply the action research because of conducting research in the education field and developing a DT approach as a tool for STEM activity design and implementation. The common characteristics between the DT approach and action research in terms of encouraging interdisciplinary collaboration, self-reflection, and iterative process also supported this decision. Drawing on the four phases of the action research process of O’leary (2004), my research had the cycles presented in Table 3.2.

Table 3.2. *Cycles of action research that was conducted in this study*

Field studies			**Pilot Study**		**Main Study I**		**Main Study II**		
Cycles of action research	Observe	Reflect	Plan	Act	Plan	Act	Plan	Act	Plan
Content of the cycles	Conducting *literature review* and *exploratory research*	Developing a research design	Planning a STEM activity design workshop process Developing a DT approach for STEM activity design and implementation	Conducting a pilot study with teachers in order to evaluate and further develop the DT approach for STEM activity design and implementation	Revising STEM activity design workshop process through co-design Revising the DT approach for STEM activity design and implementation	Conducting Main Study I study with teachers and students in order to evaluate and further develop the DT approach for STEM activity design and implementation	Revising the DT approach for STEM activity design and implementation	Conducting Main Study II study with teachers and students in order to evaluate and further develop the DT approach for STEM activity design and implementation	Revising the DT approach for creating a guide for teachers' STEM activity design and implementation

3.3 Co-design

Co-design means the engagement of people in the design process for collaboratively designing services, processes, and products to create improvement and innovation (Burkett, 2012). In co-design, customer or consumer is important and valued as an innovator of the business world (Burkett, 2012). All participants have equal roles (Dong & Yuan, 2013) and are also called as co-designers owing to their participation in the design process. Consequently, co-design is (Mattelmäki & Visser, 2011, p. 6):

- Utilized in the design context in which designers are involved, and the topic of the activity is related to design exploration, envisioning, and solution development.
- An empowering mindset and gives voice and tools to those who were not traditionally part of the design process.
- About the engagement of potential users but also stakeholder collaboration.
- A process and tools of collaborative engagement, e.g., events for learning and exploration.

According to this, the benefits of co-design can be stated as giving voice to individuals, users, and stakeholders in the project development. Because of this, in the co-design process, one of the crucial points is to define the stakeholders within the communities or human groups (The co-create handbook, 2019). According to Van Mechelen et al. (2019), the co-design process is built on two principles, which are also common in the DT approach mindsets. The first one is “everyone is creative” (p. 181), similar to the DT approach mindset about *creative confidence*. The second one is the role of collaboration in the creativity in which many people work together on a common goal to reach multiple ideas (Van Mechelen et al., 2019). The co-design process is also perceived as the facilitator and mediator among the diverse disciplines to exchange, translate the knowledge into meaningful states, and has an iterative way of working (Broadley & Smith, 2018). This principle also exists in the DT approach mindset as *radical collaboration* or *collaboration,* which means co-creation with users or stakeholders to understand the problem and develop solutions. In that circumstance, the co-design process, and DT approach have common perspectives that they both value the creativity of the people and the role of collaboration in the creativity.

Co-design practices at the early front end of the design process can have a positive impact and long-range consequences (Sanders & Stappers, 2008). Moreover, Hernandez-Monsalve et al. (2017) consider the application of co-creating activities as useful in figuring out users' needs owing to utilizing the qualitative research method. Co-design, having participatory design roots, is a design-led process that has a set of principles, practices, and tools to create engagement for solving the problems (Blomkamp, 2018). Thus, it can be used in workshops or different settings, including the educational environment (Mattelmäki & Visser, 2011) as a design approach. In the educational context, the co-design process can seem like a learning process in which stakeholders (teachers, students, etc.) and researchers collaboratively deal with producing new practices or strategies. According to Potvin (2018), the co-design process accepts teachers as professionals who share their experiences, expertise, and ideas with the other teachers. Consequently, it provides an opportunity for teachers' learning and professional growth. Therefore, the co-design process may enable value sharing between teachers by providing a collaborative engagement.

The role of facilitator in the co-design process. The challenging part of the co-design process is to facilitate the people by managing their participation, communication, relationships (The co-create handbook, 2019), and the problem-solving process to achieve collaborative, creative group work (Vidal, 2006). According to this, the facilitator has a duty about choosing the appropriate design method, creating a shared understanding of the problem, guiding the participants during the stages of the selected design method, defining strategies for enabling active participation and reaching productive solution (The co-create handbook, 2019). Vidal (2006) states that the facilitator can have different roles or role changes during the process, such as guide, coach, leader, and educator.

> The goal of the educator is to teach the participants the way of doing things. The guide intends to give counseling or suggestion to the participants for performing their responsibility. The coach provides direct instruction to enable participants' self-managing. The role of the leader is to allow excellent group performance by creating a productive working environment. "The art of facilitation resides in choosing the appropriate role at any given time" (Vidal, 2006, p.16).

Designers are also expected to deal with facilitation roles (Howard, 2015) by adopting "strategic, human-centered and design perspectives" (Body, Terrey & Tergas, 2010, p.65) due to the participatory design emergence. Designers can further have a significant role in the co-designing teams, owing to providing expertise and highly developed skills that other stakeholders cannot (Sanders & Stappers, 2008). For instance, in the study of Aguirre, Agudelo, and Romm (2017), the design researchers have three roles in the participatory design process; which are co-designers, co-facilitators, and co-participants in two case studies. In one of them, the authors facilitate and work with the experts in the co-creation process. Fogtmann and Kinch (2011) also present a different perspective in this point and state that the researcher, as a designer or design researcher, has the same working style to create knowledge. While both of them serve to clients, their clients' expectations differ. Since one of them expects a new product, the other one expects a new knowledge and an answer to the research question. They find it challenging to produce knowledge and a new product to serve two different clients at the same time. Because of this, being both a designer and design researcher is considered challenging to perform at the same time.

Howard (2015) argues that there is a scarcity of information about how designers design and execute DT in practice and the type of roles they perform. In her study, she defines four roles for designers to deal with DT in practice in organizations. According to this, while the design facilitator manages navigating teams during the DT process for encouraging people to participate, design lead presents his/her design expertise to enable participants to develop or integrate different ideas for problem-solving. The educator role emphasizes both individual and group learning about the DT approach. The composer role involves planning, establishing, and directing the whole design process (Howard, 2015). In Di Russo's study (2016) about DT in complex environments, he also considers crucial the mediation role as critical for designers during the co-creation to represent the customers for developing insights about them.

Considering the literature, while the facilitator can have different roles or role changes during the co-design process, the designer can get involved in the co-design process by performing multiple roles whether executing DT approach or not, such as being researcher, the facilitator (with experts), co-participant, co-designer (design lead), mediator, and educator. In the educational setting, the position of the researcher is essential in the co-design process, and its determination is based on teachers' expertise, educational system, and the previous tradition of collaboration (Causo, 2016; cited in Pivot, 2018). Consequently, the participants' experiences and knowledge determine the roles of the facilitator or researcher as a designer for the execution of the DT approach in the educational setting.

In the fieldwork, as the researcher and designer, I had a facilitator role during the pilot study. However, I observed that teachers had difficulty applying the DT approach for STEM activity design since they had no previous experience. Similar to the participants of the pilot study, the teachers who participated in the main studies had no prior knowledge about STEM and the DT approach, and except for one teacher, no experience about collaboration. Considering the literature review, I decided to conduct the co-design workshops in the main studies owing to having similar characteristics with the DT approach in terms of encouraging collaboration and creativity and providing the researcher's involvement in the design process with multiple roles. It was further expected that the co-design process would contribute to both teachers' and the researcher's professional development. Teachers would bring their expertise from diverse disciplines while working with the researcher as a designer, and the researcher would gain experience by getting involved in the co-design process with experts. As a result, co-design workshops were part of my action research methodology in the main studies where the DT approach developed for STEM activity design and implementation was used as a tool.

3.4 Overview of the studies conducted

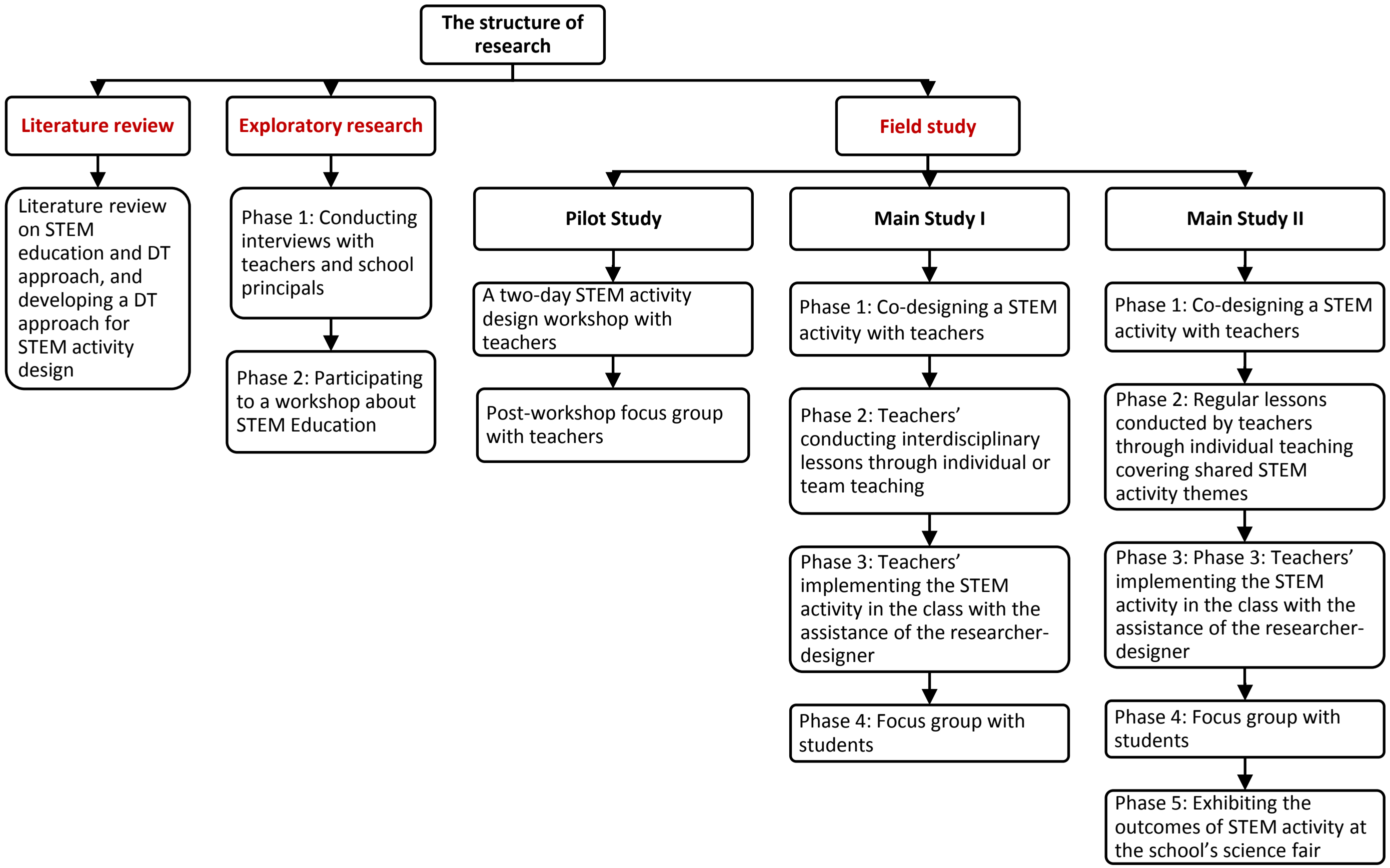
The study took three years to complete and consisted of three parts: literature review, exploratory research, and co-developing STEM activities through the design thinking approach (Figure 3.2).

The literature review was conducted to understand the state of the art of STEM and the DT approaches. This part allowed defining the research questions along with the research design. The research design remained open to changes and development owing to the situated nature of the research. The literature review continued simultaneously with the exploratory research and the field study to the end of the thesis writing. This part also included the development of a DT approach for STEM activity design and implementation and the workshop design that was applied in the pilot study. This part of the research is explained in Chapter 1 and 2 in detail.

The exploratory research had two phases; the first phase included the interviews with teachers and the school principals who executed the STEM/STEAM approaches. The second phase included participating in a STEM workshop for developing insights along with making observations and interviews. The purpose of this part was to become familiar with the situation of the STEM education in Turkey by exploring the needs and the concerns of the teachers and the school principals, due to being an outsider to the education field. This part developed and confirmed the research questions and the research design and assisted in the workshop design. This part of the research is explained in Chapter 4 in detail.

In the last part of the research, it was intended to develop and implement a DT approach to facilitate teachers' STEM activity design and implementation. This part is comprised of the pilot and two main studies. The pilot study, including a workshop ending with a focus group interview, was conducted with teachers to test the initial version of the DT approach developed and to evaluate the workshop design. After this study, some changes in the DT approach and the workshop design were made. Later, to see the impact of the revised DT approach on STEM education and test the designed STEM activities, two main studies were conducted. The Main Study I is comprised of four phases, and Main Study II consisted of five phases. The co-design workshop with the focus group session in Main Study I was conducted with secondary school teachers working in a private school. After this workshop, the designed interdisciplinary lessons and STEM activity were implemented in one of the 5th classes to evaluate the designed activities. At the end of this study, some changes were made on the DT approach, and some strategies were defined for implementing STEM education at school in Main Study II. Then, the co-design workshop with the focus group session in Main Study II was conducted in the same school, with the same teachers, and the designed lessons and STEM activity was implemented in the same 5th class. The data obtained from this study were utilized to revise the DT approach and to answer the research questions. This part of the research is explained thoroughly in Chapters 6, 7, and 8.

Figure 3.2. The structure of the research



3.5 Participants

Table 3.3 presents the participants of this study. In the first phase of exploratory research, there were four school principals and 11 teachers including robotics, Turkish, science, kindergarten, visual arts, and mathematics teachers. In phase 2, there were mathematics and primary school teachers as participants. In the pilot study, there were a total of five participants: mathematics, visual arts, English, history, and science teachers. In the Main Study I, there were 16 5th-grade students and five teachers, including mathematics, visual arts, social science, science, and English speaking teachers. In Main Study II, the participants were the same with the ones in Main Study I, except the English speaking teacher who was replaced by the English skills teacher. The design and technology teacher could not participate in the main studies, as he started working at the school after the field study started.

Table 3.3. *The participants and their backgrounds in each part of the study*

	Number of Participants	Background of Participants
Exploratory Research Phase 1: Conducting interviews with teachers and school principals	4 school principals and 11 teachers	4 school principals, 3 robotics, 3 science, 2 visual arts, Turkish, kindergarten and mathematics teachers
Exploratory Research Phase 2: Participating in a workshop about STEM Education	2 teachers	Mathematics and primary school teachers
Pilot Study	5 teachers	Mathematics, English, science, history and visual arts teachers
Main Study I	5 teachers, 16 students	Mathematics, visual arts, social science, science, and English speaking teachers
Main Study II	5 teachers, 16 students	Mathematics, visual arts, social science, science, and English skills teachers

3.6 Data collection

The research methodology was designed to utilize multiple qualitative research method in which data was obtained from researcher notes based on observations, focus group interviews with students and teachers, semi-structured interviews with teachers and school principals, mobile instant messaging (SMS and WhatsApp), and the discussions with students (Table 3.4). The reason to choose a qualitative design was to focus on what the participants said, to describe their feelings and needs in specific situations, to share their experiences, and to support the case study and co-design process.

In the exploratory research, the data was collected from the observation and the interviews in the STEM workshop and the semi-structured interviews with teachers and school principals who implement STEM, STEAM, and STEM-A approaches in their education. While in the pilot study, the data was obtained from the workshop observation and the focus group interviews with teachers, in the main studies, different aspects of the study were evaluated in every phase as follows:

- Individual interviews before the workshop: Teachers' expectations, concerns, background, and the information about the participant students.
- Workshop 1 and 2 in the Main Study I and II (observation & focus groups): Collaboration among teachers and the co-design process among teachers and designers, reflection on DT approach and workshop.
- Activities and lessons in the Main Study I and II (observation, group interview with students): Reflection on STEM activity and lessons, students' feedback, and teachers-students interaction during the lessons and the activity.
- Focus group interviews and/or individual interviews after the activities and lessons with teachers and students in the Main Study I and II: Reflection on STEM activity and lessons, the collaboration of teachers, students' feedback, workshop-method evaluation.

Table 3.4 *Studies and data collection methods used in this study*

	Data Collection Methods	Number of Participants	Number of Interviews	Duration of Interviews	Date
Exploratory Research Phase 1: Conducting interviews with teachers and school principals	Interview	4 school principals and 11 teachers	15 individual interviews	20-45 min.	14 February - 24 March 2017
Exploratory Research Phase 2: Participating in a workshop about STEM Education	Interview, Observation	2 teachers	2 individual interviews	Each 15 min.	04, 05 March 2017
Case Study I: Pilot Study	Focus Group, Observation	5 teachers	Post-workshop focus group	20 min.	**Pilot workshop** 07, 08 September 2017
Case Study II: Main Study I	Interview, Focus Group, Observation, Mobile Instant Messaging (SMS and WhatsApp), Group Interview	5 teachers, 16 students	Pre-workshop interviews with 6 teachers	06-30 min.	**Co-design workshop** 18, 25 November 2017 **Interdisciplinary lessons** 30 November 2017 04, 05, 11, 12, 26 December 2017 08 January 2018 **STEM Activity** 09 January 2018
			13 interviews with teachers after interdisciplinary lessons	05-40 min.	
			5 interviews with teachers after STEM activity	20-48 min.	
			Post-workshop focus group with 5 teachers	25 min.	
			Focus group with 6 students after STEM activity	41 min.	
Case Study III: Main Study II	Interview, Focus Group, Observation, Mobile Instant Messaging (SMS and WhatsApp)	5 teachers, 16 students	Post-workshop interviews with 5 teachers	14-32 min.	**Co-design workshop** 28 February-01 March 2018 **Regular lessons** 26, 29 March 2018 02, 09, 16, and 30 April 2018 **STEM Activity** 03 May 2018 **Science fair** 05 June 2018
			2 interviews with teachers after regular lessons	13 and 14 min.	
			Post-STEM activity interview with the visual arts teacher	49 min.	
			Post-workshop focus group with 4 teachers	65 min.	
			Post-STEM activity focus group with 3 teachers	46 min.	
			Focus group with 8 students after STEM activity	32 min.	

3.6.1 Interviews

The interview is one of the popular qualitative data collection methods in which the researcher asks “one or more people general, open-ended questions and records their answers” (p. 217). Open-ended questions can enable the interviewees to be objective in their answers without being influenced by the researcher’s considerations or findings (Creswell, 2012). The characteristics of the qualitative interview include the exchange of conversation in an interactional environment, having an informal style and flexible structure by using a subject, theme, or narrative for starting the conversation. In qualitative research, “knowledge is situated and contextual” (p. 62); thus, the interview intends to produce the situated data through the interaction (Mason, 2002).

The process of an interview can be realized in three steps: determining “the research question and interview guide” (p. 14), defining and reaching an agreement with the interviewees, and conducting the interviews (King, 2012). The interview questions should be neutral and should not direct the people. The order in which the questions are asked (p. 256) during the interviews is also significant in data collection (Moore, Lapan & Quartaroli, 2012). It is suggested to take consent forms from the participants before conducting the interviews and audiotape the interview process (Creswell, 2012). In the literature, there are structured, semi-structured, and unstructured interviews, and they can be conducted one-on-one or in groups.

- Structured interview: The questions and procedures are defined in advance, and little modification can be made by the interviewer. Therefore, it presents a closed structure (Cohen, Manion & Morrison, 2007).

- Semi-structured: There are predefined questions; however, the questions are answered by the dialogue, and thus it may also follow different directions. Consequently, these kinds of interviews are not fixed and can be flexible in the process of execution (O’leary, 2004).

- Unstructured: In this type of interview, there are no predefined questions, and it proceeds in a more “conversational style” (p. 164). The questions are developed within the direction of the conversation (O’leary, 2004).
- One-on-one: It is an interview between the interviewer and one interviewee, which enables the researcher’s control over the data collection. It can be conducted face-to-face, by telephone (O’leary, 2004), online (Cohen, Manion & Morrison, 2007) and email (Creswell, 2012).
- Group / Focus group: This kind of interview includes more people at the same time (O’leary, 2004). Group interviews can be preferred for interviewing children and collecting information in a short time because of being “less intimidating for them than individual interviews” (p. 374). The duration of an interview may be at most fifteen minutes and open-ended questions should be asked (Cohen, Manion & Morrison, 2007). A focus group interview is a special type of group interview which is further discussed in the next section.

Interviews have both advantages and disadvantages. Having more than one kind of interview makes it a flexible method. The interview can address specific questions and general issues. In this process, the participants also agreed to participate in it beforehand (King, 2012). Doing an interview is beneficial for gathering detailed information which you cannot obtain from the observation. The researcher’s facilitation by asking particular questions also enables them to have control over the collected data. There may also be disadvantages such as collecting data from the perspective of the interviewee, the influence of the researcher on the interviewee’s answers or having no clear answers from the interviewee (Creswell, 2012). Creating an interview guide, conducting interviews, and analyzing them also require more time (King, 2012). Since the interviewing has limitations due to reliance on dialogue and text in a particular context (Mason, 2002), it should be supported by other qualitative data collection methods.

A case study mostly utilizes face-to-face interviews to gather qualitative data since it can be triangulated with other techniques, such as observation, documentation, and physical artifacts (Bhattacherjee, 2012). As previously stated, the case study approach was applied in this study; the unstructured and semi-structured interviews were conducted for exploring the setting deeply and triangulating the data with the other data collection techniques. Individual interviews further supported by the focus group interviews about completing deficient answers and getting reflections from the interviewees who could not have the opportunity to answer some questions due to time constraints. Furthermore, 5-minute unstructured group interviews were conducted with students at the end of the interdisciplinary lessons for investigating their opinions about the implemented lessons. These interviews were also triangulated with the focus group interview with the students at the end of Main Study I.

3.6.2 The focus group interview

A focus group interview is one of the qualitative research methods to be used to collect data from multiple participants at the same time and to discover their shared understanding of an issue (Creswell, 2012). In the focus group interview, the group discussion is facilitated through specific subjects, and the interaction among interviewees and their negotiations can be observable (Mason, 2002). Therefore, the data is gathered through their interaction (Cohen, Manion & Morrison, 2007). The focus group also combines both the individual interview and the observation of interviewees, and it allows collecting the necessary amount of data, which are the transcripts of the discussions and the moderator's reflections, in a short period of time (Freitas et al., 1998). It generally includes six to eight people (Creswell, 2009), and the researcher asks a general question to start the conversation and receives answers from all participants (Creswell, 2012). Focus group can be used in the design context on three levels:

- To reach direct users,

- To create an environment for people to express themselves and their needs,
- To develop the empathy skills of designers with different users in various contexts (Denton & McDonagh, 2003).

Focus groups and participatory workshops may be used together in design research. For example, Burns and Evans (2000) have used participatory workshops and focus groups as design tools in which engineers work with users to produce solutions for car design. Fabius and Buur (2000) have organized participatory workshops involving three designers and two usability specialists with open-ended discussion to re-design an electrical device (cited in Bruseberg & McDonagh-Philp, 2002). Moreover, it has advantageous owing to creating an interaction among interviewees, which led to useful information. It is also beneficial compared to the individual interview when there is limited time for gathering data, and the researcher has difficulty in collecting data from some interviewees (Creswell, 2012). However, the authors (Cohen, Manion & Morrison, 2007) considered that triangulating the focus group with interviewing and observation is beneficial since the focus group may have some limitations as follows:

> The small number of the interviewees, the probability of having difficulty in analyzing the data, the possibility of non-participation, the dominance of some interviewees, the conflicts in the group, and the possibility of covering fewer topics during the interview (Cohen, Manion & Morrison, 2007).

Since the focus group can be used as a post-study to evaluate the data in participatory workshops, in this study, at the end of each workshop, a focus group interview was conducted along with making observations to get teachers' reflections. Additionally, focus group interviews were considered appropriate to get collective data and experience of teachers since teachers worked collaboratively in the workshops. Moreover, in this study, at the end of each main study, a focus group interview was conducted with students to get their reflections and suggestions about STEM education.

3.6.3 Observation

Observation is another popular qualitative data collection method in which the data is collected by observing the research setting (Creswell, 2012). Making observations has both advantages and disadvantages as a data collection method. The advantages are gathering data lively in the actual setting and working on individuals who have difficulty expressing themselves. The disadvantages are recording data limited to those settings and situations where you can have access and having difficulty in developing a relationship with the individuals (Creswell, 2012). The accuracy of observational data is also questionable (O'leary, 2004). There are two types of observation, the participant and the candid (non-participant) observation.

- Candid (non-participant) observation: In this type of observation, the researcher hides himself/herself in the research setting. This approach can make the observed feeling "under surveillance" (p. 173). For this reason, it needs ethical permission (O'leary, 2004).
- Participant observation: In participant observation, the researcher experiences and observes the particular situation herself/himself in the research context (Mason, 2002). Thus, while the researcher gathers data, she/he also deals with the activities (Creswell, 2012). Participant observation facilitates building trust between the researcher and participant and assists in understanding the accuracy of the people's behaviors and talk (Waddington, 2012). Participant observation can be productive when the primary intention is to collect descriptive data (Cohen, Manion & Morrison, 2007).

Observation is a powerful data collection method and can include both visual and oral data (Cohen, Manion & Morrison, 2007). Furthermore, according to the literature, useful and in-depth knowledge cannot be developed without observation since all data cannot be produced in an interview (Mason, 2002). However, for the reliability and validity issues, making the observation is recommended to be used with the other methods (Cohen, Manion & Morrison, 2007). Since the case study approach was applied in this study, the participant observations were conducted to collect data from the co-design workshops and the implementation of STEM education. They were also used to triangulate the data with the collected data from the interviews.

3.7 Data analysis

The qualitative data analysis. The collected data in the pilot study was analyzed based on the qualitative data analysis due to involving only the focus group and the observation data. In this respect, all data are transcribed and organized into the computer. First, the initial analysis is conducted to explore and get familiar with the data. Then the further analysis is made through the process of coding by reading the data several times. Later, codes are utilized to develop descriptions or themes for presenting the general perspective of the data. Finally, the findings are interpreted and discussed through the cause and effect relations by supporting them with direct quotes from the interview data and visuals (Creswell, 2012).

Template analysis. The collected data in the exploratory research and the main studies were analyzed based on the template analysis method owing to the complexity and huge amount of the data. Template analysis is a style of thematic analysis which is distinctive from the other techniques and can be used in different theoretical frameworks since it is a flexible technique in coding, "easy and quick to learn", beneficial in participatory research, and useful to present a "thick description of the data set" (Braun & Clarke, 2006, p. 97).

The core of template analysis is developing a list of codes representing themes defined in the data. "Some of these will usually be defined a priori, but they will be modified and added to as the researcher reads and interprets the texts" (King, 2004, p. 256). In the template analysis, first of all, the researcher needs to be familiar with the data set. In this respect, the researcher may read all data if there is a small interview data set, or select a portion of the data, if there is a larger interview data set (Brooks & King, 2014). Then according to King (2004), the template analysis begins with the "pre-defined codes" (p. 259) to assist the analysis. "For determining the initial template, generally the interview topic-questions can be used. Main questions from the guide can serve as higher-order codes, with subsidiary questions and probes as potential lower-order codes" (p. 259). Once the initial template is created, the researcher works on the full data set by using codes from the initial template to mark the relevant part of the data. The initial template can be changed or revised in the process; in this respect, four types of modification can be executed:

- insertion (adding a new code)
- deletion (deleting the pre-existing code if found unnecessary)
- changing scope (re-defined the pre-existing code)
- changing higher-order classification (changing the place of a sub-code among higher-order codes)

The final template is generally created after reading the text many times. When the final template is ready, the template and its codes are interpreted and presented in a report, paper, or dissertation with illustrative quotes (King, 2004).

3.8 Background of the researcher

My motivation for this topic is based on my observation in the Department of Art Education at Ondokuz Mayıs University, where I have worked for over five years. According to my observations, students often failed to explain what and why they are doing about their works since their education did not include making reflection. Additionally, they were generally producing similar artifacts by using the same methods or materials for material preparation lessons without making an innovation, modification, or change. Most of the studies also depended on individual work; thus, there was less teamwork or collaboration among students, in addition to no interdisciplinary collaboration with other departments. Furthermore, there was a traditional approach in their education, which depended on teacher-centered education around one discipline and included less use of technology in the courses. Additionally, these students could be the technology and design teachers in the Ministry of National Education without having adequate knowledge or experiences about design, technology, materials and production, interdisciplinary collaboration, and content knowledge of other disciplines. However, these qualifications are required in STEM education, and technology and design teachers are one of the parts of STEM education. Educating pre-service visual arts teachers is also significant for STEM and STEAM education owing to their essential roles in these educations.

One of the key characteristics of qualitative research is the researcher as an instrument (Creswell, 2009). Since the study included a co-design process and case study, I was directly involved in collecting data through the focus group interviews, interviews, and observation. I also explored data and documents relevant to this study. Having worked in the field of education for five years and having a master’s degree in Art Education, I have a comprehensive understanding of the challenges that in-service teachers, pre-service teachers, and schools have, and these experiences supported me during the field study of this study process.

Organizing co-design workshops to employ the DT approach also put me in the position of a facilitator and co-designer along with a researcher role; as previously discussed in section 3.2, the facilitator role is significant and a must in the co-design process. In the literature, designers are also expected to have a substantial role in co-designing teams, owing to providing expertise and performing facilitation roles. In this respect, working for eight years as a professional designer and having a bachelor's degree in industrial design assisted me in dealing with these roles.

3.9 Validity and reliability

Validating data is important in defining the “accuracy or credibility of the findings” and their interpretation by employing specific procedures or strategies (Creswell, 2012, p.259). Some of the validity strategies can be stated as follows (Creswell, 2009):

- Triangulating the data,
- “Using rich, thick descriptions” (p. 191) to present the evidence and to create a real understanding of the context,
- Self-reflection, and comments and reflections of the researcher that brings honesty to the research,
- Presenting or discussing the contrary or contradictory data which makes the study more realistic and credible,
- Spending a long time in the field with the participants which makes the researcher develop a profound and detailed understanding of the setting, and makes the findings more credible.

Triangulation is one of the strategies that is used for validation. It means “corroborating evidence from different individuals (e.g., a principal, a student), types of data (e.g., observation notes, interviews), or methods of data collection (e.g., documents, interviews) in descriptions and themes in qualitative research (Creswell, 2012, p.259)”. According to this, each type or source of data is explored to provide a more productive and full explanation of the people from multiple perspectives (Cohen, Manion & Morrison, 2007). Moreover, in data analysis, the researcher triangulates the data collected by different methods to discover whether “different sources of data on the same topic may complement each other” (Schensul, 2012, p. 99). According to Gibson and Brown (2009), triangulation can be beneficial by controlling the trustworthiness of diverse data sources or investigating the same context from different perspectives.

> Trustworthiness "focuses on the context of data collection and the methods of the generation of data rather than on its inherent 'truthfulness'" (p. 59). For instance, the trustworthiness of the data can be sustained from doing the individual interviews without conveying the real intention behind the investigation. In trustworthiness, the primary purpose is to get a deep understanding of the research context, people, or practices not to verify the collected data with each other (Gibson & Brown, 2009).

In the case study, to improve the validity and trustworthiness, the triangulation, multiple sources, appropriate data analyses, and member checking can be utilized (Moore, Lapan & Quartaroli, 2012). In the main studies, validity was improved by applying the following strategies:

- Before conducting the main studies, a pilot study was conducted to test and revise the DT approach and the workshop design.
- The data was collected from multiple data types and sources, such as observation notes in co-design workshops, lessons, and STEM activities, focus group interviews with students and teachers, semi-structured interviews with teachers, SMS, and WhatsApp communication and group interviews with students. For instance, individual interviews with teachers were conducted after the focus group interview with teachers to verify the knowledge and complete the deficient points. The focus group interview with students was also confirmed with teachers' interviews and observation notes. Thus, the collected data were compared and contrasted with each other to justify the findings.
- The interviews were audio-recorded to prevent the loss of data.
- Self-reflection was employed by the researcher regarding bias and assumptions to protect the internal validity of the research.
- During the data collection, the researcher remained open-minded to listen to the teachers and students carefully and understand the meaning of their responses. Moreover, the teachers and students acted naturally during the workshop and the implementations and responded freely to the questions.

- During the data analysis and interpretation, being objective was the primary concern, and the quotes were taken from the interviews to illustrate the findings. The researcher's comments and critical reflections were also included in the results. Furthermore, the iterative approach was adopted for gathering and analyzing the data.
- Detailed and thick descriptions, including both positive and negative findings, were applied to ensure the findings' credibility.
- The researcher spent more than six months in the same context to make the case studies to strengthen the research by making a comparison between the cases and developing a deep understanding of the phenomenon.
- Teachers were not informed about the intention of developing a DT approach for the STEM activity design for the trustworthiness of the research.

Reliability "involves the accuracy of your research methods and techniques" (Mason, 2002, p. 39); in other words, it measures the quality of the instruments or tools used. For example, if the same result was reached from the same setting by using the same tools, data sources, or methods, the research can be accepted as reliable (Mason, 2002). In this study, Main Study I and Main Study II were conducted in the same context and with the same participants by using the same data collection methods. Both studies nearly gave the same result considering the research questions and showed the reliability of the research instruments. Data sources and collection methods were also described and triangulated. Then, all data were analyzed, and the theoretical framework of the research and the context of the main studies were explained in detail.

3.10 Generalizability and transferability

"The wider applicability of findings can be shown by transferability and/or generalizability" (Taşar, 2001; p. 134). "External validity or generalizability refers to whether the observed associations can be generalized from the sample to the population (population validity), or other people, organizations, contexts, or time (ecological validity)" (Bhattacherjee, 2012, p. 36). Mason (2002) states that there are two types of generalizations; empirical and theoretical.

> While empirical generalization means "making generalizations from an analysis of one empirical population to another" (p. 195), the theoretical one includes multiple strategies and is considered more efficient. For example, after developing an in-depth and rich analysis of a specific process in a particular setting by using various data collection methods, this process can be utilized in the other settings for making theoretical generalization (Mason, 2002).

In some cases, generalizability can be challenging to achieve due to the small sample size. On that occasion, the lessons drawn from the research may be utilized or transferred to other settings. For transferability, the researcher should present a rich explanation of the context to make those deciding the degree of its applicability to other researches (O'leary, 2004).

As previously stated, this study utilized a case study approach that had a small sample size. Two single case studies were applied in the same school and with the same participants to develop a DT approach for the STEM activity design. Since there is no similar research in the literature to make a comparison with, the findings should be considered preliminary. Both studies were described in detail. Thick descriptions of the participants and context were applied and supported with visuals and quotes. The interaction among students, teachers, and the researcher, and among the participants and the implemented lessons and activities were explained. Therefore, this study can provide insights for researching STEM education in other contexts. Moreover, a guide for designing the STEM activity design by using the DT approach was presented in Appendix U and V to be used by teachers in secondary schools. Applying this guide for the STEM activity design requires an investigation of the context and stakeholders at schools. The same guide can further be utilized for conducting research with primary or high school teachers. It can also be used in secondary school teachers' training programs in higher education or conducted by Ministry of National Education or STEM research centers. There are some strategies listed in the guide, and they can be used by K-12 teachers in their STEM activity design and implementations. Considering the findings, integrating the DT approach in teachers' education, K-12 education, and STEM education is also suggested. The answers to the research questions and the potential findings can be used to make this study open to generalization in the educational context.

CHAPTER 4

EXPLORATORY RESEARCH

In the exploratory research, because of being an outsider to the education field, it was intended to become familiar with the situation of the STEM education in Turkey by exploring teachers' and the school principals' needs and concerns. This part is comprised of two stages: the interviews with teachers and the school principals, participating in a workshop about STEM education.

4.1 Data collection and analysis

In the exploratory research, the data was collected from the observation and the interviews in the STEM workshop and the semi-structured interviews with teachers and school principals who implement STEM, STEAM, and STEM-A approach in their education. The data was analyzed based on the template analysis method (See section 3.5), and the initial template was defined based on the interview questions as follows:

- What teachers expect from the STEM education
- How teachers learned the STEM education
- How STEM education is implemented in Turkey
- What STEM education meant for teachers
- How STEM activities/curriculum developed

4.2 Phase 1: Interviews with teachers and school principals

The interviews with teachers and school principals were executed to understand the state of the art of STEM education in Turkey. From 14 February 2017 to 24 March 2017, a total of 15 interviews were conducted with school principals and teachers from several disciplines in four private schools that give STEM, STEM+A, or STEAM education and in one of the science and art centers (Table 4.1). The reason for doing the interviews in the science and art center was owing to their activity-based education's similarity with the understanding of STEM education. In the selection of the institutions for the exploratory research, their varied approach to the perception of STEM education was considered to get rich data and insights. At this stage, the questions were prepared under five main groups: teachers' understandings about the STEM education, the creation of the STEM curriculum or the activities, the implementation of the STEM education in the school, teachers' training about learning the STEM education and teachers' expectations from the STEM education (Appendix A). The interviews were conducted in Turkish and voice-recorded, except for the eight interviews in which the interviewee did not accept the voice-recording. The duration of the conversations was between 20 to 45 minutes.

Table 4.1. *The Institutions in the exploratory research*

School	Educational Approach	Number of Interviewees	Background of the Interviewees
School A in Samsun (kindergarten, primary school)	STEM includes all disciplines	2	science teacher (robotics teacher), school principal
School B in İstanbul (kindergarten, primary and secondary school)	STEAM includes all disciplines	4	education coordinator, science, Turkish and kindergarten teachers
School C in Samsun (kindergarten, primary and secondary school)	STEM includes all disciplines	2	science teacher, school principal
School D in Samsun (kindergarten, primary and secondary school)	STEM + A (Art in STEM)	3	visual arts, robotics and science teachers
School E in Samsun (science and art center)	STEM includes all disciplines	4	school principal, visual arts, mathematic, computer education and instructional technology (robotics teacher) teachers

4.2.1 The findings of Phase 1: Interviews with teachers and school principals

The findings indicate that except for School D and School C, other schools have been giving STEM education for two years. Besides, whether it is called STEM, STEAM, or STEM+A, all disciplines are included in the STEM education instead of the four STEM (Science, Technology, Engineering, Mathematics) disciplines in their education. Therefore, while ‘S’ in STEM represents science in the literature, the definition of STEM education consists of all disciplines in these schools because of considering ‘S’ as all disciplines. However, there are variations at schools in terms of the STEM integration to their education. For instance, while School A executes the STEM education under the same theme in all lessons to teach a subject, School D uses the STEM education integrated curriculum in the lessons. Both schools also apply STEM education in projects related to robotics competitions. In School B, the collaborative STEAM projects are executed with team teaching. Besides, teaching the lessons with STEAM activities was implemented with individual teaching in primary and secondary schools. In kindergarten, a thematic STEAM approach is adopted, and the school also has robotic lessons as a club activity. In School C, under the leadership of one of the secondary school teachers, STEM education is applied in teaching science lessons with activities in primary and secondary schools. In the science and art center, project-based teaching, including robotics, is executed to solve the students’ problems; in this respect, students actively consult teachers from different disciplines to find efficient solutions.

According to the findings, implementing STEM education is more comfortable in science education owing to its inclination to experiments and projects and in English education because of having interdisciplinary books. The second place belongs to mathematics due to having easier integration between math and science subjects. Besides, using visual arts in the STEM and STEAM education means making a prototype, creating a poster, or taking support from the visual arts teacher about material usage. However, the Turkish and social sciences teachers consider STEM education difficult since they cannot figure out how to implement STEM education in their lessons owing to not having ready-made STEM activities. They also cannot find out what kind of a technological solution, prototype, or model can be required for their lessons in the application of STEM education.

Moreover, because of having limited knowledge about STEM education or not having STEM curriculum, they generally get training from their STEM experienced teachers or the STEM research centers. They also invite experienced teachers from other schools to get assistance from them. For instance, in School B, teachers take STEAM education from their kindergarten teacher, who teaches the STEAM approach to the teachers by making them involved in the STEAM activities. She further assists teachers in preparing their STEAM activities.

As stated in the literature review, in Turkey, STEM activities or education are developed and provided for science and mathematics disciplines in particular. Therefore, some disciplines such as social science and Turkish have difficulty in applying STEM education, and teachers have to adapt their lessons considering their training provided by the STEM research centers. Besides, except School D, others do not have a ready-made STEM curriculum; thus, teachers prepare their STEM curricula by themselves and sometimes get assistance from the experienced teachers. They also make necessary changes in their STEM curricula if needed to make it better for the next year. Therefore, teachers ought to learn how to prepare and implement STEM activities on their own.

In the implementation of STEM education, the representation and visibility of disciplines vary. Both in School A and School B, the disciplines are purposefully integrated by teachers in the application of the STEM and STEAM educations. However, in School C, although some disciplines such as visual arts and Turkish are ‘found to be included’ in the STEM activity, they are not purposefully integrated by teacher. In School D, the integration of the disciplines isn’t visible either due to the integrated STEM-A curriculum.

Table 4.2. *Schools' STEM education based on interviews with teachers*

School	STEM Curriculum	STEM Education for Teachers
School A in Samsun (kindergarten, primary school)	Preparing an interdisciplinary curriculum with all teachers. Having also responsible STEM teachers who assist the other teachers in designing their STEM lessons, if necessary.	Taking two types of education: 1- all teachers taking STEM certificates from İstanbul Aydın University to develop themselves 2- teachers' assisting each other to create their curriculum.
School B in İstanbul (kindergarten, primary and secondary school)	Preparing their lessons collaboratively with teachers who take STEM education and under the leadership of two people; a kindergarten teacher who worked as a STEAM teacher in the USA and a specialist on lego education.	Taking three types of education: 1- selected teachers participating to STEM education in İstanbul Aydın University 2-inviting teachers who implement successful STEM activity from outside of their school. 2- taking STEAM education from their kindergarten teacher.
School C in Samsun (kindergarten, primary and secondary school)	Preparing STEM activity for science lessons in primary and kindergarten schools under the leadership of secondary school science teacher.	No teacher had a STEM education.
School D in Samsun (kindergarten, primary and secondary school)	A prepared curriculum is sent from one of the universities to all of their schools. All teachers are gathered two times a year to revise the curriculum.	No teacher had STEM education except the science teacher who attended a seminar.

4.3 Phase 2: Participating in a workshop about STEM Education

The second phase of the exploratory research included participating in a two-day STEM workshop conducted on 04-05 March 2017 to develop insights about the implementation of the STEM education by collecting the data with making observations and two teachers' interviews. Since the participants of the workshop were unfamiliar, the unstructured interviews were conducted without voice-recording with the math and primary school teachers for whom the STEM education includes all disciplines, and each interview took 15 minutes. This activity was organized for the science teachers to teach the STEM education and engineering design process; there were also the math and primary school teachers in the workshop.

On the morning of the first day, the engineering design process and the STEM education were presented, and teachers visited one of the laboratories involving a wind turbine. Later, the discussion was held among the four engineers and the teachers about engineering as a discipline and its place in education. Afternoon, the first STEM activity about designing a mechanism for lifting a weight based on the working principle of a wind turbine was executed to teachers. After the presentation of the first activity's results by teachers, the first day of the workshop was ended. On the second day, the presentation about the engineering design process that included STEM activity examples was conducted. Then, the discussion was held between the teachers and the workshop principal about the implementation of STEM education and its challenges. Later the activity about the astronomy was conducted, and then the second activity was executed to teachers about designing a space vehicle to carry astronauts and weight while coming down from the ramp. After the presentation of the second activity's results, the workshop was ended.

4.3.1 The findings of Phase 2: Participating in a workshop about STEM Education

In this workshop, there were science, mathematics, and primary school teachers; however, there were not teachers from the other disciplines such as social sciences, Turkish, English or visual arts. Additionally, this workshop was not organized for teachers working in a particular type of education (primary or secondary school education). However, every kind of education has different curriculum and challenges based on the students' and teachers' needs and expectations. That was also clear from their discussions and the primary school teacher's interview when talking about the small age students. She stated that she revised the ready-made STEM activities in accordance with the needs of students by decreasing the stages of the engineering design process and changing the ways of giving problems. In the teachers' discussion, teachers also pointed to confusion about the definition of the problem in STEM activities. Some argued that after doing research, the problem should be defined. Some stated that the problem should be given at first, and then, the research should be conducted. Some teachers also claimed that the problem definition stage should be different considering the student's age. Another teacher pointed out the significance of the development of students’ basic skills, such as writing or cutting, in the small age group. According to her, if they do not have the basic skills, they cannot be expected to solve a problem or make a design in STEM. Considering these findings, it was clear that getting familiar with students and defining their needs were important in STEM activity design.

Furthermore, in the workshop, instead of teaching to develop a STEM activity for students to teachers, only the ready-made activities were executed on teachers to introduce STEM education. In the interviews, both teachers stated the confusion about STEM education in Turkey; the math teacher further considered the application of STEM education as a fashion. The primary school teacher also complained about not able to implement STEM education, although she took multiple trainings. Some teachers stated that they are more result-oriented than process-oriented in education. They further found teacher education and the general education as result-oriented too. The implemented STEM activity which adopted the engineering design process was also considered challenging by the teachers.

4.4 Discussion of Phase 1 and Phase 2

Exploratory research was utilized to develop and confirm the research questions and to review the research design. According to this, it was discovered that some disciplines have difficulty in applying STEM education due to the lack of materials and the teachers’ training. Besides, for implementing STEM education at school, most of the teachers had to create their STEM activities. The importance of getting familiar with students and their needs also became evident in the teachers’ discussion at the STEM workshop. Therefore, teachers ought to learn how to prepare and implement STEM activities on their own considering the students’ needs.

The findings also assisted me in developing some strategies regarding the implementation of the pilot and main studies. For instance, it was discovered that the representation and visibility of disciplines vary since the integration of disciplines can be purposefully or by coincidence. Therefore, it was concluded that conducting interdisciplinary lessons prior to the implementation of STEM activity would make the connections among the disciplines more visible both for students and teachers. Additionally, owing to its interdisciplinary books, the English lesson could be a binder in the integration of the disciplines in STEM education.

Some teachers also stated that they are more result-oriented than process-oriented in education. Teachers also considered applying the engineering design process as challenging. According to this, it was concluded that integrating a DT approach as a user-centered and creative problem-solving process into STEM activity design and implementation would ease the transition from result-oriented general education to STEM education both for teachers and students.

CHAPTER 5

PILOT STUDY

In the pilot study, it was intended to test the developed DT approach within the scope of this study for the STEM activity design. For this reason, a two-day STEM activity design workshop was realized on the 7th and 8th of September 2017 in Samsun, Turkey.

5.1 Data collection and analysis

In this study, a case study and the qualitative research method were utilized in which the data was obtained from the observation and focus group interview (Appendix B). Before the workshop, all participants were informed about the purpose of the study. Photographs were also taken to document the research. The focus group interview, executed after the workshop, took 20 minutes owing to the longevity of the workshop. It was voice-recorded after taken the participants' permission. The result of this study was based on the analysis of these documents. The data of the pilot study was analyzed through qualitative data analysis (See section 3.5).

5.2 Participants

This study aims to design STEM activities with the interdisciplinary collaboration of the teachers by using a DT approach. Consequently, I wanted to include teachers from diverse disciplines in the study. I reached the participants with the help of the two teachers who were the graduates of the Fine Arts Education Department, where I used to work. In this respect, the participants participated in the study voluntarily after the introduction of the study. The first day of the workshop has started with six teachers. However, on the second day, a second-year student in the Fine Arts Education Department has not attended the workshop; thus, it has been completed with five teachers. As a result, there were a total of 5 participants in this study who were mathematics, visual arts, English, history, and science teachers, and except the visual arts teacher, the others have pedagogic formation to work as a teacher (Table 5.1). Furthermore, they had no professional experiences at school and were not working at that time. Only three of them had an internship and private course experiences.

Table 5.1 *Teachers' background*

Gender	Areas of expertise	Schools graduated
F	Mathematics	Faculty of Arts and Sciences, Department of Mathematics (Having pedagogic formation)
F	English	Faculty of Arts and Sciences, Department of English Language and Literature (Having pedagogic formation)
F	Science	Faculty of Arts and Sciences, Department of Biology (Having pedagogic formation)
M	History	Faculty of Literature, Department of History (Having pedagogic formation)
M	Visual arts	Faculty of Education, Art education

5.3 Context of the Study

A two-day workshop was realized on the 7th and 8th of September 2017 to design STEM activity with teachers by using the DT approach. The workshop was led and guided by the researcher-designer (whose major is industrial design) in accordance with the workshop plan (Table 5.2). In the workshop, PowerPoint slides were presented for introducing STEM education, the wallet design exercise and every stage of the DT approach for STEM activity design process. Moreover, time was kept separately for every phase to measure the overall timing of the workshop. Additionally, the participants were provided with the handouts of every DT stage, the workshop program, and the necessary supplies.

The first day of the workshop started at 09.30 with the presentation about STEM education, and then the DT approach was introduced. Later, to help teachers better understand the DT approach; "the wallet design exercise" (See section 2.3) was conducted. In the wallet design exercise, the participants were divided into groups of two and designed a wallet for their partners by following the DT process (Figure 5.1). Finally, they tested their designs with their partners to find out whether they meet the needs of their partners.

Table 5.2. *The plan for the pilot workshop*

A two-day STEM activity design workshop with teachers (07th and 08th September 2017)	
First day: Starts at 9.30 Participants: 6 teachers (math, science, history, English and 2 visual arts teachers)	Second day: Starts at 9.30 Participants: 5 teachers (math, science, history, English and visual arts teachers)
• What are STEM and DT Approach? (60 min.) **Interval: 10 min.** • What are the diverse DT approaches? (5 min.) • Wallet design exercise (40 min.) **Lunchtime-12.00 (60 min.)** • Wallet design exercise (continued) (50 min.) • Dividing teachers into groups (5 min.) • Problem definition (40 min.) **Interval: 10 min.** • Understand (30 min.) • Observe (35 min.) • Evaluation of the workshop (30 min.)	• Point of view (70 min.) **Interval: 10 min.** • Ideate (70 min.) **Lunchtime-12.00 (60 min.)** • Prototype (70 min.) **Interval: 10 min.** • Test (30 min.) • Evaluation of the workshop (30 min.)

After the wallet design exercise, the participants were divided into two groups in order to test the developed seven-stage DT approach for STEM activity design process (Table 5.3). In the first group, while there were the math, history, and visual arts teachers, in the second group, there were the science and English teachers and the visual arts teacher candidate who left on the second day of the workshop.

Table 5.3. *The developed DT approach implemented in STEM activity design process in pilot study*

Stage	Methods	The purpose of the methods
Problem Definition	Brainstorming	Brainstorming for subject selection
Understand	Brainstorming	Brainstorming for defining the target group
	5W1H Questions	Examining the problem and target group systematically by asking and answering the 5W1H questions (who, what, where, when, why, and how)
Observe	Brainstorming	Preparing interview questions
	Interview	Conducting interviews
	Observation	Conducting observations
Point of View	Bundle Ideas	Compiling collected data and eliminating the irrelevant ones.
	Brainstorming	Identifying the needs, conducting an analysis and writing the problem statement
	Empathy Map	
Ideate	Brainstorming	Preparing "How Might We" questions to start brainstorming session and ideate for STEM activity design. For instance, "How might we design an ice cream to be more portable?"
	Mind map	A brainstorming method which is a graphical representation of the ideas and the point of view surrounding a central theme, and it shows how they are related to each other
	Itemised Response & PMI (Plus, Minus, Interesting)	Judging ideas quickly by listing positive and negative features of them and evaluating them for choosing the right ones for activity design
Prototype	Planning	Filling the STEM Activity Plan template about the process of STEM activity by using prototyping methods
	Journey Map	Drawing a route map to think systematically about the steps of a process
	Diagram	Venn diagram: explain some important themes and their relations with each other
		Diagrams: a process map related to the structure or the process of the idea
	Model Making	Prototyping with digital model making: Building a simple model of your idea by using digital tools
		Prototyping with physical model making (mock-ups): A three-dimensional made by using various materials (paperboard, styrofoam, paper, etc.)
		Prototyping with paper: Prototyping with large index cards to show the step-by-step process of your ideas
Test	Peer review	Sharing STEM activity designs between the groups to get feedback

On the first day of the workshop, we followed the DT approach to the "point of view" (POV) stage and the STEM activity design process started with the execution of the "problem definition" stage. At this stage, teachers were expected to identify the appropriate subjects for the STEM activity by brainstorming. Since the participants did not work as active teachers at that moment, I defined the main subject to create a starting point for the STEM activity design.

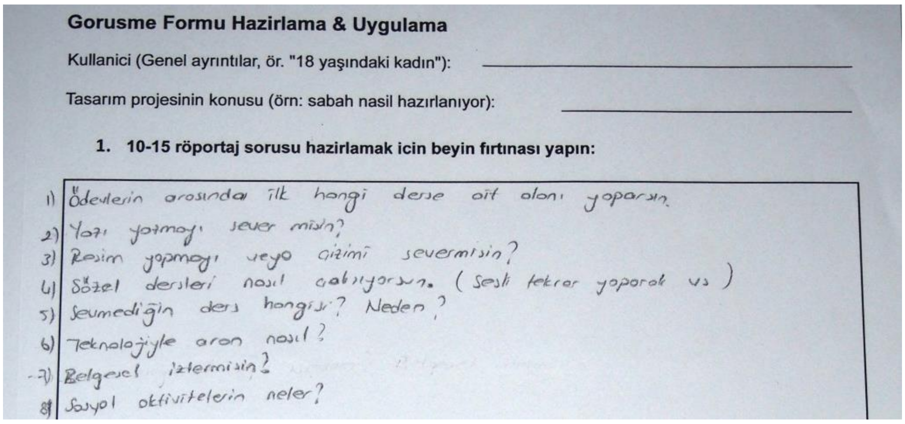
Figure 5.1. A view from the “wallet design” exercise

In this respect, before the workshop, I have sent a document by e-mail to all participants about the main subject (the lives of Homo-sapiens in the pre-historic period). In this document, I identified three main themes about this subject considering the background of the participants: the daily life, art, and nutrition and health. About these themes, I gave information, suggested related web pages and also provided related excerpts from a book named “Sapiens: A Brief History of Humankind” written by Yuval Noah Harari. Furthermore, in the workshop, I briefly explained the “problem definition” stage and the main subject and asked them to define their subjects by brainstorming. After the brainstorming session (Figure 5.2), they evaluated their ideas and wrote down their first problem statement about the selected subjects.

Figure 5.2. A poster from the “Problem definition” session (Original size: 50×70 cm)

In the “understand” stage of the STEM activity design process, they were asked to define the target group, and to understand the main subject and the target group by creating questions. This part included two methods: brainstorming and the 5W1H questions (Who, What, Where, When, Why, and How questions) (See Table 5.3). The groups first defined their target groups; in other words, the students for whom they designed their STEM activity. In this workshop, since it was impossible to reach the students, they took into consideration their past experiences related to students. I particularly wanted them to define their extreme users (extreme students) who are disinterested or distracted quickly in the classroom. Then to examine the problem and their target group systematically, they created 5W1H questions and answered them considering their previous experiences and observations. Lastly, they defined their second problem statement.

In the “observe” stage of the STEM activity design process, teachers were expected to conduct interviews and observation. This part included two methods: interview, and observation (See Table 5.3). At this stage, teachers first prepared their interview questions (Figure 5.3) and since there were no actual students, they conduct no observation. However, the teams did interviews with each other to understand other teams’ past experiences related to the students. Before the interviews, they also learned the interview tips and used the interview template (Appendix C) to write down their questions and the given answers. After the “observe” stage, the first day of the workshop finished with the evaluation of the workshop.



Gorusme Formu Hazirlama & Uygulama

Kullanici (Genel ayrıntılar, ör. "18 yaşındaki kadın"): ____________________

Tasarım projesinin konusu (örn: sabah nasil hazırlanıyor): ____________________

1. 10-15 röportaj sorusu hazirlamak icin beyin fırtınası yapın:

1) Ödevlerin arasında ilk hangi derse ait olanı yaparsın
2) Yazı yazmayı sever misin?
3) Resim yapmayı veya çizimi severmisin?
4) Sözel dersleri nasıl çalışıyorsun. (Sesli tekrar yaparak vs)
5) Sevmediğin ders hangisi? Neden?
6) Teknolojiyle aran nasıl?
7) Belgesel izlermisin?
8) Sosyal aktivitelerin neler?

Figure 5.3. A response sheet from the “Observe” session

On the second day, the workshop started with the “point of view (POV)” stage of the STEM activity design process. In this stage, teachers were expected to identify the needs and insights based on the collected data from the previous stages, and to develop a point of view for identifying a problem statement. This part included three methods: brainstorming, bundle ideas, empathy map (See Table 5.3). At this stage, teachers first collected data from the previous stages and eliminated the irrelevant ones. Then, they created an empathy map in four phases. In this respect, they first grouped the data and placed them in a four-quadrant layout of paper as follows:

SAY: What are some quotes and defining words your user said?
DO: What actions and behaviors did you notice?

THINK: What might your user be thinking? What does this tell you about his or her beliefs?
FEEL: What emotions might your subject be feeling? (d.school at Stanford University, n.d.)

Later, they identified the needs and conducted analysis respectively, and lastly, they wrote their problem statement on the POV template (Appendix C) focused on the needs and insights (Figure 5.4).

In the “ideate” stage of the STEM activity design process, teachers were asked to develop ideas for the STEM activity design. This part included three methods: brainstorming, mind map, itemised response and PMI (Plus, Minus, Interesting) (See Table 5.3). For the “ideate” stage, the preparation for brainstorming was first explained, and they learned “How might we...?” (HMW) questions to prepare questions for starting the brainstorming session.

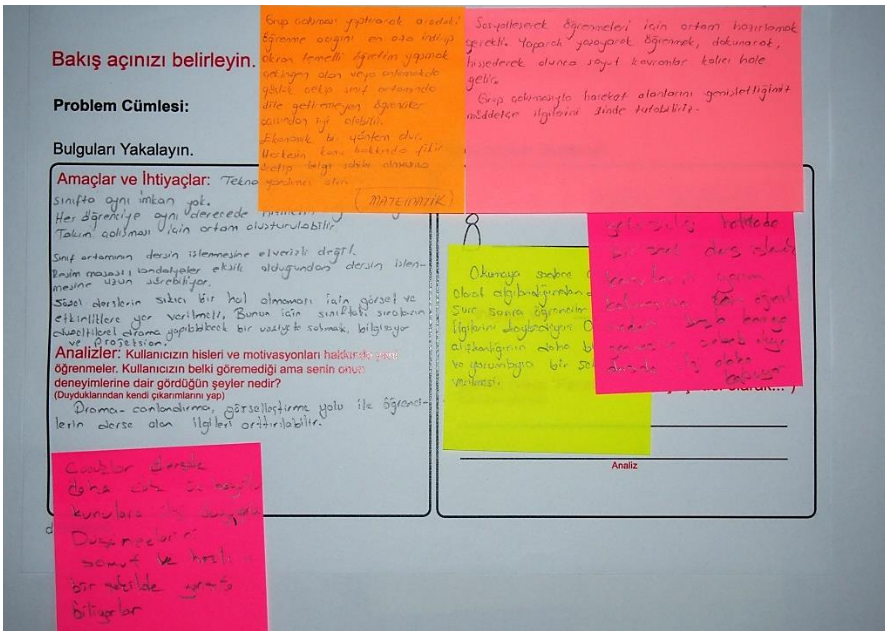


Figure 5.4. A POV template (Original size: A4)

Then, the Mind Map method was presented, and they learned tips about brainstorming. Later, they made a brainstorming (Figure 5.5) and wrote their HMW questions and solutions to the brainstorming template (Appendix C). The last part of this stage was the evaluation of the ideas. This part included the Itemised response and PMI method, which are about judging ideas quickly by listing and evaluating positive and negative features of them to choose the right ones for the activity.

Figure 5.5. A poster from the brainstorming session (Original size: 50×70 cm)

In the “prototype” stage of the STEM activity design process, teachers were required to fill the STEM activity plan template. This part included six prototyping methods; journey map, diagram, Venn diagram, model making including mock-up, digital model-making and paper prototyping (See Table 5.3). At this stage, teachers get information about the prototyping, the necessary information was explained related to the STEM Activity Plan template, and they were introduced the prototyping methods. Finally, they were given time to fill out their STEM activity plans.

The “test” stage was the last stage of the DT approach for the STEM activity design process, and the teams were required to share their activity designs to get feedback related to them. At this stage, teachers were first asked to prepare questions to ask the other groups while examining their STEM activity plans. Additionally, they were given a list of questions for the better evaluation of the activities. They were also asked to take notes, decide, and make changes to their plans if found necessary. The workshop ended with a focus group interview with teachers to assess the workshop and DT approach.

5.4 Findings

In the pilot study, the data was explored from three points; the workshop's productivity, STEM comprehension levels of teachers, and the productivity of the DT approach in the STEM activity design.

The workshop process was investigated to find out its efficiency. Although all of the teachers did not know the STEM and DT approach before, they found the workshop useful, productive, and fun. However, the introductory presentations about the STEM and DT approach made by the researcher-designer lasted longer than expected.

STEM comprehension levels of teachers were investigated based on the teachers' reflections to evaluate the workshop efficiency since they learned the STEM education with this workshop. In this respect, teachers mostly pointed out the interdisciplinary character of the STEM_education in their comments and how it could support the students in their course understanding: "Generally, if a student likes a course, he succeeds in this course. In this way, it can be ensured that he can be successful in all courses."[1] (English teacher) "All students have different ways of learning. Some understand analytically, some verbally, some visually. It gives all the students a chance to learn."[2] (Visual arts teacher)

The science teacher noticed the equal importance of all disciplines in STEM education. The visual arts teacher also said that the other teachers learned the importance of the visual arts lesson with STEM education.

> "So, there is one thing, which is interdisciplinary. Generally, if the child's visual arts lesson is good, that child is not called well in art, but, if his science is good, it is said that he is very good at science. But his art may be good; however, the parent never says that my child's art is good. But here, there is a sign of being good. So each course is equal."[3] (Science teacher)

The DT approach was investigated to understand its contribution to teachers and the STEM activity design. In this respect, the two characteristics of the DT approach were defined: the interdisciplinary collaboration and problem-solving. In this workshop, there was an interdisciplinary collaboration among teachers, which enables the exchanging of ideas and teachers' personal growth because of learning the STEM education and creating awareness about the interdisciplinary connections of the disciplines: "We previously divided the courses as verbal and analytical. We have seen that each lesson has a relationship with each other."[4] (Science teacher) "Previously, I was able to reconcile history with art and music. However, I would not think of reconciling it with science."[5] (History teacher)

Moreover, teachers referred to the problem-solving characteristics of the DT approach owing to solving the STEM activity design problem, and most of them found it useful in the STEM activity design since it made them understand the whole process. They also found learning the six stages helpful while designing a STEM activity for the first time.

Teachers had challenges when designing STEM activities with the developed DT approach. The teachers needed more time to develop activity design ideas and to understand some of the stages of the STEM activity design process. Teachers had difficulties in creating 5W1H and "How Might We?" questions and the empathy map. 5W1H and "How Might We?" questions also did not provide a useful contribution to the STEM activity design. The POV (Point of view) template functioned in a similar way with the empathy map. The researcher-designer was not able to utilize the brainstorming template (A4 paper). A large blank sheet (50×70) paper was found to be more useful in the brainstorming session. Moreover, evaluating ideas through "Itemised Response and PMI (plus, minus, interesting)" method during the "Ideate" stage were found to be unnecessarily complex. Teachers further had difficulties in filling in the STEM activity plan. Thus, the revision was executed to the DT approach.

5.5 Discussion of the pilot study

In the pilot study, it was intended to test the developed DT approach within the scope of this study for the STEM activity design. In this study, the findings provided us information about the revisions of the STEM activity design workshop process and the DT approach that was intended to be applied in the Main Study I (Table 5.4).

5.5.1 The revision in the STEM activity design workshop process for Main Study I

The revision was conducted in the workshop process. According to this, the introductory presentations by the researcher-designer about the STEM and DT approaches were decided to be made on a separate day before the workshop. Furthermore, in order to facilitate teachers' idea development, it was decided to conduct co-design workshops led by the researcher-designer for the main studies.

5.5.2 The revision in the DT approach for STEM activity design for Main Study I

Problem definition. In the "problem definition" stage, the brainstorming phase lasted more than expected. In this respect, I did not make any change in the "problem definition" stage. However, to prevent this issue, I decided to request from teachers to bring their curricula to the pre-workshop interviews to discuss the selection of the subjects before the workshop.

The first stage: Understand. In the "understand" stage, because of the inefficiency of the 5W1H questions in the STEM activity design, it was removed from this stage. Additionally, due to expecting a problem statement covering all needs and insights in the "POV" stage, defining the second problem statement was found unnecessary in the "understand" stage.

The second stage: Observe. In the "observe" stage, teachers were expected to prepare their interview questions by brainstorming and then to conduct interviews and observations to collect data about students in the real school context. Consequently, giving a one-week interval between the first and the second day of the workshop was decided to have time for implementing this stage. Moreover, an observation template was created, and the interview template was revised.

The third stage: Point of view. In the "POV" stage, the POV template was removed since the empathy map could perform the same task. Since teachers had difficulties with creating an empathy map, there are changes in the process of it and the bundle ideas was included as a part of the empathy map. According to this, teachers first were expected to group the information collected from the previous stages and placed them on a four-quadrant layout of paper (Say, Do, Think and Feel). Later considering the empathy map procedure (Figure 5.6), they were required to identify the needs and conduct analysis respectively. Additionally, in the analysis section, the participants were expected to create personas considering their findings of the students. To create this part, I benefited from the Coursera MOOCs course' (n.d.) for providing general information and MIT MOOCs course (n.d.) to give an example about personas. After finding needs and creating personas, teachers were expected to write the problem statement.

<u>Needs:</u> What do you need considering your STEM activity and school facilities? Define your needs and limitations of this activity. You can divide the needs into two parts as below.
<u>For example:</u> <u>Student:</u> What do you think about your students' needs considering your observation and interviews? (The activity needs hands-on activity, a common problem statement or theme.) <u>STEM activity:</u> What are your findings regarding the disciplines and subjects of your activity? What do you need to implement the STEM activity in your class? (Do I need material in the activity? What do I need to implement a STEM activity? How long do I need for that activity for each lesson? Which method should be used in this activity? Do I need to use any school facilities in this activity? Do I need anything else that does not exist right now at the school?)
<u>Analysis:</u> What are your insights about the STEM activity considering your information? What are your students' profiles (persona) and interests?
<u>POV:</u> What are your points of view, and the final problem statement? (including the STEM activity design, the subjects, and students). If you cannot combine them in one statement, you can write two problem statements.

Figure 5.6. The revised empathy map

The fourth stage: Ideate. In the "ideate" stage, "How Might We?" questions were removed because of its inefficiency. Besides, to create a STEM activity, the difference between the theme and problem statement was decided to be explained in the next workshop. In the evaluation stage, the changes were executed in the Itemised response and PMI's method to make the steps lesser and more understandable. Lastly, the brainstorming template was removed owing to using a large blank sheet.

The fifth stage: Prototype. In the pilot study, teachers had difficulties in filling the STEM activity plan template. Therefore, I have made some changes in the template by taking the MIT MOOCs course' activity plan (n.d.) and BAUSTEM STEM course plan (n.d.) into account to create a more comprehensive template.

The sixth stage: Test. In the Main Study I, teachers were asked to test the effect of the designed STEM activities in one of the classes. The participants were also given ready-made questions to evaluate their activities by themselves. But, additions were made to these questions considering the BAUSTEM teacher self-evaluation form (n.d.).

Table 5.4 *The revised DT approach for STEM activity design for Main Study I*

	Problem Definition	**Understand**	**Observe**	**Point of View**	**Ideate**	**Prototype**	**Test**
What is it?	Identify the subjects which will be included in the STEM activity design	Make research about the identified subjects and define the target group	Conduct interviews with and make observations about the target students	Compile and group all data from the previous stages to identify the needs, conduct an analysis, and define the problem statement	Generate ideas for the STEM activity design	Create a prototype of the STEM activity plan through multiple prototyping methods	Implement the STEM activity in the class and revise the STEM activity plan
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	Empathy map, brainstorming	Brainstorming, mind map, itemised response and PMI (Plus, Minus, Interesting) method	Planning, journey map, diagram, model making	Peer review
Revisions in the DT approach	No change	Remove 5W1H questions	Create an observation template Revise the interview template	Remove POV template Revise the Empathy Map process by involving bundle ideas	Remove “How Might We” questions Remove the brainstorming template Simplify the evaluation part	Revise the STEM Activity Plan template	Revise the peer evaluation questions

CHAPTER 6

MAIN STUDY I

6.1 Goal of the study

In Main Study I, it was intended to test the revised DT approach for the STEM activity design and implementation. For this reason, co-developing and implementing a STEM activity and interdisciplinary lessons through the DT approach was realized with 5th-grade teachers in one of the private schools in Samsun in the fall term of the 2017-2018 academic year (between 10.10.2017 and 19.01.2018).

6.2 Data collection and analysis

Main study I utilized a case study, and qualitative research methods and data were obtained through focus group interviews, individual interviews, group interview with students, observation and meeting notes, and mobile instant messaging (SMS and WhatsApp). All interviews were audio-recorded by the researcher after taking written consent from the participants. As the number of participants in the workshop and the STEM activity was high, it was difficult to monitor the discussions recorded with the voice recorder. Therefore, a video camera was used to gather data both in STEM activity and in the workshop. Besides, photographs were taken to document the study. Videos were not shared with any institution/person, and when photographs were used in prints, the faces were blurred. Before conducting the study, all participants were informed about the aim of the study. Consent forms were obtained from the participants.

To start the analysis of the data, the digital audio files of all interviews were organized into individual folders under the name of each teacher. Then separate folders were created for students' and teachers' focus group interviews. All interviews were fully transcribed in Turkish. To save the files, I first gave codes to the collected data in accordance with the realization date from the beginning of the Main Study I. Then I gave codes to the messages and the observation notes separately (Table 6.1). Then, I abbreviated teachers' and students' names to state them in the data (Table 6.2). Furthermore, the student names were coded as "Öğrenci A" and "Student A" to hide their real names. There were fifteen students, out of which eight were female (Student A, Student B, Student C, Student K, Student L, Student M, Student N, Student Z) and seven were male (Student D, Student E, Student F, Student G, Student H, Student X, Student Y).

Table 6.1 *The codes related to the phases of the Main Study I and file names*

Description	Code
Main Study I	S1
Pre-workshop interviews	P1
Post-workshop focus group interview	P2
Making interviews/discussions with teachers or students after the STEM activity or interdisciplinary lessons	P3
Focus group interview with students after the STEM activity	P4
SMS or Whats-up communication	MSJ
Observation	Observe

Table 6.2 *The participants' abbreviations used in the Main Study I*

Participants	Abbreviation
Visual arts teacher	Art
Mathematics teacher	Math
Science teacher	Science
Social science teacher	SocialS
English speaking teacher	English
English skills teacher	English1
Student	ST

I further saved the data as separate word processing files in MS Word, and I assigned a number to each paragraph to make it easier to locate the quotes if needed (Figure 6.1). For instance, a quote named "*S1-P1-English1-23Ekim-29-30*" means a pre-workshop interview with English teacher 1 (English skills teacher) on 23rd October and that the quote was taken from the paragraph "29 and 30".

Similarly, a file named "*S1-Observe-11 Aralık*" means an observation made on 11th December in the Main Study I.

<u>**Code: S1-P3-Math-11 Aralık**</u>

1. **Hocam bugünkü dersi, aktiviteyi nasıl buldunuz?**
2. Bence aktivite güzeldi. Çocuklar zaten kesirler kısmını pekiştirdikleri için hani resim dersinde kullanılan kısımlar zaten pekişmişti. Sınıfın genel çoğunluğunda zaten zorlanmadılar. Siz de gördünüz. Sadece okunuşundan dolayı bir kafa karışıyor, ya da kalem kullanmadıkları için karışıyor. Ama hani konuya da hâkimlerdi. Bence resimle pekişmesi de güzel oldu, daha farklı oldu. Benim için de farklı oldu, onlar için de farklı olduğunu zaten gözlemledim.
3. **Hocam sizin için farklı olan kısmı neydi? Bu şekilde ders işlenmesi mi? İlk defa böyle bir derse giriyorsunuz değil mi?**
4. Ben de yani hayatımda ilk defa bir STEM aktivitesine katılıyorum. Mesela derste örnek verirken, resim dersinde ki bu perspektif konusu benden önce işlenmiş olsaydı, belki hani müfredat gereği, orada kullandıkları resmi alıp, ben hani kendim 'Aaa bakın, kesirler böyle boyuyoruz, ediyoruz', hani örneklerimi zenginleştirmem açısından bana katkısı olurdu. Hani öyle şekilde bir faydası oldu. Hani zaten hep anlatıyoruz, günlük hayattan örnek veriyoruz. Ama dersler ile bağlantılı direkt materyal olarak kullanma açısından, hani benim için faydalı olurdu, ama müfredat gereği denk düşemedik.

Figure 6.1. An example from the interview transcripts with numbered paragraphs

In this study, to understand, compare, and evaluate the study, I analyzed the phases and parts of the Main Study I separately by making a comparison of the similarities and differences between the phases. The collected data was analyzed based on the template analysis method, which is a style of thematic analysis. First, an initial template with the priori codes was generated based on the interview guides. The initial template was defined as follows:

- Stakeholder expectations (Teachers, Students, Parents, Administration)
- The role of design thinking
- The role of the designer
- The understanding of STEM education
- Interdisciplinary collaboration

Once the initial template was prepared, transcriptions of interview data (207 pages), observation and meeting notes (48 pages), and mobile instant messaging (SMS and WhatsApp) (20 pages) were coded through a computer-assisted qualitative data analysis software, MaxQDA (Figure 6.2).

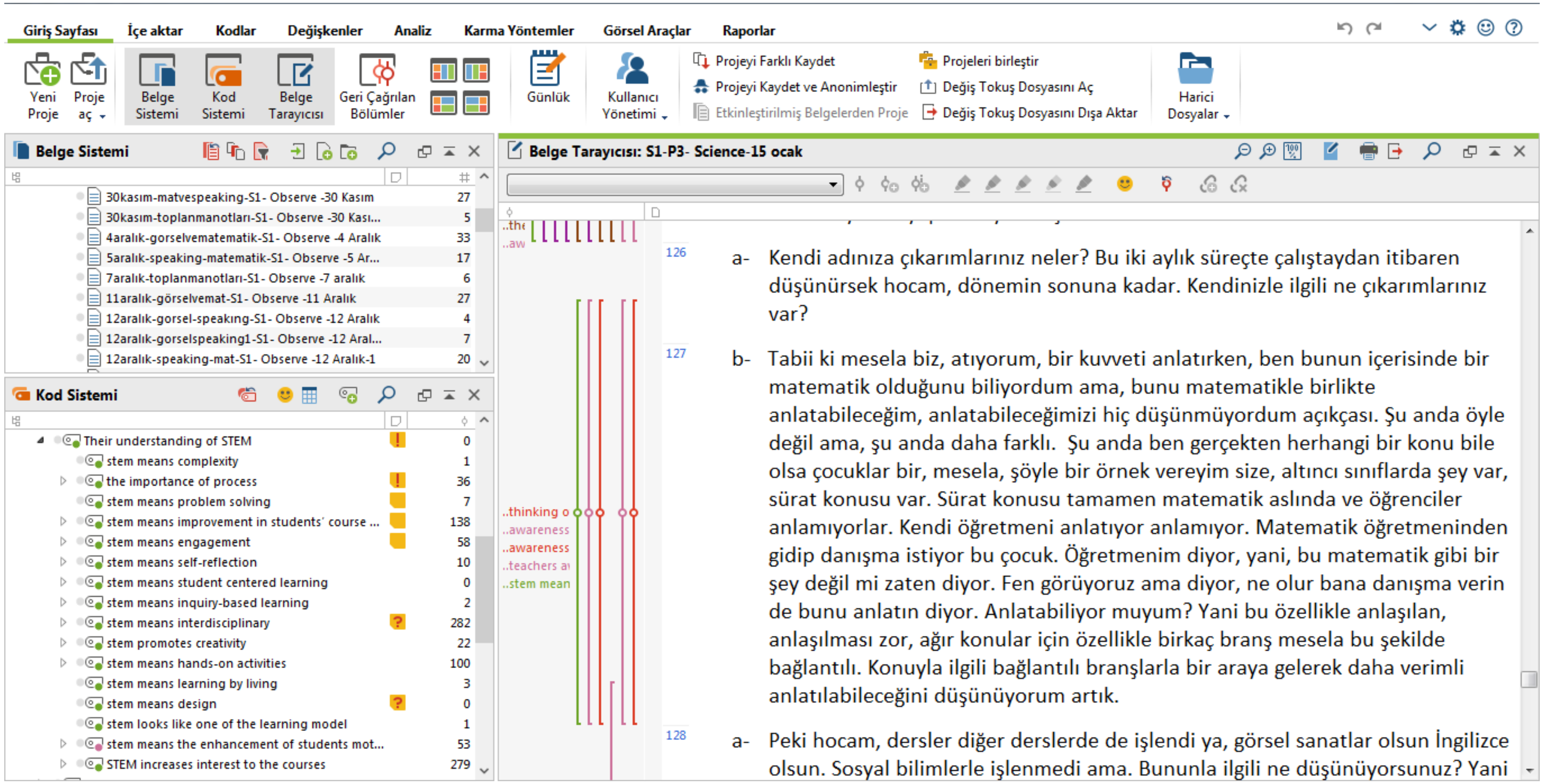


Figure 6.2. A view from the MaxQDA software program showing the coding of interviews

For the analysis, all the data were read several times until no new codes emerged, and the extracts related to the initial codes were highlighted. During the coding, the initial template was revised considering the relevancy with the purpose, and new codes were added. For example, while there was a category named “the role of designer” in the template, later, it was changed into “the role of the researcher-designer” in reference to the different roles of the researcher. Then, the findings were organized, and emerging themes were clarified. Once the emerging themes were identified, illustrative examples from the transcripts were selected and translated into English.

6.3 Participants

This study aims to design STEM activities through the interdisciplinary collaboration of teachers and to implement them in class. Considering the literature review, the exploratory research, and the local changes executed by the Ministry of National Education on the secondary school science curriculum, this study was decided to be conducted in the secondary school context in which a teacher from the relevant discipline teaches each course. Since the high school entrance exam has the lowest impact on the 5th grade, the 5th-grade was chosen as the focus.

To get permission to make Main Study I (and also II), the purpose and significance of the study were explained to the school principal, and the school principal received permission from the foundation management upon my application. Besides, the school principal informed teachers in the staff meeting, and the brief about the study was presented to the 5th-grade teachers. A presentation was further made to all 5th-grade students’ parents in 3 classes about the study. Only one of the classes wanted to be involved in the research as a whole. The permission was also received from the Ministry of National Education and METU Applied Ethics Research Center to conduct the study (Appendix K and Appendix L). Consent forms were obtained both from the parents and teachers (Appendix M, N, and Appendix O, P). In the Main Study I, there were a total of five teachers, including mathematics, visual arts, social science, science, and English speaking teachers. As a result, the sample of the study is comprised of 16 5th-grade students and five teachers who lectured in the targeted 5th-grade class.

6.4 Context of the Study

The Main Study I had four phases: co-designing a STEM activity with teachers, teachers' conducting interdisciplinary lessons, teachers' implementing the STEM activity in the class with the assistance of the researcher-designer and the focus group with students (Table 6.3).

Table 6.3 *The four phases of Main Study I*

Phase 1: Co-designing a STEM activity with teachers
Part 1: STEM and DT presentation to teachers before the workshop Part 2: Pre-workshop interviews with teachers Part 3: A two-day co-design workshop with teachers Part 4: Post-workshop focus group with teachers
Phase 2: Teachers' conducting interdisciplinary lessons
Part 1: Finalizing STEM activity design and preparations for interdisciplinary lessons Part 2: Interdisciplinary lessons conducted by teachers through individual teaching Part 3: Interdisciplinary lessons conducted by teachers through team teaching
Phase 3: Teachers' implementing the STEM activity in the class with the assistance of the researcher-designer
Phase 4: Focus group with students

6.5 Phase 1: Co-designing a STEM activity with teachers

In Phase 1, it was intended to collaboratively design STEM activities with teachers by using a design thinking approach. Phase 1 included four parts: STEM and DT presentation to teachers before the workshop, pre-workshop interviews with teachers, a two-day co-design workshop with teachers and lastly, a post-workshop focus group with teachers. In this phase, both the researcher and teachers were actively involved in the study (Table 6.3).

6.5.1 Part 1: STEM and DT presentation to teachers before the workshop

The first part was a STEM and DT presentation to teachers on 19th October 2017. The main reasons for making this presentation before the workshop were to make teachers understand the STEM and DT approach comprehensively and to prevent time management problems in the workshop, which had occurred in the pilot study. The presentation was attended by nine teachers who taught the 5th grades and lasted nearly 80 minutes. There were three teachers of English (speaking, main course, and skills teachers) and one teacher of each discipline (math[1], science, social science, music, visual arts, and Turkish). The presentation had four parts: introduction to STEM education, introduction to DT approach, the objective and scope of the study, and the STEM activity examples, respectively. At the end of the presentation, when making appointments with teachers for pre-workshop interviews, I requested them to examine their curricula to determine the appropriate subjects for the STEM activity design before the interviews. I also asked them to bring those to the interviews to discuss them together.

6.5.2 Part 2: Pre-workshop interviews with teachers

There were three primary purposes for conducting these interviews. The first one was to learn teachers' backgrounds about their education and teaching experiences to discover their awareness about STEM education and interdisciplinary education. The second one was to find out their expectations and concerns related to this study and working with other disciplines. The third one was to get information about the participant students. All information gathered was intended to be used to develop strategies for the execution of the STEM activity design workshop. I prepared my

[1]After the initial math teacher left, the same presentation was conducted to the new math teacher who participated in this study later.

questions under three main groups: teachers' background, expectations, and concerns about the study and their opinions about the participant students (Appendix D). The pre-workshop interviews were realized on the 23rd and the 31st of November 2018 with nine teachers. Out of these nine teachers, only six participated in the main studies owing to the non-availability of the teachers during the workshop dates. Therefore, only the data from six teachers, who were visual arts, math, science, social science, English speaking, and English skills teachers, were analyzed.[2] All interviews were conducted in Turkish and voice-recorded; the duration of each interview varied between 06-30 minutes.

The findings of the pre-workshop interviews. The findings of the pre-workshops interviews' provided us information about teachers' readiness level in the adoption of STEM education. In this respect, teachers' motivation and capabilities were investigated under three categories: Teachers' previous experiences about the STEM education and the interdisciplinary education, teachers' expectations and concerns about this study, and teachers' reflections about the participant students.

Teachers' previous experiences about STEM education and interdisciplinary education. Three participants had a pedagogic formation to work as a teacher. The skills, science, math, and social science teachers had only 1-year teaching experience. The English speaking, visual arts and science teachers worked in this school for more than one year; the others were in their first years (Table 6.4).

The English skills, English speaking, science, math, and social science teachers had no previous interdisciplinary education experience. However, the English teachers highlighted the interdisciplinary quality of the English lesson in reference to having interdisciplinary course books and the activities involved in it.

> Of course, I heard about it. Our English courses, more or less, have to be interdisciplinary. Because more or less, the subjects in the textbooks can be relevant.

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[2] The English speaking teacher participated in the Main Study I only, and the English skills teacher participated in the Main Study II only.

> It can positively be related to the subjects of science and mathematics courses. But I did not do it directly like this method before.[6] (English speaking teacher)

> And English is also divided into three. Teacher X is giving the main course and grammar. I am the English skills teacher; for example, it's more about skills and reading. Teacher Y is offering writing and speaking courses. For me, we can say reading, writing, or listening. I am preparing them in this way by consolidating them, or by preparing activities, materials.[7] (English skills teacher)

Table 6.4 *Teachers' background*

Gender	Areas of expertise	Schools graduated	Experience in the current school	Total teaching experience
F	English skills teacher	Faculty of Letters, Department of Western Languages and Literature (with pedagogic formation)	1st year	1-year experience in the study center
F	English speaking teacher	Faculty of Education, Department of Foreign Language Education	5th year	7-years of experience at school
F	Science	Faculty of Art and Sciences, Department of Chemistry (with pedagogic formation)	2nd year	1-year experience at school
F	Mathematics	Faculty Of Sciences, Department of Mathematics (with pedagogic formation)	1st year	1-year experience
F	Social Science	Faculty of Education, Social Studies Education	1st year	1-year experience in the study center
M	Art	Faculty of Education, Art education	4th year	35 years' experience at school

The math teacher stated that she heard about STEM education for the first time; she also found it similar to one of the learning models. Among teachers, only the visual arts teacher had interdisciplinary collaboration and team teaching experiences because of the past educational tradition he experienced.

> In fact, since I went into this profession, there was such an interdisciplinary section in our plans—a collaboration with the other teacher groups. When I say the other teacher groups, I mean a history teacher, a mathematics teacher, a science teacher in a mutual relationship […] When the inspectors arrive, they're looking at to what extent you cooperate with those teachers of school! I was doing something like this in my area.[8] (Visual arts teacher)

He correlated the STEM education with the educational approach adopted in the "Village Institutes" and emphasized the significance of knowing other disciplines as follows:

> What we think about STEM education, the things we already experienced. As I said when we first met, the things which were applied in the Village Institutes as they call it today total quality. It may not be my discipline, but every teacher should understand more or less from every other discipline. And she/he should discuss, talk this with the other.[9] (Visual arts teacher)

Teachers' expectations and concerns about the study. Teachers were enthusiastic about STEM education and had several expectations from the study. For instance, the math and English speaking teachers stated their eagerness about learning STEM education and its applications; the English speaking teacher further pointed out her desire for the sustainability of this study: "As I said, learning something new, learning something permanent. So I want sustainability. I want it to be a sustainable teaching practice, not for once. To tell you the truth, I also expect a certificate."[10] (English speaking teacher)

Teachers also stated their opinions about the expected STEM activities considering their disciplines. For instance, the English skills teacher was very enthusiastic about STEM education and expected to teach the lessons with interdisciplinary collaboration: "I'm also just wondering what's going to happen. I understand that the lessons will be parallel with each other. So I'm wondering, I haven't been able to understand clearly yet. […] For example, when I teach, I'll be in touch with mathematics teacher, visual arts teacher, or Turkish teacher, and we will work in parallel."[11] (English skills teacher)

Since the visual arts teacher had a previous interdisciplinary education experience, his motivation was one of the highest. Because he observed a connection between STEM education and education in the "Village Institutes", he expected the blending of the past with the current educational model, which creates continuity in the educational traditions. He also connected STEM education with a hands-on design activity and described it in detail:

> When I first met you, you said to me this sentence; it caught my attention. The thing about the Village Institutes. It is similar. In villages, in these schools, this lesson plan will be followed, isn't that so? Of course, it will be followed. The whole point here is the teacher's constructive and creative attitude. Let's say we tried to do something about design, let's say jewelry. There's a quilt yarn if you could not find anything. There are such plants in nature, like the Canary grass. Even if you string them in a

> thread, you create a design. Or there are rose hips, and they are stiffer. String them in a thread. Put a piece of paper, you made, between the sheets. There used to be some papers, what they call them? Women used to do needlework with them, the ones with the aluminum foil paper. They wrinkled them round and strung them in a thread. They designed the edges of their scarves. It would be chic; they swung in their small and bun form. When they are all together, it will create a different image. So it's waste material.[12] (Visual arts teacher)

The social science teacher correlated STEM education with material design. She also expressed the benefits of making connections with other subjects, with non-verbal ones in particular.

> In the first place, we discussed defining a specific subject. In my mind, here, I looked at the annual plan and shaped a subject in my mind. I planned to develop it with the methods I knew before. I thought if I make children design a material, with whom I can work with. I thought I could work with our visual arts teacher, or we can include the music lesson to make students love the lesson. If we can teach a verbal lesson, a boring lesson, in a way that provides for a fun, and if we can attract children's attention, I think the lesson will be more productive.[13] (Social science teacher)

The social science teacher further could not connect the social science subjects with the math and science subjects in the first term 5th-grade curriculum: "I do not think I can involve the science. Particularly, math."[14] (Social science teacher)

The science teacher stated her expectation about the persistence of students' learning owing to combining several disciplines and using different methods. Although teachers had some expectations regarding the STEM activities, the English skills teacher stated her concern about developing new ideas: "I am not very good at producing ideas, but I am very good at putting the produced idea into practice. I am practical. I am ready for all kinds of cutting-mowing. I'm good at drawing."[15] (English skills teacher)

Although teachers barely knew STEM education, all of them were motivated to learn STEM education, and they had different expectations from the study. While the science teacher expected the persistence for learning, the social science teacher hoped to see an increase in students' engagement. Furthermore, social science and the visual arts teachers expected hands-on activities, and the English skills teacher highlighted the collaboration among teachers. The visual arts teacher gave reference to teachers' creativity in developing activities. Therefore, it can be concluded that teachers correlated the STEM education with some notions and stated their expected STEM activity by considering their disciplines.

Teachers' comments about participant students. Pre-workshop interviews also aimed at getting information about the participant students. Teachers gave information about the students' academic level, their learning styles, their behavior, and attitudes while conducting a lesson. Except for the visual arts teacher, all teachers newly met with the class in that term; all of them found the students academically well. The English speaking teacher referred to the students' multiple learning styles as an advantage. The science teacher considered the class better than the other 5th grades in terms of their behavior and academic performance. The visual arts teacher stated that the students loved the visual arts lesson and perceived it as a lesson to relax:

> Class 5X is an excellent class, it's a good class academically, and this class is very convenient to conduct a lesson. Children's perception is open. There are several types of intelligence that you can address. They love more learning through visual, auditory methods and by acting and getting up, making, touching. You can implement everything in that class.[16] (English speaking teacher)

> How are they? Well, if you asked our other teachers, actually there are three 5th grades, and I can say that it's the best class you can teach courses very easily and it's our well-behaved class. Yes, for example, it's the same for all of the 5th classes. When you asked them a question, they are not just raising their hands but also climbing to the school desks by saying, "Mam, Mam, Maam." I do not know if it's right to compare them only academically, but of course, they are learning what you gave them as a course. It's a class you can teach courses very quickly. Students are interrogators. For example, they love homework. It's so exciting.[17] (Science teacher)

> But they usually like it; they love it that they want canvas from me. When students are tired of studying math at noon, in their free time, or when they get bored of math, science, social subjects, I'm saying to them, "come to my workshop, I am there.[18] (Visual arts teacher)

The findings indicated that, except for the visual arts teacher, the teachers' familiarity with the students was low due to teaching this class for the first time. However, they were pleased with the students in terms of their performance and engagement. Besides, they enjoyed teaching this class because of their openness to learning.

The discussion on the pre-workshop interviews. The findings of the pre-workshop interviews provided us information about the teachers' readiness level in the adoption of STEM education. In this respect, teachers' motivation and capabilities were investigated under three categories: teachers' previous experiences, expectations, and concerns. The information about students was also collected from teachers. All of these findings, the findings of the exploratory research and the STEM & DT presentation, were utilized to determine the strategies for the STEM activity design workshop as follows:

- The visual arts teacher considered having interdisciplinary knowledge significant for teachers in interdisciplinary education. Moreover, the social science teacher thought no relationship between her subjects with the science and the math subjects; however, there was a relationship between them. These findings made me think about creating a collaborative workshop environment and designing interdisciplinary lessons along with the STEM activity in the workshop. I also considered that the students would need an interdisciplinary perspective during the STEM activity. Thus, I intended to make team teaching in the interdisciplinary lessons to make teachers and students aware of the interdisciplinary connections of the disciplines. Since experiencing the teaching of multiple teachers in the lesson could make students understand and remember the knowledge about the interdisciplinary connection of the subjects.
- The English lesson was defined as an interdisciplinary and activity-based lesson by two English teachers. Besides, in the STEM & DT presentation, one of the English teachers proposed an example of STEM activity by adapting herself quickly to STEM education. Moreover, as previously expressed in the exploratory research, the English lesson was found one of the most suitable lessons among the others in terms of implementing STEM education. All of these findings made me consider taking advantage of the English lesson in STEM education.

- I wanted to involve the visual arts lesson in STEM education because of the students' positive perceptions about this lesson.
- After discussing teachers' subjects for the STEM activity design in the pre-workshop interviews, I created a list of the teachers' left subjects based on their curricula and some example themes related to these subjects to be distributed in the workshop as an example for teachers.
- I used teachers' background information to create teachers' groups in the workshop.

6.5.3 Part 3: A two-day co-design workshop with teachers

A two-day co-design workshop was realized on the 18th and the 25th of November 2017 to design STEM activity and interdisciplinary lessons with five teachers by using the DT approach. The participants were the English speaking, social science, visual arts, science and math teachers, and the workshop was partly video-recorded. The workshop was led and guided by the researcher-designer. The previous workshop plan has been changed (Table 6.5) due to having conducted the STEM & DT presentation before the workshop (Section 6.4.1).

Table 6.5 *A two-day STEM activity design workshop with teachers*

<table>
<tr><th colspan="2">A two-day STEM activity design workshop with teachers
(18th and 25th November 2017)</th></tr>
<tr><td>Partly video recorded
Duration: 9.30-15.45
Participants: 5 teachers (math, science, social science, English speaking and visual arts teachers)</td><td>Partly video recorded
Duration: 9.30-17.00
Participants: 5 teachers (math, science, social science, English speaking and visual arts teachers)</td></tr>
<tr><td>• What are the diverse DT approaches? (5 min.)
• Wallet design exercise (75 min.)
Interval: 10 min.
• Wallet design exercise (continued) (35 min.)
• Dividing teachers into groups (5 min.)
• Problem definition (20 min.)
Lunchtime-12.00 (60 min.)
• Problem definition (continued) (40 min.)
• Understand (15 min.)
Interval: 10 min.
• Observe (30 min.)</td><td>• Point of view (70 min.)
Interval: 10 min.
• Ideate (70 min.)
Lunchtime-12.00 (60 min.)
• Prototype (70 min.)
Interval: 10 min.
• Test (10 min.)
• Evaluation of the workshop (30 min.)</td></tr>
</table>

In the workshop, I created a collaborative and participative co-design workshop experience with the necessary supplies. I brought many materials (templates, handouts about the stages of the DT approach, and the workshop program) to be used in the wallet design exercise and the STEM activity design process. PowerPoint slides were prepared and presented, and the time was kept separately for every stage of the DT approach for STEM activity design process in the workshop.

The first day of the workshop started at 09.30 am with brief information about DT approaches. Later, to help teachers better understand the DT approach, "the wallet design exercise" was conducted. In the wallet design exercise, at first, teachers were divided into groups of two, and then they were asked to design a wallet for their partners without getting a direction. At that moment, they drew their designs on the template prepared for this activity in a given time. Then the execution of the DT process started, and they designed a wallet by following the DT process (Figure 6.3). With this exercise, they discovered the function of making empathy about getting familiar with their partners and how this changed the design of the wallets.

> Teachers understood the importance of getting familiar with the target group and understanding them with the "wallet design exercise". Since the wallet that they designed was different after they had interviewed them about the wallet, they thought they knew their partners in the beginning. It appeared that they could have prejudices or specific ideas about people. [19] (Observation note from the workshop)

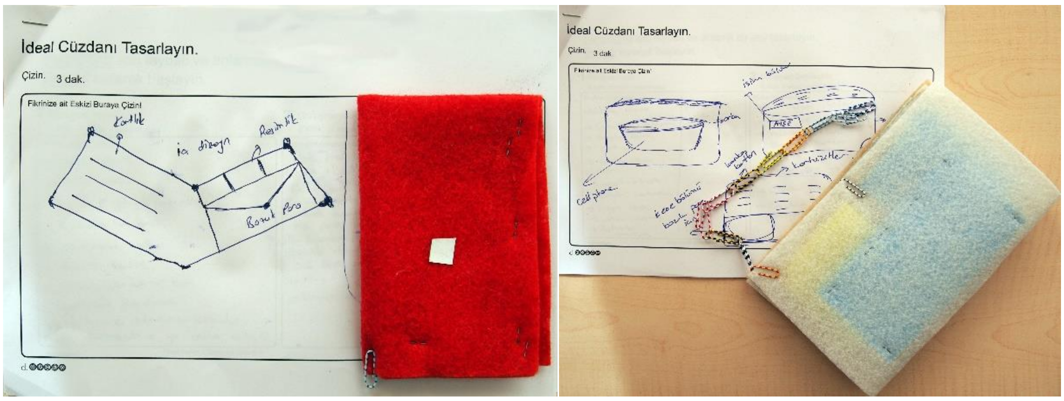


Figure 6.3. Teachers' wallet designs

After the wallet design exercise, I divided teachers into two groups considering the data obtained in the pre-workshop interviews in order to test the revised seven-stage DT approach for STEM activity design process (Table 6.6). While the science, English speaking, and social science teachers were into one group, and the visual arts and math teachers were into the other group. The reason for making two groups was because of thinking that the English speaking teacher could support both groups separately at the same time owing to having a flexible and interdisciplinary curriculum. On the first day of the workshop, we followed the DT approach to the "point of view" (POV) stage.

Table 6.6 *The revised DT approach implemented in STEM activity design process in Main study I*

Stage	**Methods**	**The purpose of the methods**
Problem Definition	Brainstorming	Brainstorming for subject selection
Understand	Brainstorming	Brainstorming for defining the target group
Observe	Brainstorming	Preparing interview questions
	Interview	Conducting interviews with students
	Observation	Conducting observations
Point of View	Brainstorming	Compiling and grouping collected data, identifying the needs, conducting an analysis and writing the problem statement
	Empathy Map	
Ideate	Brainstorming	Ideate for STEM activity design
	Mind map	A brainstorming method which is a graphical representation of the ideas and the point of view surrounding a central theme, and it shows how they are related to each other
	Itemised Response & PMI (Plus, Minus, Interesting)	Judging ideas quickly by listing positive and negative features of them and evaluating them for choosing the right ones for activity design
Prototype	Planning	Filling the STEM Activity Plan template about the process of STEM activity by using prototyping methods
	Journey Map	Drawing a route map to think systematically about the steps of a process
	Diagram	Venn diagram: explain some important themes and their relations with each other
		Diagrams: a process map related to the structure or the process of the idea
	Model Making	Prototyping with digital model making: Building a simple model of your idea by using digital tools.
		Prototyping with physical model making (mock-ups): A three-dimensional made by using various materials (paperboard, styrofoam, paper, etc.)
		Prototyping with paper: Prototyping with large index cards to show the step-by-step process of your ideas
Test	Peer review	Sharing STEM activity designs between the groups to get feedback

Under the stage of "problem definition" of the STEM activity design process, which included brainstorming method, teachers were expected to decide the appropriate subjects for the STEM activity design and the interdisciplinary lessons. The challenge of this stage was being fewer subjects left in each discipline due to being in the middle of the term. At this stage, they first were told the brainstorming rules and learned how to brainstorm. Later considering their pre-workshop interviews, I handed out to teachers a word document that has the list of the left subjects of their curricula and some example themes. In this way, while I wanted them to be aware of the other teachers' curriculum, I also tried to show them with examples of how the subjects could have common points between themselves. In the brainstorming session, they first decided on the possible dates of the interdisciplinary lessons (in December) and the STEM activity (in January). After that, teachers discussed their subjects and their relation to each other. It was observed that teachers tried to determine the subjects by making a common decision. Therefore, instead of many ideas, the result-oriented ideas came up with a joint decision. Because of having a flexible curriculum, the English speaking teacher also took her subject in the second term to the first term to be compatible with the science lesson. At the end of this stage, teachers selected the subjects and decided on the possible dates of the lessons and the STEM activity. They further created the general contents of the interdisciplinary lessons (Figure 6.4).

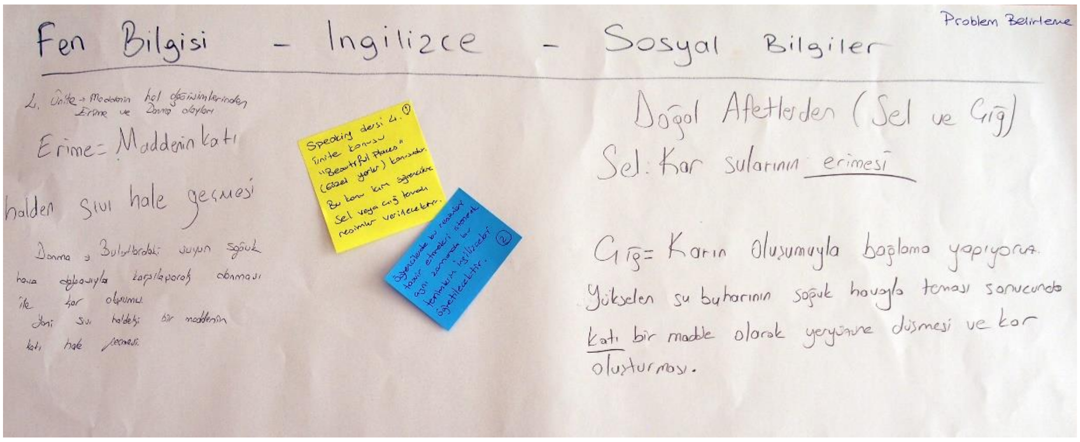
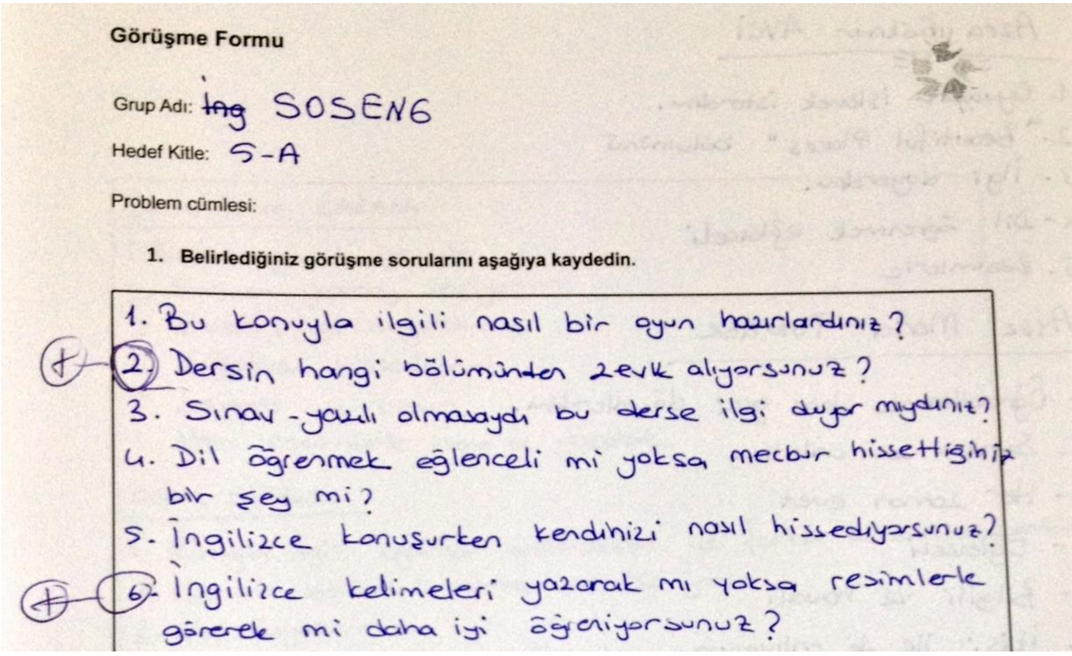


Figure 6.4. A poster from the "Problem definition" session (Original size: 50×70 cm)

In the "understand" stage of the STEM activity design process, they were asked to define the target group and this part included one method: brainstorming. In the workshop, the two groups tried to define their target groups; in other words, the students for whom they designed their STEM activity. I suggested them looking for their extreme users (extreme students) who are disinterested or distracted quickly in the lessons. For this reason, at first, they tried to define the target group separately according to their lessons, and everybody made their own students' lists considering their success or social relationships (Figure 6.5). However, when they got together, they could not generalize their findings and decide which of the lists they chose since there were variations in their comments about the same students. Although they could not define the target group on the first day of the workshop, they got more familiar with the students by collaboration, and they wanted to complete this stage after making interviews and observations about the students.

Figure 6.5. A poster from the "Understand" session (Original size: 50×70 cm)

In the "observe" stage of the STEM activity design process, they were expected to make interviews and observations and transfer the knowledge about the students to STEM activity. This part included three methods: brainstorming, interview, and observation. At this stage, they first prepared their interview questions by brainstorming and getting feedback from each other about their questions. Although I requested them to do interviews with students, the visual arts teacher wanted to give the prepared questions to the class in a written format due to their heavy workload. Before the interviews, they also learned the interview tips and used the interview template to write down their questions (Figure 6.6). Besides, they were given the observation template to be used for compiling students' observation data. They were also required to collect and summarize the students' data between the two workshop days.


Görüşme Formu

Grup Adı: ~~Ing~~ SOSENG

Hedef Kitle: 5-A

Problem cümlesi:

1. **Belirlediğiniz görüşme sorularını aşağıya kaydedin.**

1. Bu konuyla ilgili nasıl bir oyun hazırlardınız?
+ 2. Dersin hangi bölümünden zevk alıyorsunuz?
3. Sınav - yazılı olmasaydı bu derse ilgi duyar mıydınız?
4. Dil öğrenmek eğlenceli mi yoksa mecbur hissettiğiniz bir şey mi?
5. İngilizce konuşurken kendinizi nasıl hissediyorsunuz?
+ 6. İngilizce kelimeleri yazarak mı yoksa resimlerle görerek mi daha iyi öğreniyorsunuz?

Figure 6.6. A response sheet from the "Observe" session

The first day of the workshop has ended at 15.45 after giving information about the "POV" stage of the STEM activity design process. Everybody found the workshop productive, and they understood better what to do. Moreover, after observing the English speaking teacher struggle for supporting both groups, the two teacher groups were decided to be united to create a more interdisciplinary study environment and to get better performance from teachers.

Figure 6.7. A view from the workshop

On the second day of the workshop, teachers conducted the “problem definition” stage of the STEM activity design process again owing to uniting the two teachers’ group (Figure 6.7). Furthermore, they could able to define the target group after making interviews and observations with students. However, in this part, every teacher decided the target group separately considering their lessons instead of defining one common target group. As a result, making the “problem definition” and “understand” stages of the STEM activity design process twice made longer the workshop duration (Figure 6.8).

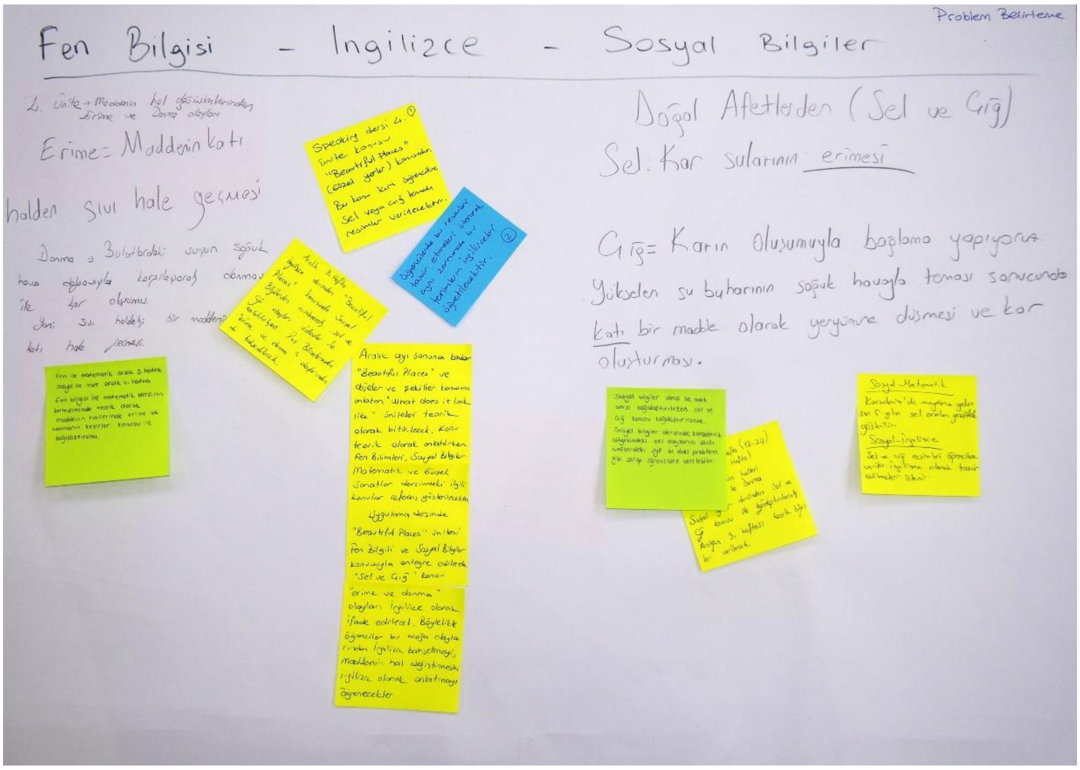


Figure 6.8. A poster from the "Problem definition" session (Original size: 50×70 cm)

At the "POV" stage of the STEM activity design process, teachers were expected to identify the needs and conduct an analysis after collecting the data from the "understand" and "observe" stages and to develop a point of view for identifying a problem statement. This part included two methods: brainstorming, and an empathy map. At this stage, teachers first grouped the data and placed them in a four-quadrant layout of paper (Say, Do, Think, and Feel) (Figure 6.9). Later, they created an empathy map to find out the needs and conduct analysis, respectively. Lastly, they wrote their problem statement focused on the needs and insights. In the previous "observe" stage, teachers were required to make interviews and observations about the students and to bring this information to the workshop for the "POV" stage. Therefore, teachers had a meditative role while transferring the students' data into needs and insights for the STEM activity design. For the "observe" stage, all teachers preferred to give the interview questions in a written format instead of asking them orally. On the workshop day, it was discovered that some teachers could not gather the students’ information entirely owing to not getting answers from all students. Some of them had the answers; however, they did not write the information into the interview and observation templates. Thus, the “POV” stage was longer than expected.

Figure 6.9. A poster from the “POV” session for grouping the information (Original size: 70×100 cm)

Teachers had difficulty in synthesizing the information for identifying the needs and conducting an analysis due to the lack of information about students and experience about the DT approach. Additionally, in the analysis section, the participants were expected to create personas considering their findings of the students. However, they did this part by creating four types of student groups based on the level of students’ success, and they could not unite their findings under one persona. At the end of this stage, teachers wrote two problem statements. One of them was about the compatibility problems of some students and the disruption of the class order. The other problem statement was about how disciplines were connected in the STEM activity and the interdisciplinary lessons (Figure 6.10).

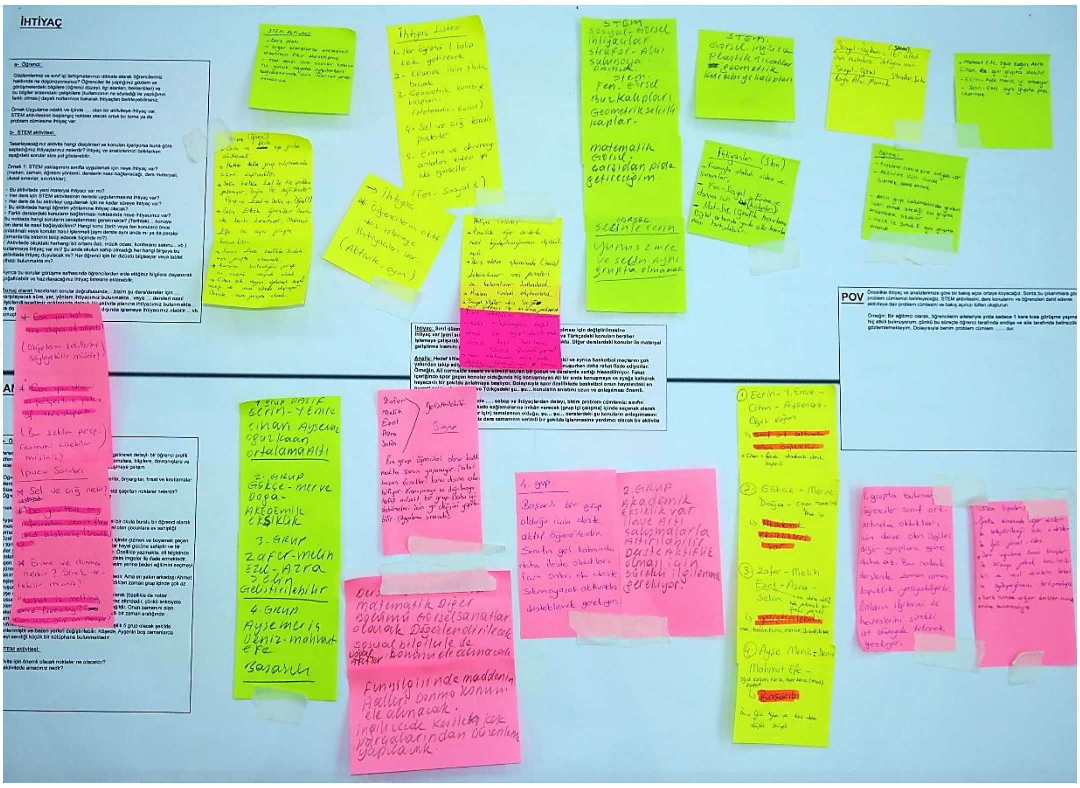


Figure 6.10. An empathy map (Original size: 70×100 cm)

In the “ideate” stage of the STEM activity design process, the participants were asked to find ideas for STEM activity design. Moreover, they were expected to complete the context of the interdisciplinary lessons. This part included three methods; brainstorming, mind map and itemised Response and PMI (Plus, Minus, Interesting) method for the evaluation of the ideas (See Table 5.3). In the workshop, the preparation for brainstorming and the Mind Map method was explained, and detailed information about creating a problem statement for STEM activity was presented. Later, they learned tips for brainstorming, and the brainstorming session was executed. This stage ended with the evaluation of the ideas. One of the critical limitations of this study was related to the dates of the school exams (in December and January) and also the MİS exam (the national exam) (in December) since on these dates, we had to make interdisciplinary lessons and the STEM activity. Furthermore, teachers had a busy schedule because of following the Ministry of National Education curriculum. Particularly in the math lesson, there was a problem of being behind the curriculum. Considering these issues, the content, dates, and the order of the lessons were first revised for the interdisciplinary lessons.

Teachers later created the general content of the STEM activity. In the designed STEM activity, they first created the main theme (having lunch at the cafeteria), and around this theme, they created three questions. Two of them included three disciplines, and one of them included four disciplines. Besides, upon my suggestion about integrating the HPI's DT approach in one of the STEM activity questions as a problem-solving process, teachers agreed on my idea. Instead of integrating all the six stages of the DT approach, we included the "understand", "ideate", "prototype", and "test" stages to make the problem-solving process easier for students. As a result, in the "ideate" stage, teachers decided the order and the exact dates of the lessons and the activity, created the general content of the STEM activity, and completed the missing points of the interdisciplinary lessons (Figure 6.11). However, some parts that had to be considered for both interdisciplinary lessons and STEM activity remained incomplete due to teachers' time constraints.

Figure 6.11. A poster from the brainstorming session (Original size: 70×100 cm)

In the "prototype" stage of the STEM activity design process, teachers were required to fill the STEM activity plan template. This part included six prototyping methods: journey map, Venn diagram, diagram and model making including mock-up and paper prototyping (See Table 5.3). At this stage, teachers got information about the prototyping, and the "STEM Activity Plan" sheet was given to the teachers. The necessary information was presented related to it, and then they were introduced the prototyping methods. Finally, they were given time to fill out the STEM activity plans about the STEM activity and the interdisciplinary lessons. While creating the STEM activity plan, teachers also used the journey map.

The "test" stage of the STEM activity design process was the last stage of the DT approach, and this stage included the implementation of the interdisciplinary lessons and the STEM activity. In the workshop, time usage was not practical owing to making the "problem definition" and "understand" stages twice, and teachers could not obey the time set correctly. Consequently, they wanted to finish the workshop at 17.00. In the workshop, the visual arts and English speaking teachers' contributions were better, and the social science teacher was less active than the others. Having only one group also made my facilitation easier. Besides, teachers considered the DT approach useful for learning STEM education.

The findings of the two-day co-design workshop with teachers. A two-day co-design workshop was realized with teachers to design STEM activity with teachers by using a DT approach. The observation notes taken during the workshop were analyzed from two points; the researcher's role in the workshop and the teachers' experiences about the design thinking approach.

According to my findings, two characteristics of the DT approach were observed in the STEM activity design workshop, which are the human-centeredness and interdisciplinary collaboration. For instance, with the wallet design exercise, teachers discovered the significance of the target group and getting familiar with them because of the human-centered nature of the DT approach. According to this, empathy was observed as an essential characteristic from the point of getting familiar with a person. Besides, because of teachers' involvement as a stakeholder, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher- designer in the STEM activity design. The co-design process among teachers and the researcher enabled teachers to learn STEM education since the researcher guided and educated teachers in the activity design. As stated before, teachers had difficulty in defining the target group since every teacher evaluated the students considering their situation in their lessons. Therefore, the perceptions about the students varied in different lessons. Except for the visual arts teacher, the other teachers were new to the class. However, an interdisciplinary collaboration among teachers enabled them to get familiar with the students. Their perceptions of the students have also been changed.

Moreover, in the workshop, instead of developing many ideas, the result-oriented ideas came up with a joint decision. While difficulty in developing ideas could be caused by having a result-oriented perspective owing to focusing on the solution not to the process, having less knowledge about the STEM and DT approach could affect the idea development negatively. It could also be originated from the less interdisciplinary collaboration experiences, which caused teachers to have inadequate knowledge about the other disciplines.

In the workshop, the researcher's role as a designer was also explored to discover her facilitator roles in the STEM activity design. The findings suggested that as a researcher, I had different facilitator roles before and during the workshop. Before the workshop, I prepared the STEM activity design process based on the pre-workshop interviews, such as developing a list of the left subjects of each lesson and some example themes related to these subjects. I also formed the teachers' group considering the findings of the pre-workshop interviews. Moreover, I decided to implement interdisciplinary lessons and STEM activities. In the workshop, I guided teachers in the activity design due to their inexperience about the STEM and DT approach. For instance, in the "problem definition" stage, I facilitated the teachers' brainstorming sessions to assist in deciding their subjects. As a researcher, I also had a co-creator role in helping teachers in the STEM activity design. Furthermore, mediation was executed by teachers in the STEM activity design when transferring the students' data into STEM activity design. It can be concluded that teachers acted as a mediator between the students and the researcher, a collaborator in teachers' collaboration and a co-creator in the STEM activity design. Besides, teachers represented students in the STEM activity design.

Although we had some challenges originating from the education system, by establishing a collaborative and participative co-design workshop experience with necessary supplies and using the DT approach as a tool, I tried to guide teachers in many points to make the STEM and DT approach tangible for them. Moreover, in this workshop, the DT approach was used as a tool in the two places; the developed DT approach was executed to facilitate the STEM activity design, and HPI's DT approach was integrated into the STEM activity to facilitate the problem-solving process. At the end of the workshop, teachers considered the co-design workshop efficient, and they stated their satisfaction with understanding the STEM and DT approach. They also referred to the researcher as the creator of their whole design experience. Besides, because of some challenges confronted in the application of the DT approach, some changes about the DT approach were considered, which was discussed comprehensively at the end of the Main Study I.

6.5.4 Part 4: Post-workshop focus group with teachers

After the workshop, a focus group interview was conducted with teachers to evaluate the workshop. I prepared my questions under four main groups (Appendix E): the evaluation of the workshop, the role of the DT approach in the STEM activity design, the contribution of the researcher in the workshop, and lastly, teachers' suggestions about the workshop and the DT approach. There were three purposes of the focus group interview. The first one was to learn teachers' opinions about the workshop process. The second one was to find out the efficiency of the DT approach applied in the STEM activity design. The third one was to get teachers' evaluations about the role of the researcher-designer in the workshop. The interviews were all conducted in Turkish and voice and video-recorded. The duration of the conversation was 25 minutes owing to the long period of the workshop. Consequently, additional questions related to the workshop were asked to the teachers later in the individual interviews.

The findings of the post-workshop focus group with teachers. The findings of the focus group interview provided us information about the researcher roles, the workshop process, and the teachers' perceptions about the STEM and the DT approach. In this respect, this interview was investigated under five categories: The perceived characteristics of the DT approach by teachers, the perceived characteristics of the DT approach from the point of education, the role of the researcher-designer in the co-design process, and the perceived qualities of STEM education by teachers.

Perceived characteristics of the DT approach by teachers. Teachers' perceptions about the DT approach in the STEM activity design process was explored.

Empowering teachers about getting familiar with the students through the DT approach in the STEM activity design process. Teachers discovered the significance of the target group and getting familiar with them because of the human-centered nature of the DT approach. In this respect, the human-centeredness was found as a key term from the point of getting familiar with a person and students. While the wallet design exercise worked for getting familiar with teachers' partners and discovering the importance of the target group, it also made them realize the importance of getting familiar with the students in the activity design.

> **Science teacher**: I am in favor of defining the target group.
> **Researcher:** I thought it worked very well when making the grouping.
> **Science teacher**: Yes, we tried to understand our partner while designing a wallet. After that, we tried to make something for his/her demands. If we want to get a good result here at the end of this study, we should get to know the children. We should get to know them with their general aspects so we can get efficiency as a result of our study and make a %100 design.[20] (Science teacher)

Structuring the STEM activity design as a process through the DT approach. In this workshop, one of my purposes was to find out the efficiency of the DT approach applied in the STEM activity design. According to teachers, DT approach structured the STEM activity design as a process by dividing it into meaningful steps and approached the activity design problem with a holistic manner. When executing the DT approach in the wallet design exercise and STEM activity design, they understood the importance of the process (holistic thinking) to reach different solutions when discovering their result-oriented perspectives as one of their challenges in the problem-solving process.

> **Science teacher**: I want to add something. Design thinking. For instance, you showed a photo in the example you gave. We focus on the right solution.
> **Researcher:** Well, we've progressed step by step.
> **Science teacher**: Exactly.
> **Researcher:** For example, what do you think about it? You know, we started by doing need analysis.
> **Science teacher**: Exactly. We can look at different perspectives. In general, what we are doing is to focus on the result, if we think in our lives.
> **Math teacher**: We're always looking at a point.[21] (Science and math teachers)

Besides, the findings indicated that applying the DT approach made the STEM activity design process easier and understandable. All teachers gave credits to the DT approach in terms of assisting them in understanding the STEM education in the workshop. The other important point that teachers mentioned was that the DT approach enabled them to define the problem statement in the STEM activity design process. Therefore, the math and the science teachers considered using the DT approach in the second time for the STEM activity design.

> **Researcher:** So, do you think the design thinking method has helped you to teach the STEM and helped you to complete this workshop?
> **Science teacher**: Yes.
> **Math teacher**: Yes, yes.
> **Everybody:** Yes, yes.
> **Math teacher**: In other words, if the wallet had not been designed in the first place, I think we might not be able to progress so fast.
> **Science teacher**: Exactly, eventually.[22] (All teachers)

> **Science teacher**: What did we do here? Here, when designing something, designing a wallet, we saw that there were steps, that there was a row of steps, and when we went accordingly, we could create the desired product for the other one. This method was beneficial. Design thinking gave me that. So when you think about something, also think about its steps.
> **Researcher:** Systematically.
> **Science teacher**: Yes. We got the idea that we should think.[23] (Science teacher)

> **Researcher:** Okay, you saw this first; would you proceed in the second time like this again? Or would it be different? In terms of designing activities, how would you progress?
> **Math teacher**: We would follow step by step. (Everyone nodded)
> **Science teacher**: Because it shows the way and provides us convenience.
> **Math teacher**: This approach has brought us closer to the problem sentence. If we did not follow this approach, maybe we could not have made a more accurate problem statement.[24] (Math and science teachers)

It can be concluded that in teachers' first attempt, the DT approach assisted teachers from five disciplines to design the STEM activity. The wallet design exercise also facilitated teachers' understanding of the DT approach, and consequently, this made the workshop time shorter about creating the STEM activity. The science teacher further highlighted the time-saving side of the DT approach based on its systematic work structure. According to her, this can be a solution to overcome teachers' time constraints: "But as my teachers say, when it becomes a memorizing system, and when the time is limited, unfortunately, we cannot do this. In this sense, we learned that there is something systematic. It was perfect for us."[25] (Science teacher)

Moreover, the social science teacher found the practice order of the DT approach appropriate by giving an example from the wallet design exercise. She stated how following the DT approach made her design a wallet, although she considered the reverse.

> **Researcher:** How do you think about the progress of the presented method? Were there any redundancies or deficiencies?
> **Social science teacher**: At first, before we started the workshop, you said that we are going to design a wallet. I said I would draw "Cin Ali (stickman)" even more difficult.
> **Researcher:** But you did an excellent job.
> **Social science teacher**: Then I was surprised when I saw the wallet I designed.
> **Researcher:** Because you took the data directly and acted considering the data.
> **Social science teacher**: Yes. This is also the same. Our workshop is run step by step.
> **Researcher:** And do you think it was right to run it step by step?
> **Everybody:** Yes, yes.[26] (Social science teacher)

Furthermore, using the DT approach made the science teacher feel like a designer owing to gaining courage about making design: "In other words, we have seen here in practice that the design is not done only by the designers."[27] (Science teacher)

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating the STEM activity design process. In this workshop, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher. Since the collaboration means designing with people rather than designing for people, in this study, it supported the interdisciplinary lesson and the STEM activity preparation. It also provided teachers' personal growth in terms of learning STEM education and increasing awareness about collaborative lesson preparation and teaching practices. The co-design process among teachers and the designer also enabled teachers to learn STEM education.

This workshop allowed the teachers about experiencing the interdisciplinary collaboration in the STEM activity design process since, except for the visual arts teacher, the others had no previous experiences. For instance, the visual arts teacher gave credits to interdisciplinary collaboration along with the teamwork in the STEM activity design and found team teaching significant in teaching with the sentences:

> I understand that teamwork is essential. So I know that interdisciplinary teamwork is important. I even realized that as many teachers and as many disciplines as possible are required to participate in the lessons. It used to be strict rules such as only one teacher would enter the class, not two teachers. But with this program, the possibility of this has increased.[28] (Visual arts teacher)

Designing interdisciplinary lessons with team teaching caused a perspective change in teachers' professional practice in terms of understanding the significance of making collaboration with the other teachers for lesson preparation. They became familiar with the idea of interdisciplinary collaboration in STEM education and started thinking of making changes in their teaching practice in the future.

> **Researcher:** After the workshop, do you think you'll do something differently? It may be from the perspective of your profession or other angles.
> **Visual arts teacher:** Yes.
> **Science teacher**: So, of course, we had a different perspective. About teaching methods of the courses, in other words. We have learned the interdisciplinary, more or less.
> **Math teacher**: We gain some things. So we've put something verbal into practice.
> **Social science teacher:** Even though we are not so coordinated with each other, I think we can add some secondary school subjects as a result that we already know some of them.
> **English speaking teacher**: Or at least we can go and ask each other for help. (**Science teacher**: Exactly) I have this issue, but as far as I remember, you have that subject or how we can integrate them here. No matter how small an activity (Everyone gave their approval for this idea).[29] (All teachers)

Perceived characteristics of the DT approach from the point of education. The visual arts teacher associated the DT approach with thinking, planning, and idea generation, which was defined as the basis of the education by him. He also considered learning design valuable for teachers.

> **Visual arts teacher:** Before applying the material directly, by doing sketches, drawings, rough copies as brainstorming. It is already the primary thing of education. It is necessary but wishes we can do it. In some situations, we do, but in some cases, due the short of time, we are doing it in a concise and fast way. At that short time, I teach this quickly, so there, the subtleties of teaching begin.
> **Math teacher**: Exactly.
> **Visual arts teacher:** Yes, it is the time. It is all about the time you have.[30] (Visual arts and math teachers)

> **Researcher:** Well, you learned design thinking. You even followed its steps one by one when designing the activities. What are your thoughts on this?
> **Visual arts teacher:** Well, Designing as an educator […], I think every educator needs design in every way. So this is basic once. As a thought, as a drawing, as a 3-dimension, as a 2-dimension, in all of them, almost all the teacher friends think about this. You, as a designer, have brought me extra value. In my name, it brought me additional value.[31] (Visual arts teacher)

With these sentences, while the visual arts teacher highlighted the course time as a challenge of implementing the DT in the education system, the math teacher also referenced another challenge caused by following the national curriculum: "Our biggest problem is trying to implement a curriculum like a clerk. Without a curriculum, it can be thought of as more design thinking."[32] (Math teacher)

Additionally, the English speaking teacher connected the DT with creativity and she considered the education system based on memorization as a challenge: "I think it's also because of the system a bit. A mention of the concept 'design' brings to mind creativity. Because of this speed in the education system, it can be a memorizing system, but I wish we could study design."[33] (English speaking teacher)

Perceived role of the researcher by teachers in the co-design process. In the focus group interview, the role of the researcher-designer was explored to test the productivity of the researcher during the STEM activity design. Teachers first stated that they had a pre-workshop doubt about the study owing to the management of an educational study by a researcher who has a design background. However, they changed their minds after the workshop. Besides, they emphasized their needs to a designer owing to providing the necessary materials and made them gain a new viewpoint.

> **Math teacher**: I had it. I mean, it's not personal. For me, as an educator, I always considered; education is not given by educators. In particular, our education systems are ever-changing. From the beginning, I was on the side of an educator. So I had a question in my head about "How a designer could implement the educational model". Is it supposed to be like this or without an education? I thought I did it without knowing them.
> **Science teacher**: By skipping the design, you also will give it to the people and ask them to design it. This is a difficult situation.

> **Math teacher**: Because the person in front of you is not a designer. Yes, you are the designer, you are not an educator, but we are not designers, we are educators. It was also difficult for you.[34] (Math and science teachers)

> **Researcher:** So what do you think about working with the designer?
> **Science teacher**: But because you have provided us all the necessary resources.
> **Math teacher**: I mean, because you have provided us all the necessary resources, it was very productive and compatible.
> **English Speaking teacher**: Yes, everything was ready. And you taught us something new. You gave us a point of view.
> **Science teacher**: Exactly.
> **English Speaking teacher**: I do not think you need to be a teacher or an administrator for this.
> **Math teacher**: Yes, yes, you do not.[35] (Science, math and English speaking teachers)

Both the speaking and the science teachers requested to work with a designer for the second time because of their inexperience. They further stated seeing the designer as an educator owing to providing comprehensive answers to their questions and considered not expecting these contributions from an educator.

> **Visual arts teacher:** It brought extra value. I never felt anything. I mean, like, being a graduate of the Faculty of Education.
> **Math teacher**: Yes, yes.
> **Visual arts teacher:** I see it as an ordinary teacher. I still see it as like that.
> **Math teacher**: I mean, we received all the answers to our question very comprehensively.
> **Visual arts teacher:** We received the answers very quickly.
> **Math teacher**: Maybe if we had an educator in front of us, we could not have it.
> **Visual arts teacher:** We could not have that much. Yes, yes.
> **Math Teacher**: We could not have that much. I mean, not to compare. I wanted to talk about the system. Perhaps, if there were an educator, it would not be so clear.[36] (Visual arts and math teachers)

As a result, for teachers, I, as a researcher, acted as a facilitator who made the STEM and DT approach more understandable for teachers by creating a design experience with all the necessary supplies. The researcher was further described as an educator because of providing a new viewpoint to the teachers.

Perceived qualities of STEM education by teachers. One of the researcher roles was an educator owing to teaching the STEM and DT approach. Consequently, the change or improvement in the perception of STEM education became essential to test the researcher role. As stated before, to integrate STEM education into the school, the interdisciplinary lessons, along with the STEM activity, were designed, and teachers further met with team teaching as one of the teaching methods. Thus, in the evaluation of STEM education, all of them were taken into consideration together.

In the focus group interviews, teachers stated their expectations about the effect of STEM education on students. For instance, the science, English speaking, and the social science teachers considered interdisciplinary lessons with team teaching different compared to their previous teaching experiences owing to including more disciplines in a single lesson. From these lessons, the English speaking teacher expected an increase in teachers' and students' awareness about the interdisciplinary relationship of the subjects.

> **Researcher:** Were they different from what we have done so far? Both the workshop itself and this way you will try to give the course.
> **Science teacher**: Of course it's very different. I mean, I was telling the kids about the state change of matter last year. But, surely, you give examples of life.
> **Social science teacher:** Also applying is…
> **Science teacher**: For example, our teacher was available, and he entered our class. Try to reinforce this issue by illustrating together and so on. These are different things.
> **Social science teacher:** So detailed.
> **Science teacher**: No, I did not make it so detailed, I did not.
> **English Speaking teacher**: For example, in English lessons, there are different subjects in books. Not at all, but at least, it is clear that the subject is related to mathematics or science. It's just superficial. In other words, while the subject was to be taught in English, we were casually teaching the subject. But now we will be a little more aware of what we are doing like students.[37] (Science, social science and English speaking teachers)

Moreover, the science teacher gave credits to the inquiry-based character of the STEM education with the sentence: "What we do, for example, will lead children to think, develop ideas, and produce things."[38] (Science teacher)

With these sentences, she also referred to the productive side of STEM education, which has a hands-on activity similar to the DT approach. She also thought that STEM could increase students' interest in the lessons owing to the interdisciplinary side of the activities:

> But sir, actually, as I told at the beginning, the child has some courses that he loves, and there are some courses that he does not like. We can give him even the lesson he does not like this way. Or there's something he understands and something he does

> not understand. I think we can help him understand a subject he does not understand by using a lesson he likes. In this sense, I think it will be okay.[39] (Science teacher)

Additionally, the math teacher pointed out the practice aspect of STEM education and how this can cause an expectation about better comprehension of the course content because of enabling learning by living: "As abstract, we apply it to other courses, of course, teach interactively. Mathematics is applied to each course. We also apply math problems to everyday life, but only remains at the question. But in this way, with learning by living, it is strengthened."[40] (Math teacher)

Besides, while the English speaking teacher referred to the importance of discipline harmony in the design of the interdisciplinary STEM activity, the English speaking and visual arts teachers also discovered the need to know other disciplines: **"**We took the interdisciplinary harmony into consideration."[41] (English speaking teacher)

"We understand that we need to know the subjects well. To know at least the subjects about the other disciplines. I think we need to know something. (**Visual arts teacher:** Yes.) I mean, at least to make an introduction to the subject."[42] (English speaking teacher)

As a result, teachers had expectations from the STEM education, such as increasing students' interest in the courses, raising students' awareness about the interdisciplinary connections, and a better comprehension of the course content. Furthermore, they correlated the STEM education with interdisciplinary collaboration, hands-on activity including prototyping, learning by living, and inquiry-based learning.

6.5.5 Discussion of Phase 1

In Phase 1, it was intended to collaboratively design STEM activities with teachers by using a design thinking approach. Phase 1 included four parts: STEM & DT presentation to teachers before the workshop, pre-workshop interviews with teachers, a two-day STEM activity design workshop with teachers, and lastly, a post-workshop focus group with teachers. The findings of Phase 1 provided us information about the perceived role of the researcher in the co-design process and the perceived characteristics of the DT approach by teachers.

Perceived role of the researcher in the co-design process considering teachers' feedback and observation notes. In this phase, the researcher-designer has three facilitator roles: a guide, educator, and co-designer. Teachers also performed co-designer, mediator, and collaborator roles during the STEM activity design. According to this, the facilitator roles of the researcher and using the DT approach as a tool had three impacts on the study:

- Facilitating teachers' perspectives by changing their mindsets and creating awareness about collaborative lesson preparation and teaching practices to teach the STEM and DT approach and to integrate STEM education into the institution.
- Facilitating the workshop process by establishing a participative workshop environment.
- Facilitating the STEM activity design process between the teachers.

Perceived characteristics of the DT approach by teachers. In this phase, the DT approach was executed for two different purposes; the developed DT approach was applied as a tool in the development of the STEM activity design, and HPI's DT approach was integrated into the STEM activity to facilitate the problem-solving process of the students. In light of the findings, teachers considered the DT approach useful in the STEM activity design process, and the three characteristics of the DT approach were discovered in this respect: human-centeredness, interdisciplinary collaboration, and problem-solving.

In this workshop, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher in the STEM activity design process. The co-design process empowered teachers as stakeholders in the STEM activity design process by making them co-designers. Choosing the DT approach as a tool for enabling the collaboration between the teachers created a significant impact on the STEM activity design process. It facilitated the teachers' perspectives on the designerly way of thinking. While the co-design process focused on students as a target group and the creation of the STEM activity, teachers' collaboration focused on including teachers from different disciplines to create interdisciplinary participation in the STEM activity design. It was expected to inspire teachers to generate positive attitudes towards new educational possibilities in terms of applying STEM education. The researcher also hoped to cultivate an interdisciplinary collaborative culture between the teachers due to being one of the critical requirements for the implementation of STEM education.

Conducting the wallet design exercise through DT approach enabled teachers to discover the significance of developing empathy. This finding was important for teachers who were new at school and never collaborated before.

Moreover, the DT approach facilitated the STEM activity design process by empowering teachers with interdisciplinary collaboration and teamwork in the co-design process to enable familiarity with students. The human-centered nature of the DT approach also allowed teachers about getting familiar with the students by using empathy as a tool in the STEM activity design process. Therefore, both developing empathy and teachers' collaboration assisted teachers in getting familiar with the students in the STEM activity design.

The DT approach solved the complexity of the STEM activity owing to structuring the STEM activity design as a process by dividing it into meaningful steps. This situation also made the STEM activity design process easier and understandable and made the time spent on the activity design process shorter. This was an important finding for teachers who had a busy teaching schedule. Conducting the wallet design exercise through DT approach further contributed to teachers about discovering holistic thinking mindset in the problem-solving process to reach multiple ideas in developing solutions. While this mindset created awareness in teachers' ways of approaching problems, it could also contribute to teachers' integration of disciplines in the STEM activity design. Furthermore, with this exercise, teachers gained courage about making design.

6.6 Phase 2: Teachers’ conducting interdisciplinary lessons

Phase 2 included three parts: finalizing STEM activity design and preparations for interdisciplinary lessons, interdisciplinary lessons conducted by teachers through individual teaching, and interdisciplinary lessons conducted by teachers through team teaching (Table 6.3). There were three purposes in this phase. The first one was to make teachers gain interdisciplinary lesson experience conducted through individual and team teaching. The second one was to make students aware of the interdisciplinary connections of the subjects before the implementation of the STEM activity. The last one was to discover the appropriate strategy regarding the implementation of the interdisciplinary lessons to integrate STEM education into the school. In these lessons (Table 6.7), the general aim was to show the interdisciplinary relationship of the subjects from diverse disciplines but not to teach these subjects during these lessons since all subjects were taught individually before conducting these lessons.

Table 6.7. *The interdisciplinary lessons conducted through individual and team teaching*

Interdisciplinary lessons conducted by teachers through individual teaching	
Math-English speaking lesson (30th November)	
Aim of the lesson	To present the connection between the “fractions” and “objects and shapes” subjects within the framework of the math and English disciplines
Place	Math lesson
Participants	Math teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Visual arts-Math lesson (4th December)	
Aim of the lesson	To present the connection between the “fractions” and “perspective” subjects within the framework of math and visual arts disciplines
Place	Visual arts lesson
Participants	Visual arts teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
English speaking-Math lesson (5th December, continued lesson of 30th November)	
Aim of the lesson	To present the connections between the “object and shapes” and “fractions” subjects within the framework of math and English disciplines
Place	English speaking lesson
Participants	English speaking teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Interdisciplinary lessons conducted by teachers through team teaching	
Visual arts-Math lesson (11th December, continued lesson of 4th December)	
Aim of the lesson	To present the connections between the subjects of “fractions” and “perspective” within the framework of the math and visual arts disciplines
Place	Visual arts lesson
Participants	Visual arts and math teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
English speaking-Math-Visual arts lesson (12th December, two lessons in a sequence)	
Aim of the lesson	To present the connections between the “shapes”, the “fractions” and the “composition” subjects within the framework of math, English, and visual arts disciplines
Part 1	
Place	English speaking lesson
Type of teaching	Team teaching
Participants	English speaking and math teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Part 2	
Place	Visual arts lesson
Type of teaching	Individual teaching
Participants	Visual arts teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
English speaking-Social Science-Science lesson (26th December)	
Aim of the lesson	To present the connections between the “natural disasters” and “melting and freezing” subjects within the framework of English, social science and science disciplines
Place	English speaking lesson
Participants	English speaking, science and social science teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Art-Social Science-Science Lesson (8th January)	
Aim of the lesson	To present the connections between the “earth shapes”, “natural disasters” and “melting and freezing” subjects within the framework of visual arts, social science, and science disciplines
Place	Visual arts lesson
Participants	Visual arts, science and social science teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)

6.6.1 Part 1: Finalizing STEM activity design and preparations for interdisciplinary lessons

In the workshop, the general outline of seven interdisciplinary lessons and one STEM activity was created. Consequently, we met four times to complete the details; 30th November, 7th December, 21st December 2017, and 4th January 2018. Regarding the preparation for the STEM activity and interdisciplinary lessons, the meeting notes were taken to describe these meetings. We further communicated through mobile instant messaging (SMS and WhatsApp) to work on STEM activity and interdisciplinary lessons. As a result, the co-design process between the researcher and teachers and teachers' collaboration continued about preparation for the interdisciplinary lessons and the STEM activity after the workshop.

I examined all the STEM activity plans about the interdisciplinary lessons and STEM activity after the workshop; I took my notes and wrote them on the sticky notes to discuss with teachers the necessary issues in these meetings. For instance, for the STEM activity, I asked them to revise the students' groups, prepare the activity questions, and their assessments. I asked from them their availability for the team-teaching process and to define assessments of the lessons. During these meetings, while I guided teachers about preparing the questions owing to their inexperience about preparing the interdisciplinary questions, teachers developed them by themselves. For instance, the math teacher asked my advice about preparing a question, and I suggested her using the activity theme for creating the question. Moreover, math and English speaking teachers wanted to cancel one of the questions due to making only one lesson about the question's subject. However, the science teacher and I had conflicts about preparing a question. For example, upon my request from the science teacher to develop an additional question, including both the science and social science disciplines for the STEM activity, she refused to prepare it. Since by taking advice from another science teacher, she considered that one of the questions could be accepted as I wanted.

Some of the contexts and implementation days of the interdisciplinary lessons have been changed. For instance, while the lesson on the 12th December included only the English speaking and the visual arts teachers, I requested from the math teacher to join this lesson to support the lesson. The 8th January lesson was previously planned to be made on the 25th of December, but the date was changed owing to the MİS and school exams. Furthermore, teachers altered the context of the 8th January lesson, and instead of making two following lessons, they joined all three disciplines into one lesson. They also canceled the 28th December lesson, including social science, math, and English speaking disciplines, and instead, they prepared common evaluation questions for students. Additionally, while following a national curriculum was a big challenge for teachers, they had to give extra training to students, and this busyness prevented them from making collaboration. For instance, teachers were expected to prepare common evaluation questions to be delivered on the 4th of January for preparing the students for the STEM activity. However, the math and science teachers could not prepare for the questions because they could not come together due to the intensity of the course and the presence of the MİS exam.

6.6.2 Part 2: Interdisciplinary lessons conducted by teachers through individual teaching

In the Main Study I, teachers conducted three interdisciplinary lessons with individual teaching on the 30th of November, 4th of December and 5th of December 2017. For collecting data, the in-class observations were executed to explore the teacher’s interaction with students and the reaction of the students to the lesson. After the lessons, because of the lack of time at school, the five-minute group interview with students was generally realized to take their reflections about the implemented lessons. Furthermore, the individual interviews were conducted with teachers to evaluate the lessons. In these lessons, the general aim was to show the interdisciplinary relationship of the subjects but not to teach them during these lessons since all subjects were taught individually before conducting these lessons. To achieve my purpose, I prepared questions for teachers to evaluate the implemented interdisciplinary lessons (Appendix F). In this part, these lessons were examined respectively by giving reference to the collected data, which included the in-class observation, group interview with students, and teachers' interviews. All interviews were conducted in Turkish and voice-recorded; the duration of each interview was approximately 5 minutes owing to having to do at the end of the lessons.

Math-English speaking lesson (30th November 2017). On the 30th of November in the math lesson, it was intended to show the connection between the "fractions" and "objects and shapes" subjects within the framework of the math and English disciplines. The lesson was conducted in a one-lesson hour and involved the math teacher, along with one of the 5th-grade classes. I was in the class as a participant-observer. At the end of the lesson, an audio-recorded group interview with students was carried out about the lesson (Table 6.8). In this lesson, the interdisciplinary relationships of the subjects were presented to the students. The practice part was planned to be conducted separately on the 5th of December by the English speaking teacher owing to the math teachers' problem about being back in the curriculum.

Table 6.8. *Math-English speaking lesson*

Math-English speaking lesson (30th November 2017)	
Subject	Objects and shapes, and fractions
Place	Math lesson
Participants	Math teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation, the group interview with students (audio recorded by the researcher)

The math teacher started the lesson by drawing the shapes, such as triangle, square, on the board. Then, she asked their English names to the students and wrote these names to the board. Since she made no explanation to the students about why she used the English in the math lesson when students heard their teacher question, one of the girl students said. "What relevance". At this time, the teacher asked, "Did not you ask me to teach the lesson in English?", and then the students said "Ok" and did not show any more reactions. Later, she continued her lesson by asking questions, such as the English name of the shapes, the number of parts that the shapes were divided, and the interpretation of these parts by fractions. The students answered the questions correctly; one of them even said: "I wish we called the English teacher". Another girl student told her that "They had given a survey asking about which lessons you would like to study in English at school, I wish I wrote math". After the question & answer part, the math teacher finished the lesson.

The findings of the Math-English speaking lesson (30th November 2017). Students' opinions were explored for the evaluation of the lesson. Some of them considered this lesson as "very beautiful" and "entertaining", and some of them surprised about conducting this type of lesson. The connection between the math and English disciplines were intended to be presented to the students with this lesson. Although the math teacher stated her satisfaction from the students since presenting the lesson with English increased their attention to the lesson, students could not comprehend the disciplines' integration. However, their awareness about the relationship between the math and English disciplines was created. It was observed that the math teacher made less preparation for the lesson, and she did not make any explanation about the reason for making this lesson. This was due to not having time to review the interdisciplinary lessons, due to finishing the workshop on November 25, five days before the lesson. There was also no collaboration between the English speaking and math teachers for the lesson preparation, and an activity to consolidate the subjects' integration could not be realized due to the math teacher's curriculum problem. Thus, the subjects were presented as a part of a regular lesson.

Visual arts-Math lesson (4th December 2017). On the 4th of December in the visual arts lesson, it was intended to show the connections between the "fractions" and "perspective" subjects within the framework of math and visual arts disciplines. The visual arts teacher also mentioned the main colors and toning values to explain the fractions. He prepared the lesson by creating a worksheet that included the perspective drawing of a rectangle prism. The lesson was executed in a one-lesson hour and involved the visual arts teacher and one of the 5th-grade classes. I was in the class as a participant-observer. At the end of the lesson, an audio-recorded group interview with students was conducted about the lesson. After the lesson, an audio-recorded interview with the visual arts teacher was carried out for the evaluation of the lesson (Table 6.9).

Table 6.9. *Visual arts-Math lesson*

Visual arts-Math lesson (4th December 2017)	
Subject	Perspective and fractions
Place	Visual arts lesson
Participants	Visual arts teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation, the group interview with students (audio recorded by the researcher)
Post-lesson interview	Individual interview with the visual arts teacher (audio recorded on 4th of December)

The visual arts teacher started the lesson by giving information about the perspective, and then he mentioned the fractions by referring to the math lesson. After distributing the worksheet about the perspective to the students, he requested them to write the “right” and “left” sides of the prism on the paper. Later, he asked them to draw a line from top to bottom by using the points on the rectangular prism since he divided the left and right parts of the prism into three sections by using points. Then, he requested from students to paint one of the pieces with yellow and the other one with red on the right side of the prism. (Figure 6.12)

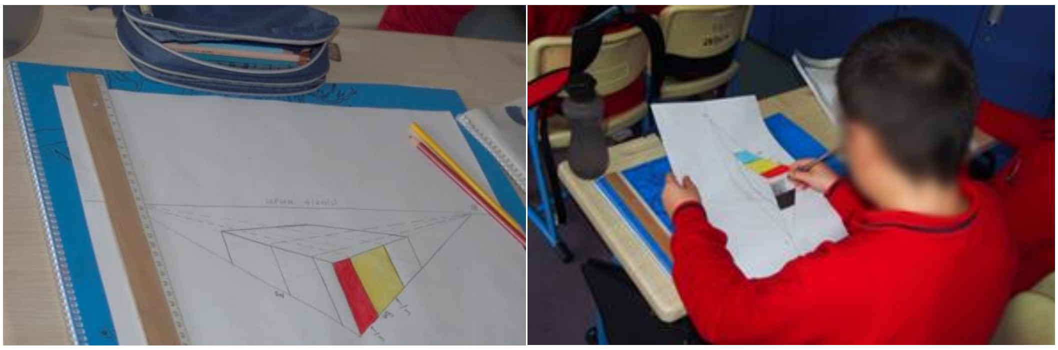


Figure 6.12. Views from the visual arts-math lesson on December 4

At that time, when they were painting the prism, one of the students complained: “Yaaa, we are learning math”. Some students repeated their reactions by saying, “My teacher, we are making math now.” The teacher ignored their responses and continued the lesson. Finally, he requested from students to paint with blue the remaining 1/3 part on the right side. In the end, students stated that they painted three primary colors on the worksheet. Later, the students continued with the left side of the prism by scanning the prism with a pencil to show different toning values. Some of the students made what was asked immediately, some of them could make it after getting an explanation, and the lesson ended after this practice.

The findings of the Visual arts-Math lesson (4th December 2017). During the lesson, some students showed their reactions about using math in the visual arts lesson, and some did not object because of their love of math. For instance, while Student G said, “My favorite lesson is math, that works for me”, Student B complained by saying, “Why math?” At that time, the visual arts teacher made an explanation, “I connected the math with art.” However, some of the students objected to this by saying “No”. In the discussion part, I asked students their evaluation of the lesson as follows:

> **Researcher:** My friends, you did math at the visual arts lesson today. What do you think?
> It was so dull.
> **Researcher:** Why was it so boring? Do not you like Math?
> Mam, because we had two math lessons in the morning.[43] (Students)

> **Student G:** Mam, I think it was perfect.
> **Researcher:** Why it was good. Isn’t there math in the visual art lesson?
> Yes (some students).
> No (some students).
> There are shapes, shapes.
> Mam, because the math teacher answered ten questions in one minute, all the class gets bored with math.[44] (Students)

It was discovered that students showed reactions to the lesson owing to overexposure to math on the same day; but, they did what was required from them in the lesson. In the individual interview, the visual arts teacher stated how he and the class showed outstanding performances.

With this lesson, the connection between the math and art disciplines was intended to be presented to the students. However, integrating math with the visual arts lesson caused a reaction by some of the students, and they could not make sense of the lesson since an explanation about the reason for making this lesson was not made to the students. They also considered that they were making only math by taking the visual arts lesson by ignoring the visual arts subjects that were covered (primary colors, toning) during the lesson.

> **Student G:** We were studying math at the Turkish lesson.
> **Researcher:** How were you studying?
> **Student G:** Ours was not making math in Turkish lesson in a real sense, you know how? The math teacher was canceling the Turkish lesson and put the math lesson instead. So he was changing the syllabus directly.[45] (Student G)

Moreover, it was apparent that having two math lessons on the same day made students bored with this lesson. Another reason why students reacted could also be related to their first meeting with the interdisciplinary lesson in the visual arts lesson. As previously stated, the visual arts lesson was found enjoyable by students, thus, making interdisciplinary lessons in the visual arts lesson could affect the students negatively. Although the visual arts teacher prepared the lesson by himself, it was observed that there was no collaboration between him and the math teacher before the lesson.

English speaking-Math lesson (5th December 2017). On the 5th of December, in the English speaking lesson, it was intended to show the connections between the "object and shapes" and "fractions" subjects within the framework of math and English disciplines (Table 6.10). This lesson was the practice part of the 30th November lesson. It was conducted in a one-lesson hour and involved the English speaking teacher along with one of the 5th-grade classes. I was in the class as a participant-observer. At the end of the lesson, an audio-recorded group interview with students was conducted about the lesson. After the lesson, an audio-recorded interview with the English speaking teacher was also carried out.

Table 6.10. *English speaking-Math lesson*

English speaking-Math lesson (5th December 2017, continued lesson of 30th November)	
Subject	Objects and shapes, and fractions
Place	English speaking lesson
Participants	English speaking teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation, the group interview with students (audio recorded by the researcher)
Post-lesson interview	Individual interview with English speaking teacher (audio recorded on 5th of December)

The English speaking teacher started the lesson by talking about the object and shapes and drew some of the shapes on the board. Then, she gave plastic knives to the students and asked them to make the shapes drawn on the board from the play-doh. Later, the teacher gave labels to students on which the names of the shapes were written. She requested them to stick the labels on the shapes that they made from the play-doh. She asked the English names of the shapes drawn on the board, and she wrote the right answers on the board. She further checked whether students matched the correct labels with the right shapes that they created and finally finished the activity by asking the students' opinions about the activity. Students said they liked the activity, and they showed no reaction similar to the previous one. In the second part, students played a game named "guess the object". The teacher first divided the students into two groups and requested them to find a group name. Then she stuck two papers for two separate groups on the board to be stamped by the students of each group when they gave the right answers. For the game, she brought glasses which were covered by fabric to prevent students from seeing anything. She took students to the board, respectively, and made them put the glasses on. She put objects into students' hands and asked them to guess the shapes of objects and their names. For instance, she gave a puzzle box and asked its shape and name to one of the female students. She first said a box for the shape and "game box" for the name of the object. Since she gave the right answer, she stuck a stamp to the paper on the board, which belonged to her group. The groups which took the more stamps won the game, and the lesson ended after this game. (Figure 6.13)

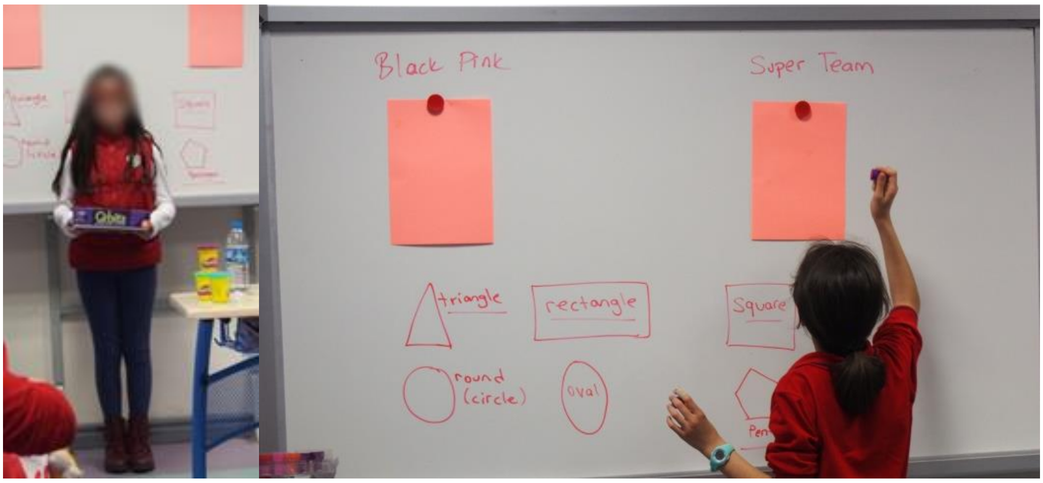


Figure 6.13. Views from the English speaking-math lesson on December 5

The findings of the English speaking-Math lesson (5th December 2017). At the end of this lesson, a group interview with students was conducted. Students stated positive comments about the activity, such as “very beautiful”, “very entertaining”, and “perfect”. In the individual interview, the English speaking teacher stated that she found the lesson as expected and planned. Thus, she was satisfied with the result. As previously stated on the 30th of November, the math teacher used fractions to teach objects and shapes without making activities. Although the math teacher had a problem owing to keeping up with the curriculum, the English speaking teacher stated that it would be better to make this lesson on the 30th of November after the math lesson. Furthermore, in this lesson, only the activity about the objects and shapes was conducted, it’s relevance with fractions was not presented. Besides, the English speaking teacher was not aware of this missing part. Additionally, the second missing part in this lesson was about making an explanation to the students about the reason for making this lesson. Although students did not show any reaction to the lesson, they probably could think that it was a regular English lesson. However, they were also making an activity that involved both the math and English disciplines. There was no collaboration between the teachers regarding the activity since the English speaking teacher prepared the lesson by herself. Consequently, instead of making separate lessons, it would be better to make both the activity and the lecture parts together if possible, with team teaching to make students connect the subjects of the two disciplines. Since team teaching needs collaboration before and during the lesson, this way of teaching can prevent making incomplete lessons.

The findings of the interdisciplinary lessons conducted by teachers through individual teaching. Three interdisciplinary lessons with individual teaching were realized in the Main Study I, and these lessons were conducted in the math, visual arts and English speaking lessons. In all of the lessons, no explanation was made to the students about the purpose of these lessons. The explanations were made after students' questions or comments during the lessons. In the 5th December lesson, there were also some missing parts in the lesson. While there was no activity in the 30th November lesson, its practice part was carried out separately in the 5th December lesson. This planning caused inefficiency and the lack of connection between the two lessons. Additionally, except for the math teacher, the other two teachers prepared the lessons by themselves; however, it was observed that teachers made no collaboration between themselves before the lessons. In these lessons, we also had some issues regarding the students. For instance, students could not be able to comprehend the connections of the subjects easily because of the appearance of the lesson as a regular one and conducting the activity and the lecture parts separately. Mainly, doing math with the visual arts lesson caused students' reactions owing to having multiple math lessons on the same day. Moreover, some of the students showed no reaction to the lessons because of loving these lessons or perceiving them as regular lessons. Although there were some adverse reactions during the lessons, students participated in the lessons. Their interest increased to the lessons, and their awareness about the interdisciplinary relationship between the disciplines was created.

6.6.3 Part 3: Interdisciplinary lessons conducted by teachers through team teaching

In the Main Study I, teachers conducted four interdisciplinary lessons with team teaching in 11th, 12th, 26th of December 2017, and 8th January 2018. For these lessons, the in-class observations were executed to explore the teacher's interaction with students and the reaction of students to the lesson. After the lessons, the five-minute group interview with students was generally realized to take their comments about the lesson. Additionally, the individual interviews were conducted with teachers to evaluate the lessons and get further reflections to develop them. In these lessons, the general aim was to show the interdisciplinary relationship of the subjects from different disciplines but not to teach these subjects during these lessons since all subjects were taught individually before conducting these lessons. To achieve my purposes, I asked the same questions prepared for the interdisciplinary lessons with individual teaching to evaluate the implemented interdisciplinary lessons with team teaching (Appendix F). In these individual interviews with teachers, additional questions related to the STEM activity design workshop were also asked to get a comprehensive evaluation of the workshop. In this part, these lessons were explored respectively by giving reference to the collected data, which includes in-class observation, teachers' interviews and students' reflections. All interviews were conducted in Turkish and voice-recorded; the duration of each interview varied between 05-40 minutes.

Visual arts-Math lesson (11th December 2017, continued lesson of 4th December). On the 11th of December in the visual arts lesson, it was intended to show the connections between the subjects of "fractions" and "perspective" within the framework of the math and visual arts disciplines. The visual arts teacher also mentioned the secondary colors along with the perspective subject to explain the fractions. It was conducted in a one-lesson hour and involved the visual arts and math teachers, along with one of the 5th-grade classes. This lesson was the continuation of the 4th December lesson since one lesson hour was not enough to complete the activity. I was in the class as a participant-observer. At the end of the lesson, an audio-recorded group interview with students was conducted about the lesson. Audio-recorded interviews with the visual arts and math teachers were also executed after the lesson (Table 6.11).

Table 6.11 *Visual arts-math lesson*

Visual arts-Math lesson (11th December 2017, continued lesson of 4th December)	
Subject	Perspective and fractions
Place	Visual arts lesson
Participants	Visual arts and math teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation, the group interview with students (audio recorded by the researcher)
Post-lesson interview	Individual interviews with visual arts and math teachers (audio recorded on 11th of December)

The lesson began with the math teacher's scaffolding questions about the fractions. The visual arts teacher also reminded students about the secondary colors, and then, he requested from the students to paint 1/4 of the top of the prism with orange by mixing red with yellow. Later he asked students to paint the other half of the top with orange without giving a clue about the portion of the area. After students finished the painting, the math teacher asked the fractional expression of that portion of the painted area (Figure 6.14).

Figure 6.14. Views from the visual arts-math lesson on December 11

Later the visual arts teacher requested from students to paint some parts of the top of the prism with the green color by mixing the yellow and blue colors (Figure 6.15). After painting with green, the math teacher asked the fractional expression of the unpainted areas to the students, and the lesson ended after this question.

Figure 6.15. A view from the visual arts-math lesson on December 11

The findings of the Visual arts-Math lesson (11th December 2017). Individual interviews were conducted with the visual arts and math teachers after the lesson since this was the first experience of the teachers about team teaching. Students also experienced team teaching for the first time, and they showed no reactions during the lesson. One of the essential parts of this lesson for the math teacher was the confusion of Student B about the mixing of the primary colors. For this issue, the math teacher stated that: "For example, today the visual arts teacher said, paint with orange. They cannot think of an alternative way for the orange. For example, they know which mixture of two colors becomes orange. But they cannot put it into practice."[46] (Math teacher)

From these sentences, it was apparent that students could have confusion about using their knowledge in real practices without taking direction since they got accustomed to using ready-made knowledge. This issue was also the sign of how the education system based on memorizing, not on developing information. As previously happened in the 4th December lesson, some students reacted to this lesson and told that the math is not in everything. For example, one of the students who wanted to be an ophthalmologist stated that there was no math and art in this job. One of the students who loved math but considered no relation between the medicine, visual arts and math disciplines did not like the lesson. It was discovered that students did not know what was needed to perform the jobs, and that could have originated from their lack of interdisciplinary viewpoint. While some students could not figure out the relationship between math and visual arts, some students, like Student G, understood what we aimed to do: “We are integrating the math with visual arts, my teacher, I know.”

The math teacher also complained about the students’ reactions about the jobs, and thus, she accepted my offer to include jobs in the STEM activity of the Main Study II as this quote shows:

> **Math teacher:** We are not able to tell. For the last fifteen days, I have been trying to tell the children, all the fifth classes, how much mathematics takes part in every section of life and every profession. Some say, “True.” For example, I told them that a sunflower demonstrates the Fibonacci sequence. Some of them do not know this, they gaze at me in astonishment, but they cannot understand that mathematics is in every section of life.
> **Researcher:** It is necessary to tell about the occupations. STEM education includes informing about jobs. As the students do not know what the contents of these jobs are, they suppose that they won’t need mathematics in their jobs.
> **Math teacher:** For instance, they want to choose a job that is not related to mathematics; however, mathematics is everywhere, even in performing ballet. Informing about the jobs is not ready in this term’s plans, but we should include it in our plan for the second term.[47] (Math teacher)

Similar to the math teacher, the visual arts teacher also felt students’ confusion about thinking there is no relation between math and visual arts lessons. This confusion could be caused by making the interdisciplinary lesson in the visual arts lesson since some of the students showed similar reactions to the previous lesson conducted in the visual arts lesson. Another reason for this issue could be the higher level of material, as the visual arts teacher stated in his interview. While the perspective material he used was initially used in the 6th or 7th-grades, in this time, he used the same material for the 5th-grade.

In group interview with students, one of the students stated that she was bored dealing with math in every lesson and wanted to do math only in the math lesson.

While one of the students found the lesson enjoyable, in the meantime, the other one found it annoying due to making it in the visual arts lesson. Some of them also considered that it was not a visual arts lesson. However, in this lesson, many subjects were taught about the visual arts discipline (such as secondary colors). Because of having similar previous reactions, it was apparent that the response to the math lesson originated from doing math continuously in every lesson. Students also wanted to make art and math in their own lessons since they did not get familiar with these kinds of interdisciplinary lessons. Although there were students' reactions, both teachers were satisfied with the lesson and students' performances. For example, the visual arts teacher stated that he was content with the result and found students more successful than he expected. He also said that students who lacked interest in art showed improvement in this lesson.

> **Visual arts teacher:** Look, I mean that the child who is not even remotely close to the mathematics has felt the 'one third', 'the whole'.
> **Researcher:** Have you noticed a difference in anyone who could not make?
> **Visual arts teacher:** Sure, I am aware of them.[48] (Visual arts teacher)

Furthermore, the math teacher considered students successful in this lesson; she was further surprised by some of the students' performances in the visual arts lesson.

> **Math teacher:** Well, Student N is successful but not very much successful. She is not at the same level as Student D or Student C., but her paper was good, too. Or the more successful ones were a little bit disorganized and studied more differently. This is what I've observed.
> **Researcher:** In other words, there have been ones who surprised you and ones who you found more successful.
> **Math teacher:** Yes, the successful ones did not amaze me; however, some students surprised me.[49] (Math teacher)

The participation of the math teacher made the lesson more interactive compared to the previous one with individual teaching. In the interview with the visual arts teacher, he stated that he was relieved owing to the existence of the math teacher since she shared the responsibility of the teaching. Additionally, after making two interdisciplinary lessons, while the visual arts teacher's intention about making the interdisciplinary lessons increased, he also pointed out the significance of the interdisciplinary collaboration among teachers to conduct interdisciplinary education.

> My dear teacher, honestly, I have discovered that it is necessary to use this. I do not tell this simply because you are here today and won't be here tomorrow. As we said at the very beginning, the cooperation with the other group teachers in this old education process is unavoidable. I deal with the social science teacher on Republic Day, in the classroom, in the corridor, in the workshop. Or I deal with the primary school teachers on the 23rd of April for the organization of the stage, the creation of the stage design, the distribution of the subjects, and the certain building subjects. What I do is already something existing in education. Instead of throwing away, we should develop the system.[50] (Visual arts teacher)

From these sentences, it was apparent that the visual arts teacher was more open to collaboration with other disciplines owing to the nature of the visual arts course. Furthermore, the visual arts teacher pointed out his intention about the continuity of this lesson in the other classes. He stated that he could improve this lesson by changing the material with bread (such as design your imaginary bread for preventing the bread waste) to make students deal with more high level and artistic thinking. The math teacher also stated her pleasure about making the lesson with the visual arts teacher because of increasing her perspective about using the new material opportunities. As a result, this lesson created an impact on both teachers' professional growth in terms of developing teaching practices with new material opportunities and sustaining the continuity of the lesson in other classes. This finding also showed the benefits of making interdisciplinary collaboration between teachers during interdisciplinary lessons. Consequently, according to the teachers, this lesson enabled better comprehension of the course content and increased students' interest in the lesson.

English speaking-Math-Visual arts lesson (12th December 2017). On the 12th of December, two lessons were conducted respectively to show the connections between the "shapes", the "fractions" and the "composition" subjects within the framework of math, English, and visual arts disciplines (Table 6.12). The "fractions" and the "shapes" subjects were previously presented with the individual teaching in the 30th November and 5th December lessons. Since the lecture and the activity had to be conducted separately, students could not find out the connection between these subjects. Consequently, this lesson provided students an opportunity to experience the relationship between these subjects in three different disciplines. The first lesson involved the English speaking and math teachers and one of the 5th-grade classes. The second lesson involved the visual arts teacher and the same 5th-grade class. I was in the class as a participant-observer in both lessons, and after the lessons, audio-recorded interviews were conducted with all teachers.

Table 6.12. *English speaking-Math-Visual arts lesson*

English speaking-Math-Visual arts lesson (12th December 2017) Two lessons in a sequence	
Part 1	
Subject	Shapes, fractions
Place	English speaking lesson
Type of teaching	Team teaching
Participants	English speaking and math teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation
Post-lesson interview	Individual interviews with English speaking and math teachers (audio recorded on 21th of December)
Part 2	
Subject	Shapes, fractions, and composition
Place	Visual arts lesson
Type of teaching	Individual teaching
Participants	Visual arts teacher, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation
Post-lesson interview	Individual interview with the visual arts teacher (audio recorded on 21th of December and 07th of January)

The first lesson was conducted in the English speaking lesson. In this lesson, the “shapes” subject was intended to be taught by connecting with the “fractions” subject. In this lesson, the math teacher started the lesson with scaffolding questions. For instance, she asked the English name of the square and the fractional expression of its parts after drawing it on the board and dividing it into four parts. She further made students remember the meaning of the “half”, “whole”, “quarter” by using the shape of the “round”. After this reminding, the English speaking teacher taught the English meaning of these fractional expressions by using additional material prepared for this lesson. At that point, some students reacted doing math since the previous interdisciplinary lessons involved math along with other disciplines.

Students brought cakes to the lesson upon the English speaking teacher's request. In the lesson, she requested students to divide the cakes into four parts. In the meantime, the math teacher asked the fractional expression of the cakes’ pieces. Later, the English speaking teacher asked the same question to get the answer in English. Since students wanted to eat their cakes, by using the fractions, the English speaking teacher said to them, “You can eat the quarter part of your cakes” to make them involve more with the subjects. After that, the English speaking teacher continued with the “shapes” subject to prepare a base for the next visual arts lesson and asked students, “Can you carve your cake pieces and make some shapes of them?” Then, students made some shapes from the cakes by using plastic knives. Later, the English speaking teacher opened up music about the shapes to consolidate the subject better, and the lesson ended after listening to this music. At the end of the lesson, the English speaking teacher asked students whether they liked the lesson and except Student Y, the others said: “Yes, we enjoyed much”. When I asked them what they learned, they answered as “fractions and shapes” (Figure 6.16).

Figure 6.16. Views from the English speaking-math-visual arts lesson on December 12

After this lesson, an activity was executed in the visual arts lesson. In this lesson, the “shapes”, “fractions”, and “composition” subjects were connected to integrate the visual arts, math, and English speaking disciplines by making an activity. The visual arts teacher first mentioned the surface, composition, and harmony by referring to the Piet Mondrian artworks because of including geometric shapes.

Then, he continued with the shapes, and by using the cakes, he created five geometrical shapes: triangle, pyramid, rectangle, round, and square. Later, he requested from students to develop their composition from these geometrical five shapes. Students started to create their compositions on the paper by considering the relationship between the geometrical elements. The lesson was ended with this activity. (Figure 6.17)

Figure 6.17. Views from the English speaking-math-visual arts lesson on December 12

The findings of the English speaking-Math-Visual arts lesson (12th December 2017). There were some missing points when conducting these lessons. For instance, the cake pieces created by the students were planned to be used first in the English speaking lesson, and then, they were expected to be brought to the visual arts lesson to be used for making composition on the paper. However, in the visual arts lesson, the visual arts teacher created the shapes from the cakes by himself, and students created composition by using these shapes instead of the ones created by them in the English speaking lesson. These changes in the lessons showed the importance of communication and collaboration before the interdisciplinary lessons. Since, according to teachers' interviews, none of the teachers communicated with each other before the lessons. Although there were some missing points in these lessons, teachers were pleased with the lessons. The English speaking teacher stated her expectation about the change in students' perception of the relationship between the math and English disciplines. The math teacher also considered that students were aware of the connection of the math with other disciplines and started to find out the interdisciplinary relationship of the disciplines by themselves in her lesson as these quote shows:

> I do not know whether they are aware of this, but their perspective might have changed. I mean the children themselves. If I had only given them 'the objects' in that lesson since our subject needed to be taught like this, and the book itself had limited the lesson, they would have learned only the things inside. However, they saw how to connect it with another lesson or another concept. For example, they gave a reaction like "What's the connection?" for the fractions. "Why did the math teacher appear?" Then, at the end of the subject, when they realized the connection, we might have touched their perspectives. They may now think as "These can be connected like this and how effective it is."[51] (English speaking teacher)

> For me, the lesson was outstanding. I mean 'with a Speaking'. Mathematics is a field that suits everything; nevertheless, the activity of making a cake done by the English speaking teacher was delightful for them. It was so lovely; actually, she discussed the fractions in the activity. The children now get used to everything, including mathematics inside. They got it. While I was treating a subject today and typically speaking, one of them said, 'Oh, Turkish has got involved in mathematics.' They are aware of what is done in lessons from now on. You see, I said something, and someone said: "Oh, cause-effect relationship, we have referred to Turkish."[52] (Math teacher)

According to the visual arts teacher, the previous lessons enabled better comprehension of the course content and more engagement. He stated that the last interdisciplinary lessons contributed to this lesson in terms of creating composition owing to the change in students' perceptions about the relationship between the math and art disciplines. According to him students, who did not want to deal with the lesson, were more participative and successful. For instance, he found Student Y, who did not care about the visual arts and math lessons, and Student G, who was monotonous in the visual arts, was very motivated. He also found Student X's artwork, who is a successful student, very original compared to the previous ones. Therefore, he discovered an unexpected achievement in students' understanding.

> Math, Math. That is to say; there were differences in their perceptions. In other words, the kid was able to feel the depth at the farthest corner, the right side, the left side, and the top. He directly saw the shape himself while painting without overflowing. He felt that it was to be continued, and there was a depth of a cubic shape therein. Referring to the English lesson - At least they felt that most of the students there never arranged

> the other pieces side-by-side like a soldier's suitcase. They put them behind or at the front. They made a composition that could be integrated with a circle. Therefore, when appropriate, I compared it with roof decoration.[53] (Visual arts teacher)

Using the cake as course material made students very engaged and increased their interests in the lesson. According to my observations, the students also found the lesson enjoyable, and they showed nearly no reactions during the lesson. While the visual arts teacher found students' work creative and original, the English speaking teacher also pointed out the creativity of the lesson: "For instance, they formed the shapes as they wished. We did not give a measure or tell them how to do it. It was because they had different types of cake shapes."[54] (English speaking teacher)

With these sentences, she referred to the independence of the students' decision-making process in the hands-on activity and how this situation contributed to their creativity. Furthermore, both teachers and students experienced a hands-on activity for the first time in which students created a composition. Additionally, because of the hands-on activity executed in the lesson, the English speaking teacher stated that students requested more activities after the lesson: It was lovely; the lesson was very productive and full. Oh, I can say that it was as good as I planned so I enjoyed it, too. After all, I got the feedback from children as "Teacher, do not we do one more? We wish to do it again." You see, they enjoyed it, too.[55] (English speaking teacher)

The visual arts teacher considered students more enthusiastic in this lesson compared to the previous ones, and according to him, it enabled better comprehension of the course content owing to making the lesson with team teaching:

> **Visual arts teacher:** They were more willing this time. Especially for cutting the cakes, forming the shapes and painting them; moreover, I was telling them the color tones and giving some information. I said to them, "What is essential in a drawing is a line, spot, and color. Think about three triangles; line, spot, and color. What is a drawing? It is fifty-fifty; is the line, is the spot, and is the color." And I tried to emphasize this all the time. Now it is easier for them. At least not in a class, but in corridors, I heard, "Teacher wants to tint." (**Researcher:** While the children are speaking to each other). I witness such speeches while they are talking to each other. That makes me happy.
> **Researcher:** Does this something happen after the lessons or before?

Visual arts teacher: Yes, this is what I heard after the lesson in that classroom; "Teacher wants to tint."
Researcher: That's to say the information you gave formerly has been mastered in that lesson and after the lesson.
Visual arts teacher: Yes, it has.
Researcher: Do you think that that the activity contributed to this?
Visual arts teacher: Yes, it did. That is due to our collaboration, the unity of me, the math teacher herself, and some other friends.[56] (Visual arts teacher)

Making the interdisciplinary lessons contributed to the teachers' personal growth. For example, the math teacher stated that she wanted to stay both in the visual arts and English speaking lessons to the end because of being entertained and intending to observe the process of the lessons. She further stated that her awareness about the connections with other disciplines increased, and she wanted to use these kinds of interdisciplinary relationships in her future lessons.

Math teacher: So our awareness of the work we are doing has increased. We have made sense of our work. We have already been doing it before, but now we are more conscious. While teaching, every teacher is telling about daily events or mentioning about the other fields. We do it with awareness now; we pay attention to choosing the subjects. We have realized what we have done. At least, I have understood, and I have made a bit sense of it.
Researcher: In other words, you said we related the subjects before, this time with more conscious.
Math teacher: With more conscious or by knowing what I am doing. For example, I have already related this to science, but now I am aware of this relation. Maybe I used to connect it without awareness in the past. [57] (Math teacher)

The visual arts teacher highlighted the continuity of this study instead of leaving it as a pilot one; thus, he stated that he would consider this in his lesson planning. After experiencing the team teaching, he also favored the collaboration in team teaching owing to enabling teachers' learning by idea-sharing.

Visual arts teacher: The collaboration with other group teachers in the National Education curriculum…
Researcher: Did the collaboration involve teaching the lesson together?
Visual arts teacher: It involved when needed, of course. Hmm, do the teachers enter one classroom together? It is told that they shouldn't be in practice; there must be a single teacher in the class. Why? I mean, we will learn several things altogether; nobody can know everything. (Visual arts teacher)[58]

After making this lesson in the English speaking lesson and observing the students' engagement, the math teacher considered that being back in the math curriculum affected students negatively in the previous lessons owing to making intense math in their lessons. Furthermore, according to her, how students perceive English lessons can lead to this conclusion because they think this lesson is more enjoyable compared to math and science lessons.

> Other than this, English Speaking, Skills, Main course lessons, these are the lessons that students love. They go fun comparing to Math, Turkish, Science. I mean, I do not know the other lessons, but they go fun comparing to the math. They found the math boring due to my missing from the curriculum.[59] (Math teacher)

Students previously reacted to the interdisciplinary lessons, which included math and the visual arts disciplines; they showed nearly no reaction to this lesson. However, both English and visual arts lessons mean fun for the students. This result could have originated from students' familiarity with the interdisciplinary lessons including the math since, according to the teachers, they enjoyed the lessons executed on 12th December and started to see the interdisciplinary relationship of the disciplines. Additionally, as previously stated in the pre-workshop interviews, the English lesson was defined as an interdisciplinary and activity-based lesson, thus, making interdisciplinary lessons could be perceived as a part of regular English lessons. Another reason for having no reactions could also be related to making hands-on activity by using cakes, which could be eaten by students instead of having a worksheet executed in the previous lesson. Besides, in the earlier lessons, students were directed by the visual arts and math teachers; however, in these lessons, they were freer due to giving their decisions by themselves.

Although there were some missing parts because of teachers' lack of collaboration and communication before the lessons, teachers were pleased with the lessons. Besides, they observed students' personal growth, such as increased awareness about the interdisciplinary relationship of the disciplines, a better comprehension of the course content, increased engagement, and enhancement in their motivation, raised the interest to the course, and unexpected student achievements. With this lesson, from the beginning of the interdisciplinary lessons, the "shapes" subject was presented within the framework of the visual arts, English speaking, and math lessons to show how one subject was related to the multiple disciplines.

English speaking-Social science-Science lesson (26th December 2017). On the 26th of December in the English speaking lesson, it was intended to show the connections between the “natural disasters” and “melting and freezing” subjects within the framework of English, social science and science disciplines (Table 6.13). The lesson was conducted in a one-lesson hour and involved the science, social science and English speaking teachers along with the same 5th-grade class. Furthermore, this was the first time for making an interdisciplinary lesson with three teachers. I was in the class as a participant-observer. At the end of the lesson, an audio-recorded group interview with students was conducted about the lesson. After the lesson, an audio-recorded interviews with teachers were also executed for the evaluation of the lesson.

Table 6.13 *English speaking-Social science-Math lesson*

English speaking-Social Science-Science lesson (26th December 2017)	
Subject	Natural disasters, melting, and freezing
Place	English speaking lesson
Participants	English speaking, science and social science teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation, the group interview with students (audio recorded by the researcher)
Post-lesson interview	Individual interviews with science (29th December), social science (26th December) and English speaking teachers (29th December) (audio-recorded)

At the beginning of the lesson, after the entrance of the science, social science, and English speaking teachers to the class, students expressed their astonishment of seeing multiple teachers by saying, “Four teachers are here. …For the first time, we are making a lesson like this”. The English speaking teacher started the lesson with the repetition of the disasters since she had given them “disaster cards” as course material in the previous lesson. After that, the social science teacher asked questions to the students about natural disasters. For instance, she wondered what the earthquake is and how people can protect themselves from it, and students answered these questions. At that moment, one of the students stated that “I understood now" by referring to the existence of the three teachers in the class. Then, the English speaking teacher opened up an animation about the flood, after the animation, she asked the name of the disaster, and students answered correctly. In the meantime, the English speaking teacher also took confirmation about the answer from the social science teacher. Later, another animation was watched about freezing, and at that moment, the science teacher started to mention "the change of the state of matter". Then, the English speaking teacher brought frozen water and candle, and by using the frozen water, she said, "freeze and melt" and "solid and liquid". At that moment, the science teacher also supported the English speaking teacher about the subject. After that, the English speaking and science teachers lighted the candle to show how the solid matter changes into the liquid. Then, the English speaking teacher gave a worksheet exercise about natural disasters, which includes matching the pictures with the relevant natural disasters, and the lesson ended after this practice (Figure 6.18).

Figure 6.18. Views from the English speaking-social science-math lesson on December 26

The findings of the English speaking-Social science-Science lesson (26th December 2017). Considering my observation notes and teachers' feedback, this lesson was mostly organized by the English speaking teacher and the other teachers' contributions were lower. Thus, there was the unequal role of the teachers in team teaching because of the less planning and collaboration before the lesson. According to the social science teacher, the reason behind the lack of cooperation was originated from their busy teaching schedules.

In group interview with students, students mostly stated that they found the lesson enjoyable and different. Student B, who generally opposed to the interdisciplinary lessons, liked the lesson by saying, “it was different; it was very nice.” This response was surprising. However, the English speaking teacher said that her English lesson is also good; therefore, loving the English could make her enjoy this lesson. Furthermore, since the animations and the materials used in the lesson attracted the students’ attention to the lesson, Student H wanted to have similar lessons: “I liked the movie, I also enjoyed much. We always have to do that.” This lesson was the first interdisciplinary lesson in which there were three teachers. While some of them liked having three teachers in the class, three of the students did not like having multiple teachers.

According to the teachers, making team teaching caused more engagement in the lesson and increased students’ motivation and interest: “I enjoyed it very much and liked it. If I had told this subject without the activity, they wouldn’t have enjoyed it so much and been affected. But with this different point of view, children also handle the case with a different view.”[60] (English speaking teacher)

Considering the students’ and the science teachers’ feedback, their awareness about the interdisciplinary relationships of the disciplines increased, and these contributed to the students’ personal growth. Some students also showed unexpected interest in the lesson, and there was no students’ reaction.

> **Researcher:** What is your observation about the class?
> **Social science teacher:** They were excited. Even the students who never participated in the lesson began to speak.
> **Researcher:** Can you give examples?
> **Social science teacher:** Student F, for example, he hardly ever attended to the lesson. I observed him […] Then, Student L did not actively raise her hand and used to answer when I asked something to her. She raised her hand voluntarily and attended to the lesson.[61] (Social science teacher)

According to the science teacher, the students experienced how one lesson could be connected with another one, and this was one of the advantages of the interdisciplinary lessons. For instance, one of the conversations between the students and me showed how they learned the connection of the “natural disasters” with “melting and freezing” since they were not aware of that before.

> **Researcher:** Well, what was taught in the lesson?
> **Student X:** Teacher, we read the definition of natural disasters. Then we watched an animated movie about natural disasters. Our teachers reminded us of some things. We did this activity later.
> **Female student:** You forgot something.
> **Researcher:** I also think you forgot something.
> **Female student:** Changes in states of matter.
> **Researcher:** Exactly, you have learned changes of state. Are changes in state and natural disasters related to each other?
> **Many students:** Yes, yes…
> **Student H:** Teacher, I did not say anything.
> **Researcher:** Well, say then.
> **Student H:** For instance, floods can be caused by the melting of snow.[62] (Students)

With this study, teachers’ awareness about the interdisciplinary relationship of the disciplines increased, and some of the teachers started to think of making changes in their teaching practices. For example, the English speaking teacher wanted to make this kind of teaching in every lesson owing to expecting the persistence of students' learning: Well, it was good. I liked it, and actually, I hope this in every lesson. To a degree, a lesson should touch the other lessons. In this way, I guess, the knowledge is more persistence for the children.[63] (English speaking teacher)

Similarly, the science teacher stated that her teaching practice and viewpoint were changed with this study since she started to collaborate with other disciplines. She further pointed out making interdisciplinary lessons with team teaching in the future by cooperating with the other teachers since, according to her, these lessons made students more engaged and the lessons more enjoyable. She also gave an example of how she could teach her lesson differently due to the changes in her perspective. As a result, teachers discovered the importance of making collaboration with other disciplines to conduct interdisciplinary education.

> Since I have learned it recently, I consider whether I should teach in one way or the other instead of telling in a monotonous way when I enter the classroom as time passes. Of course, there are differences. After using the STEM method, one tries to teach a lesson more differently. The mind is directed to STEM unavoidably. We get the other fields’ opinions; we certainly do this. Does not it improve us? For me, it developed; moreover, I have learned to look from a different point of view.[64] (Science teacher)

> At the moment, there isn't. I certainly think about it. Why not for it after looking over the curriculum? In my opinion, it is enjoyable. If two or three teachers give a lesson by combining the subjects after getting ready for it, it will be excellent. As long as I am available, I want to do this. Because the lesson is no longer dull, in other words giving a lesson directly to the children is very boring. Instead, giving a lesson with these activities together with several teachers is more interesting for them. So you attract the children to the lesson, and I think this is better. I am planning to practice this; I mean, I desire to do it. [65] (Science teacher)

> For example, I am giving a lesson; suppose that I am teaching the Forces. There are calculations in the dynamometer, and the children should know this subject. For example, the Forces subject could be used. While I was giving the lesson once, I thought that there was a dynamometer question, and we were trying to solve it. The children reacted by saying, 'Again, math, teacher!' the fractions were involved. The solution needed ratio and proportion. Seeing the children's reactions, I understood that this lesson could be taught together with math. Thus, I thought if Filiz teacher had entered this lesson, it would have been more useful. I began to consider from this point of view, is it clear?[66] (Science teacher)

Visual arts-Social science-Science lesson (8th January 2018). On the 08th of January in the visual arts lesson, it was intended to show the connections between the "earth shapes", "natural disasters" and "melting and freezing" subjects within the framework of visual arts, social science, and science disciplines (Table 6.14). It was conducted in the one-lesson hour, which involved science, social science, and visual arts teachers, along with the same 5th-grade class. The visual arts teacher contributed to the lesson by preparing a 3D model to show the relationship between the subjects. Furthermore, this was the second interdisciplinary lesson, which included three teachers at the same time. I was in the class as a participant researcher. After the lesson, audio-recorded interviews with the visual arts, science, and social science teachers were conducted to evaluate the lesson.

Table 6.14 *Visual arts-Social science-Science lesson*

Art-Social Science-Science Lesson (8th January 2018)	
Subject	Earth shapes, natural disasters, melting, and freezing
Place	Visual arts lesson
Participants	Visual arts, science and social science teachers, researcher, 16 students
Duration	40 minutes (One-lesson hour)
Data collection methods	Researcher observation
Post-lesson interview	Individual interview with the visual arts teacher (8th January), social science (11th January), science teacher (15th January) (audio-recorded)

For this lesson, the visual arts teacher brought some materials to the class, such as plaster, watercolor, and styrofoam. He first started the lesson by mixing the plaster with water, and then he mentioned the earth shapes. At that moment, one student questioned the relevance between the visual arts and the science. The science teacher explained the freezing of the plaster after mixing with the water and the reason behind this fact by correlating it with the "melting and freezing" subject. This explanation made students understand the aim of the lesson. In the meantime, the visual arts teacher made a mountain from the plaster on the styrofoam and painted it with the brown watercolor. At that moment, the social science teacher asked a question to the kids whether the model of the visual arts teacher was relevant to social science. Upon this question, Student D stated his reaction by saying "what relevance". Then, the social science teacher asked another question about how the mountain is showed on the map. When the students answered "Brown", they understood the connection of making model with the social science lesson (Figure 6.19).

Figure 6.19. A view from the visual arts-social science-science lesson on January 8

Later, the visual arts teacher painted the top of the mountains with white color and asked what there is on the peak points of the mountain. Students answered by saying "snow"; after this answer, the science teacher asked how the snow occurs. The students answered correctly, and then the science teacher gave information about the snow. Later, the visual arts teacher mentioned the rivers and mountains by using his model and asked what happened if the snow was melted to make a connection with the flood. In the meantime, the science teacher related the snow melting with her subject “melting and freezing” to make students correlate these natural events with the science. The visual arts teacher continued with the ways of protecting the people from the flood by giving examples about how the settlements should be around the rivers since we had a question related to this subject in the STEM activity. While he was giving the examples, the social science teacher did not speak, although this was her subject. After the visual arts teacher completed the model, the students started to draw the model to their notebooks, and the lesson ended with this practice.

The findings of the Visual arts-Social science-Science lesson (8th January 2018). Some students enjoyed the lesson; however, some of them did not like it. For example, Student G liked the model, although he was one of the students who found irrelevant making this model. Student B and Student A complained about not making art in the lesson.

Student A: I want to make art, but Ahmet teacher is doing.[67]

These were the students who always complained in the interdisciplinary lessons, which included art. Besides, the visual arts teacher criticized the social science teacher about her less contribution, while he found the science teacher more participative. At that point, while the social science teacher admitted her less participation to the previous 26th of December lesson, she considered the reverse for this lesson. According to my observation notes, the lesson was managed mostly by the visual arts teacher. She made the less contribution since knowing what is planned in the lesson was not enough for the lesson preparation and conduction.

> Is there any question mark about the activity in my mind? I think that she should have taken more responsibility. (**Researcher:** Who?) The social science teacher […] For instance, I asked if it was a meander of a river. She said, ‘Yes, it is a meander.’ As a social science teacher, she could get much more involved while telling that there shouldn’t be any settlement, or there should be a farming area along the river borders, and landforms shouldn’t be damaged, but she did not. Mrs. Emine got involved when it was time for Science; she said something.[68] (Visual arts teacher)

> **Researcher:** How did you contribute to the English speaking and visual arts teachers while preparing the activities?
> **Social science teacher:** We often discussed how to do the activities with the visual arts teacher. We did not have the opportunity to discuss it with the English speaking

> teacher. We only talked about how she would give the lesson in no time. In her lesson, the English speaking teacher had control. But we worked with the visual arts teacher in cooperation, so I knew what he would do.[69] (Social science teacher)

We again confronted with not making enough preparation before the lesson, and this caused teachers' unequal role in the team teaching. Furthermore, according to the visual arts and social science teachers, making a live model in the class increased students' interest and engagement: "According to the participation of the children in the lessons, they were enthusiastic and enjoyed. They learn as soon as they are concerned."[70] (Social science teacher)

> In today's activity, it must have drawn your attention; we silently said, "This is plaster. It freezes, and if it combines with water, this happens." We planned to animate a little sample of it by using plaster, and they listened to us very carefully. They watched its turning into a pastry material in silence.[71] (Visual arts teacher)

The findings of the interdisciplinary lessons conducted by teachers through team teaching. In part 2, the interdisciplinary lessons with team teaching were explored and compared with each other to find out their effects on teachers and students. Moreover, during the individual interviews, additional questions related to the activity design workshop were asked to get a comprehensive evaluation of the workshop. Therefore, the findings of the interdisciplinary lessons, along with the STEM activity design workshop, provided us information about teachers' perceptions about the DT approach and teachers' and students' opinions about the interdisciplinary lessons. In this respect, this interview was investigated under six categories: comparison of the interdisciplinary lessons conducted through team teaching based on the students' and teachers' reflection and researcher's observation, teachers' and students' personal growth through STEM and the DT approach, the leading role of visual arts and English disciplines in introducing the STEM education empowered by DT approach, the significance of the DT approach in education and the perceived characteristics of the DT approach by teachers.

Comparison of the interdisciplinary lessons conducted through team teaching based on the students' and teachers' reflection and the researcher's observation. The four interdisciplinary lessons were realized in the Main Study I. While in two of them, two teachers conducted the lessons, three teachers presented the other two lessons. The lessons were realized in the visual arts or English speaking lessons owing to the availability of the teachers.

For the interdisciplinary lessons with team teaching, one of the most important points was the interdisciplinary collaboration among teachers before the lesson for the lesson preparation and during the lesson to facilitate team teaching. Accordingly, there was less or no collaboration before the lessons, and the social science teacher put forward the busy teaching schedule as an excuse for this issue. Consequently, there was unequal responsibility of the teachers; the teachers whose lesson was used made most of the lesson preparation by themselves. Besides, there were some missing parts in the 12th December lessons because of the lack of collaboration and communication before these lessons. Additionally, we confronted some of the students' reactions at the beginning or end of the lessons. They were not significant reactions that prevented the lesson process and were mostly stated by the same students. They generally occurred in the lessons, which included the visual arts or math. There were multiple reasons for the students' reactions. These are seeing numerous teachers in the class, not being familiar with the interdisciplinary lessons, the exposure to intense math due to the need to keep up with the curriculum, not accepting math in every discipline, and wanting to deal with only art in the visual arts lesson.

Furthermore, before starting the lesson, no explanation was made to the students; instead, the explanations were given after the students' reflections and with teachers' scaffolding questions. These also caused some reactions at the beginning of some lessons. The students' responses got lesser after the 11th December lesson, because of getting familiar with the interdisciplinary lessons by making reasoning about the disciplines' integration. The reason for no reaction from some of the students was because of the students’ positive perceptions about the math and English lessons, having no math in the lesson, and dealing with hands-on activities.

Teachers’ and students’ personal growth through STEM and the DT approach. There was interdisciplinary collaboration during the interdisciplinary lessons owing to the nature of the team teaching. This collaboration contributed to teachers’ professional growth in terms of considering making changes in their education. Teachers discovered the significance of making collaboration with other disciplines when planning and conducting the lessons since the collaboration caused interactions and sharing of experiences among teachers. For instance, in the 11th December lesson, while the math teachers’ awareness raised about the new material opportunities, the visual arts teacher stated his desire to conduct this lesson in other classes. In the 12th December lesson, all teachers expressed their willingness to enable the sustainability of this study in their lessons. According to the math teacher, her awareness about the connections among the disciplines increased in her teaching practices. Thus, she considered making changes in her lessons. In the 26th December lesson, the science teacher expressed her intention to make interdisciplinary lessons with team teaching by cooperating with the other teachers. She also stated that her teaching practice and viewpoint were changed, and she started to collaborate with other disciplines. As a result, while these lessons, along with doing an interdisciplinary workshop, contributed to the English speaking, math, science, and visual arts teachers in their profession, the social science teacher stated no contribution about herself (Table 6.15).

Table 6.15 *The contribution of each lesson to the teachers' personal growth*

	Visual arts-Math lesson (11th December 2017, continued lesson of 4th December)	English speaking-Math-Visual arts lesson (12th December 2017, Two lessons in a sequence)	English speaking-Social science-Science lesson (26th December 2017)	Visual arts-Social science-Science lesson (8th January 2018)
Considering of making changes in their teaching	Visual arts-Math teachers	English speaking-Math-Visual arts teachers	Science-English speaking teachers	
Raising awareness about the interdisciplinary relationships		Math teacher	Science teacher	
Raising awareness about making collaboration with other teachers			Science teacher	
Having the intention to conduct interdisciplinary lessons in other classes	Visual arts teacher	English speaking-Visual arts-Math teachers	Science-English speaking teachers	
Raising awareness about different material opportunities	Math teacher			

Although we confronted reactions in some of the lessons, which included visual arts or math, according to the teachers, these lessons increased students' motivation, engagement, and interest in the lessons. Additionally, there was an increase in students' awareness about the interdisciplinary relationships. The 12th December lesson also contributed to the students' creativity because of the independence of students' decision-making process in the hands-on activity. Since, in the previous lesson, the students were directed by the teachers (Table 6.16).

Table 6.16 *Benefits of the interdisciplinary lessons with team teaching for students*

	Visual arts-Math lesson (11th December 2017, continued lesson of 4th December)	English speaking-Math-Visual arts lesson(12th December 2017, Two lessons in a sequence)	English speaking-Social science-Science lesson (26th December 2017)	Visual arts-Social science-Science lesson (8th January 2018)
Students' personal growth	✓	✓	✓	✓
Unexpected student achievement	✓	✓		
Increasing students' engagement	✓	✓	✓	✓
Increasing students' motivation		✓	✓	
Increasing students' interest in the lesson	✓	✓	✓	✓
Promoting students' creativity		✓		

It can be concluded that the lessons contributed to the students' personal growth in terms of raising awareness about interdisciplinary relationships and a better comprehension of the course content (Table 6.17). However, in the 11th December lesson, it was discovered that one of the students was unable to use her knowledge in practice, which could be a problem, particularly in the STEM activity for idea generation. Moreover, students' participation in the lessons was high in all of the lessons. According to the students' feedback and observation notes, making team teaching and a hands-on activity, being free in the decision-making process, teacher's live model making, and using materials such as cakes or animations in the lesson contributed to students' enjoyment and engagement.

Table 6.17 *Students' personal growth in each lesson*

	Visual arts-Math lesson (11th December 2017, continued lesson of 4th December)	English speaking-Math-Visual arts lesson(12th December 2017, Two lessons in a sequence)	English speaking-Social science-Science lesson (26th December 2017)	Visual arts-Social science-Science lesson (8th January 2018)
Raising awareness about the interdisciplinary relationships	✓	✓	✓	✓
A better comprehension of the course content	✓	✓		

The leading role of visual arts and English disciplines in introducing the STEM education empowered by the DT approach. In the literature, the STEM education is based on the math and science disciplines, and the other disciplines seemed to assist them. However, in this study, we integrated most of the lessons with the visual arts or English speaking disciplines, and empowered them in STEM.

> "We approached the STEM from the reverse. In the literature, the participation of the visual arts discipline occurs within the framework of mathematics and science. The visual arts teacher is perceived as a teacher who supports the others in material design or preparing a poster. With this study, by using the visual arts lesson, we taught math, science, social science, and English to the students. Even there was a live material creation, the appropriate material selection to serve the teaching of the subjects in the interdisciplinary lessons." (Observation note)

I wanted to learn the visual arts teacher's reflections about this issue. He stated that the visual arts lesson was considered as an accessory lesson and less important than the theoretical lessons by the school administration. However, he discovered that his lesson had the same effect as the other ones in education, mainly for STEM.

> For the school administration, theoretical lessons are more important, and visual arts, music, and physical education and training lessons are pushed into the back. I said it before […] At least I understood that my lesson is as useful as an English lesson, as a Mathematics lesson. Before that, I experienced that it was as effective as social science, too. The fact that I am in the center of the work despite one hour a week means my existence. My lesson should be the main one. (**Researcher:** In other words, it should be a significant lesson). A major lesson. Like math, Turkish, social science, physics, chemistry, etc.[72] (Visual arts teacher)

> In fact, visual arts […] Visual arts […] I joined every lesson, every activity from the beginning of this workshop, and I gave an interview with you in every subject. Here I've realized how great art is. I've found out that life cannot be without art, without design. I am a visual arts teacher. The lesson is one hour a week. It is a garniture lesson. The other fields' exams are made in this lesson. (**Researcher:** Yes, your lessons are always borrowed from you.) But when it is the right time and place, everyone expects something from the visual arts lesson. When there is a painting contest, success is expected. When social or special days come, stage design, organization, and decoration are expected from the visual arts teacher. Never mind, it is art; you do not read exams like in math …[73] (Visual arts teacher)

The social science teacher told that the visual arts is perceived as a secondary lesson by society owing to not being included in the exams. This perspective can also affect the students' perceptions about the visual arts lesson: "In our society, there is a prejudgment for those lessons, and there are people who see them as a hobby. Because they won't be asked such subjects throughout their lives and will ever come across with them in tests or exams."[74] (Social science teacher)

Furthermore, the science teacher gave credits to both visual arts and English speaking lessons in terms of discipline integration. She particularly pointed out the visual arts lesson because of facilitating students' understanding of the interdisciplinary relationships between the science, visual arts and social sciences: "Of course, it is easier for children to relate the subjects. For example, for social science, the student knows how snow is formed, but he/she learns via a visual material. That snow is formed, but what happens next? He/she learns this in a social science lesson. So making the relation becomes easier."[75] (Science teacher)

She said she was concerned about the integration of science with the other disciplines before the workshop. However, after the implementation of these lessons, her viewpoint about the different disciplines, mainly for visual arts, has changed in terms of teaching.

> **Researcher:** Well, my teacher, what kind of point of view did you have for visual arts, English, and social science fields before the workshop?
> **Science teacher:** I said that I did not know how to relate them to my lesson.
> **Researcher:** So what do you think now?
> **Science teacher:** I am concerned more with them, of course. That is to say, I enjoyed it, too. To give an example, we joined a visual arts lesson. We told a few theoretical things, but the visual arts teacher created a new product. He provided the students to see every aspect as much as he could. It was delightful not only for them but also for us. So I said to myself that this lesson could be given like this.[76] (Science teacher)

As previously stated, one of the problems we confronted during the workshop was that teachers could not easily create an activity since they had a lack of interdisciplinary viewpoint owing to not collaborating before. However, after making the workshop and the interdisciplinary lessons, their perspectives related to the other disciplines have changed. Therefore, making collaboration with other disciplines is significant for teachers to implement an interdisciplinary STEM education and to have the knowledge and experience of different disciplines.

The social science teacher also stated that the visual arts lesson could be combined with the other lessons. Consequently, she suggested arranging its curriculum in align with the social science and science curricula: “At this point, when the lessons are combined, it is more meaningful for the sake of the children. This lesson is more relevant to combine with all lessons as you said before; however, the Ministry of National Education can arrange the curriculum according to the social science and science.”[77] (Social science teacher)

The math teacher discovered the value of the visual arts lesson after seeing the material opportunities in the 11th December lesson. In her previous comments regarding the 12th December lesson, including math and English speaking, she also stated that students showed no reaction to this lesson since the students love the

English lessons because of involving more enjoyment compared to the math and science lessons.

In Turkey, according to the exploratory research, using art in the STEM and STEAM education means making a prototype, creating a poster, or taking support from the visual arts teacher about material usage. However, in this study, while we took support from the visual arts teacher about similar topics, he also contributed to the integration of the disciplines by using his discipline to teach math, science, and social science in the interdisciplinary lessons. Therefore, the art as a subject should be taken into consideration in introducing the STEM education, owing to its flexible curriculum and activity-based nature. Besides, as stated by the social sciences teacher, natural integration can be achieved by arranging the visual arts curriculum in harmony with other disciplines. The literature also supports this finding concerning the arts in particular; according to Drake (2001) arts (fine arts, drama, music, poetry, etc.) are strategic for developing a teaching approach using themes, and a teacher having an expertise in the arts can easily correlate any theme with art techniques. However, when conducting an interdisciplinary lesson including the visual arts, instead of making the lesson in this lesson, it would be appropriate to make it in another lesson to prevent students' reaction in the first place and to make them get familiar with the STEM education.

The English lesson also had an essential place in this study, and it was observed that students enjoyed more in the interdisciplinary lessons, including the English speaking lesson. Therefore, the inclusion of English with other disciplines also had an advantage similar to the visual arts lesson due to its interdisciplinary curriculum and activity-based nature.

Significance of the DT approach in education. The English speaking and visual arts teachers highlighted the importance of knowing DT in education after experiencing the interdisciplinary lessons and working with a designer. For instance, after conducting the interdisciplinary lessons, the English speaking teacher stated that an educator needs to know the DT approach: "Together with being an educator, we have to know this field, I mean design. Although we try to give information, to tell what we know, the design is a much more different thing. As we participate in, we understand."[78] (English speaking teacher)

As previously stated in the co-design process among teachers and designers, after meeting with the designer and DT approach, the visual arts teacher made changes in his teaching practice because of finding out the significance of the DT process. He stated that meeting with the DT approach assisted him in the STEM activity design process in terms of providing a design viewpoint. Thus, he started to perceive the design as significant as the other disciplines. He further pointed out the considerable place of design in education because of the position of the design in life in terms of creating forms, having aesthetics concern as follows:

> Look, it was amazing for me. I have learned that I need to produce distinctive things and that I should declare the students should create unique things, too, while I am giving the lesson. There I felt that design was as important as visual arts, math, and English. I think that design is the essential factor in education, which has improved recently. In the past, there used to be designed. While developing forms on a surface or up to the sky through space, think about these buildings. They are also products of design. You see, the shape of a building is a result of design. Without design, never. I mean, it should be used much more nowadays. Because design arises aesthetical values, and it makes everyone feel these values. It destroys several disfigurements.[79] (Visual arts teacher)

Additionally, by pointing out the wallet design exercise in the workshop, he further associated making design with prototyping because of including hands-on activity. Since according to him, the aim of the education is making a prototype (making a production): "When we first met, you did something with several materials, and you gave felts. After that, I began to be adapted to the fact. I found out that this could be a production, and a child could be taught with it."[80] (Visual arts teacher)

While the visual arts teacher considered significant making a protoype in education and DT approach, the social science teacher previously pointed out the significance of hands-on activity in the STEM education owing to including making a prototype. It can be concluded that according to teachers, general education, STEM education and DT approach all serve prototyping; this also means that all of them involve a creative process. Because of sharing a common purpose with education, both the STEM and DT approach are considered significant for education.

Perceived characteristics of the DT approach by teachers. The individual interviews were investigated about teachers' perceptions about the DT approach in the STEM activity design process as follows.

Empowering teachers about getting familiar with the students and the other teachers through the DT approach in STEM activity design. DT approach assisted teachers to empathize with the students and the other teachers because of its human-centered nature. At that point, empathy was observed as an essential characteristic from the point of getting familiar with a person, getting familiar with the students and the other teachers.

The importance of developing empathy was discovered in the workshop when teachers dealt with the wallet design exercise. In this exercise, they learned the function of developing empathy for getting familiar with their partners. They realized how this could change the design of the wallet: "Yeah, I am a teacher, but I now think of myself as a student. What will I do more differently? I mean, what can I create more different? Then, I tried to design a wallet, considering a cell."[81] (Visual arts teacher)

> Of course, I made such a great brainstorming that one can think of everything. What should I ask somebody to know him? You see, I studied how to ask a question. Is it clear? I considered in detail. This task is a bit difficult for me, but in my opinion, a person needs to be forced. When you do not ask anything to a person, you cannot know about him/her; you do not know his/her hobbies, you do not know anything about him/her. Naturally, you do something by yourself. But of course, after speaking to the person in front of you, well, there are many additions. So the design has changed.[82] (Science teacher)

Furthermore, the most outstanding contribution of the wallet design exercise for the social science teacher was giving value to the person's wish. She also stated her awareness about getting familiar with the students after the wallet design exercise: "I've already said this before, the section of designing a wallet seemed interesting to me for giving importance to the wishes of the person in front of us. Here, we somehow determined the interests of the children."[83] (Social science teacher)

The English speaking teacher discovered the importance of getting familiar with the other teachers by developing empathy to work collaboratively in the STEM activity design process and to share ideas and teaching experiences: "I tried to understand the other fields. We tried to develop empathy towards each other. At least towards other in-field teachers by questioning how they are giving the lessons or what it should be in the lessons, etc. We gave suggestions to each other, such as; "It will be better if you do this." Nobody felt offended. We saw all of these."[84] (English speaking teacher)

With this sentence, while she was the first person who used the term "empathy" as one of the words related to the DT approach, this was also the sign of internalizing the DT approach. Since only the visual arts teacher had an experience with the interdisciplinary collaboration and two of the teachers were new at the school, developing empathy in teamwork functioned as an icebreaking tool in the interdisciplinary collaborative study. Executing the wallet design exercise was also significant for teaching developing empathy and the DT approach to teachers and getting familiar with their co-workers. Besides, it enabled them to understand the significance of getting familiar with the students; in other words, the target group.

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating the integration of STEM education. There was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher-designer in the STEM activity design process and during the preparation for the interdisciplinary lessons and the STEM activity. The co-design process among teachers and researcher enabled to develop ideas and teachers' personal growth in terms of making a change in teaching practices, comprehending the STEM education and being aware of the interdisciplinary relationships. The interdisciplinary collaboration among teachers enabled them to exchange and develop ideas, get familiar with the other teachers' and teachers' and students' personal growth. For instance, the science teacher stated the contribution of working with teachers and the researcher about developing ideas to synthesize the disciplines for the STEM activity design as this quote shows:

> For example, in social science [...], I thought about how we could relate to the subjects, especially at first sight. I examined the curriculum, but we are five, and you are here; you show, give suggestions, and guide us to do. As a result, I've noticed from which point I have to look. Therefore, I can now say that we can relate these subjects and those while I am giving the lesson.[85] (Science teacher)

The co-design process also caused the learning of STEM education and increased the science teacher's awareness about the interdisciplinary relationship of the subjects. Moreover, it can be inferred from the science teacher's statements, the researcher-designer was mentioned as a co-creator for contributing to idea generation, a guide for facilitating the activity design process, and an educator for teaching the STEM and DT approach.

Additionally, interacting with the designer and the DT approach affected the visual arts teacher's professional growth, and he changed his teaching practice. In this respect, from his perspective, the DT involves thinking, planning, and brainstorming before implementing: "When I give a subject to a student, I tell them to think and design first. While giving a simple subject, I ask how we should think, what we will design, which materials we will use. I consider all of these."[86] (Visual arts teacher)

Furthermore, while the English speaking teacher pointed out the idea generation as one of the benefits of the interdisciplinary collaboration, she also linked the DT to brainstorming with the sentences: "When it is for design, I remember to make a brainstorming. Designing on one's own can be more difficult, or when we gather, better ideas are put forward by brainstorming. Consequently, the person who is leading is a designer."[87] (English speaking teacher)

Similarly, the social science teacher gave credit to the interdisciplinary collaboration from the point of developing ideas: "…It was easier when all the in-field teachers were together. If I had been alone, I could not have thought in detail."[88] (Social science teacher)

As previously stated by the English speaking teacher, developing empathy with the other teachers in the collaboration process assisted her in getting familiar with the other teachers in terms of developing ideas, teaching experiences and working together without having conflicts. Therefore, developing empathy with the participants is essential in the collaboration process to understand each other in teamwork. Additionally, the science teacher pointed out the benefit of interdisciplinary collaboration from the point of developing and exchanging the ideas among the teachers for designing a better STEM activity as this quote shows:

> It is different to produce something with the help of two minds; on the other hand, it is more unusual to create something with the help of five minds. Your point of view differs from my point of view. Thus, it was better to be one group. When these minds come together, an exciting and distinctive product can come into existence. In my opinion, it was better to be a single group. Personally, I can say that I was not able to be as active as the English speaking teacher, for instance, as I joined such an activity for the first time. I know this myself.[89] (Science teacher)

As previously stated, because of the interdisciplinary collaboration during the interdisciplinary lessons with team teaching, there was teachers' personal growth. These collaborations also contributed to the students' personal growth in terms of raising awareness about interdisciplinary relationships and a better comprehension of the course content. It was apparent that the collaboration among the teachers and also the co-design process among teachers and the researcher were the critical points of STEM activity design and implementation. Since most of the teachers had no interdisciplinary collaboration experience before, with this study, they experienced the beneficiary points of working together.

Structuring the STEM activity design as a process through the DT approach. Because of the efficiency of the DT approach in the STEM activity design, according to teachers, DT approach structured the STEM activity design as a process by dividing it into meaningful steps, synthesized the disciplines and approached the activity design problem with a holistic manner. For example, according to the social science teacher, the DT approach facilitated the integration of the disciplines: “Yeah, it made it easier in terms of combining the disciplines. We thought more detailed.”[90] (Social science teacher)

For the science teacher, the DT approach made the STEM activity design process more comfortable and understandable owing to customizing the activity design: “For me, it made it easier, because like I said, working systematically. I mean, going step by step is specifically good for me. Because of that, it made it easier, not harder.”[91] (Science teacher)

The DT approach was perceived as a guide for the activity design process owing to synthesizing disciplines, including need analysis and defining the target group. For instance, both the English speaking and math teachers stated that they needed the DT approach in the activity design of two disciplines if designing a STEM activity for the first time. The social science teacher said that she could not handle the STEM activity design of five disciplines without the DT approach owing to not having the need analysis and not being aware of defining the target group: “No, I do not think so. Because we did not aware of need analysis, defining the target group.”[92] (Social science teacher).

Moreover, the science teacher considered following the DT approach if designing the STEM activity for the second time.

> I think that we should follow this way now. Our students are new, so we are. We haven’t known them much longer; at most for four months. Till now, a long time has passed, and we have had the chance to observe the children more. We’ve done a study, and this study will result in some way. We will see. According to the result, maybe the same method will be followed, or it will no longer last.[93] (Science teacher)

As previously stated, the visual arts teacher made a change in his teaching practice after meeting with the DT approach since, from his perspective, the DT involves thinking, planning, and brainstorming before implementing. In other words, the process is significant in the problem-solving process of the DT approach. Although making collaboration among teachers and using the DT approach was beneficial for getting familiar with the students, teachers had difficulty in defining the target group. According to the social science teacher, the reason for having trouble in determining the target group was related to the individual evaluation of the teachers for their lessons: “Everyone evaluated for their discipline. A student who was good in my lesson was bad in English. I’m telling you, we’ve had difficulty in that…”[94] (Social science lesson).

The science teacher associated this problem with students’ changeable behaviors. The unexpected students’ reactions in some of the interdisciplinary lessons showed the importance of understanding the open and latent needs of the targeted group. Thus, it was discovered that getting familiar with the students and defining the target group is more significant than expected in the STEM activity design.

> Miss Ahsen, I mean, this is a bit variable. The most significant factor is already children. In other words, they are so changeable that you cannot make the right decision in any way. In short, you cannot make a specific decision. You cannot tell certain things about the students. They are students as a matter of course; therefore, they are very different from each other. So what was forcing us mostly while grouping was these differences. The students go from one mood to the other; first of all, they are children, then they are changeable, really very unpredictable. As a result, we had difficulty. However, they understood this as they participated in this study. In my opinion, if you ask it for the second term, it will be much easier.[95] (Science teacher)

6.6.4 Discussion of Phase 2

Phase 2 included three parts: finalizing STEM activity design and preparations for interdisciplinary lessons, interdisciplinary lessons conducted by teachers through individual teaching and interdisciplinary lessons conducted by teachers through team teaching. There were three purposes in this phase. The first one was to make teachers gain interdisciplinary lesson experience conducted through individual and team teaching. The second one was to make students aware of the interdisciplinary connections of the subjects before the implementation of the STEM activity. The last one was to discover the appropriate strategy regarding the implementation of the interdisciplinary lessons to integrate STEM education into the school. In Phase 2, while the interdisciplinary lessons were examined to discover their effects on teachers and students, additional questions were also asked the teachers to explore the workshop process better. The findings of Phase 2 provided us information about the perceived role of the researcher in the co-design process, the perceived characteristics of the DT approach by teachers, and the comparison of interdisciplinary lessons conducting through individual teaching with team teaching.

Perceived role of the researcher in the co-design process considering teachers' feedback and observation notes. The role of the researcher-designer was explored under three stages: during the STEM activity design process, in the preparation of the interdisciplinary lessons and the STEM activity, and during the implementation of the interdisciplinary lessons. During the STEM activity design process, teachers mostly referred to the researcher's guiding role in facilitating the activity design process and assisting teachers in the integration of the subjects. For instance, the English speaking teacher stated that my guidance in the STEM activity design made the process tangible and more comfortable to proceed. She further said that without my facilitation, they could continue on the wrong path in the activity design. Besides, the science teacher stated that the prepared materials and documents and using the DT approach in the STEM activity design facilitated their work. Additionally, the researcher-designer was mentioned as a co-designer for contributing to the idea generation and an educator for teaching the STEM and DT approach.

The co-design process continued during the preparation of the interdisciplinary lessons and the STEM activity, and the researcher guided this process by working with the teachers to facilitate the implementation of the interdisciplinary lessons, the team-teaching process, and the preparation of the activity questions. During this process, teachers also acted as a co-designer and collaborator because of the need to collaborate before the interdisciplinary lessons. During the preparation, I, as a researcher and teachers had more active roles owing to the continuity of the co-design process. However, during the implementation of the interdisciplinary lessons, by being a participant-observer, my role as a researcher was more passive. During this part, teachers acted as an educator because of teaching subjects to the students and also as a collaborator in team teaching practice. In this respect, the researcher guided the co-design process during the preparation for the activity and interdisciplinary lessons. However, teachers facilitated their collaboration during and before the implementation of the lessons. The researcher also collected data during and after the lessons to explore the challenges, problems, and useful points about the lessons. These data were used to develop strategies for the implementation of the interdisciplinary lessons and to make changes in the DT approach. According to this, the facilitator roles of the researcher and using the DT approach as a tool had five impacts on the study:

- Facilitating teachers' perspectives by changing their mindsets and creating awareness about collaborative lesson preparation and teaching practices to teach the STEM and DT approach and to integrate STEM education into the institution.
- Facilitating the STEM activity design process between the teachers.
- Facilitating the preparation for the interdisciplinary lessons and the STEM activity.
- Facilitating the implementation of interdisciplinary lessons.
- Facilitating defining strategies after the implementation of the interdisciplinary lessons.

Perceived characteristics of the DT approach by teachers. According to the findings, the three attributes of the DT approach were defined: human-centeredness, interdisciplinary collaboration, and problem-solving.

In this workshop, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher. The co-design process focused on students as a target group, the creation of STEM activity, the planning and the development of the interdisciplinary lessons, and the STEM activity. Teachers' collaboration focused on including teachers from diverse disciplines for the creation of the interdisciplinary STEM activity, facilitating the lesson and activity planning, and sharing the responsibility of teaching. In this study, the researcher also intended to make a change in teachers' perspectives, mindsets, and teaching habits along with students' perceptions to integrate a new educational approach and to create awareness about the interdisciplinary relationships.

The DT approach was perceived as a guide for the STEM activity design process owing to structuring the STEM activity design as a process. According to teachers, the structured DT approach made the STEM activity design easier and tangible and, therefore, contributed to teachers' collaboration. Consequently, all teachers wanted to use it in the STEM activity design. Team teaching also enabled teachers' interdisciplinary collaboration before and during interdisciplinary lessons. These collaborations caused interactions among teachers and among teachers and students since, at school, all participants affected each other. As a result, teachers' perceptions about education changed, and they considered making changes in their teaching. These collaborations also contributed to the students' personal growth. Besides, the structured DT approach changed the visual arts teacher's perception of education after discovering holistic thinking in the problem-solving process. Learning this mindset caused a change in his teaching practices.

The structured DT approach enabled to generate and exchange of ideas for synthesizing disciplines in the STEM activity design process. Teachers' collaboration in the co-design process also contributed to teachers' integration of

disciplines. At that point, using empathy as an icebreaking tool enabled getting familiar with teachers in terms of their disciplines and teaching experiences. Considering the findings in Phase 1 and Phase 2, the collaboration among teachers is needed for getting familiar with the students and getting familiar with the other teachers by using empathy as a tool (Figure 6.20).

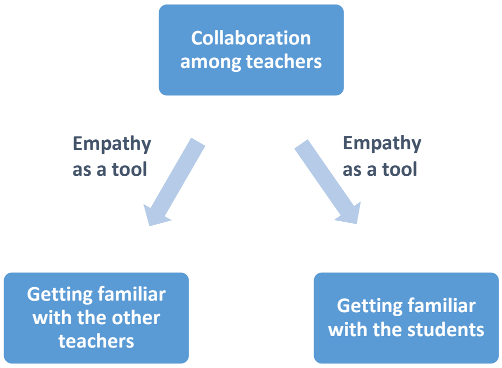


Figure 6.20. The relationship between empathy as a tool and teachers' collaboration

In this study, teachers were considered as a stakeholder in the STEM activity design process because of the human-centered nature of the DT approach. Students were involved as users, and thus, a user-centered approach was adopted to collect the data about them. In the STEM activity design process, teachers had difficulty in defining the target group and getting familiar with the students owing to the teachers' different perceptions about the same students, students' situated behaviors, and not bringing all the observation and interview forms to the workshop. Consequently, this caused an ambiguity in the study and resulted in unexpected students' reactions. While we expected to get familiar with the students in the STEM activity design workshop, we totally got to know them during the implementation of the interdisciplinary lessons. Therefore, it was discovered that students were both users and stakeholders in this study, and students' understanding based on accepting them as both stakeholder and user, should be constructed in the early stages of the study. In this way, we can understand their open and latent needs or concerns in the fuzzy front end before implementing the lessons or activities. According to this, the DT approach should be revised for the future application in the STEM activity design process to facilitate getting familiar with the students, and the students should be accepted not only users but also the stakeholders of this study.

The comparison of interdisciplinary lessons conducted through individual teaching with team teaching. In this phase, we implemented seven interdisciplinary lessons, out of which three were done through individual instruction, four of them through team teaching. When making a comparison between these two types of lessons, it was apparent that the lessons with team teaching were more efficient than the other ones. The most important reason behind this situation was the need to make collaboration before and during the interdisciplinary lessons with team teaching. While the interdisciplinary lessons with individual teaching also needed collaboration before the lessons, it did not happen, and teachers prepared the lessons by themselves. In these lessons, students could not be able to comprehend the discipline integrations because of the appearance of the lesson as a regular one, teachers' preparing the lessons individually and making the activity and the lecture parts separately. However, students mostly participated in the lessons, and their awareness about the relationship between the disciplines was created.

The interdisciplinary lessons with team teaching contributed to both teachers' and students' personal growth. Teachers' awareness about the interdisciplinary relationships was created, and they wanted to make changes in their teaching practices owing to getting familiar with the other teachers by observing their way of teaching, and discovering the content of their lessons and different material opportunities. Moreover, students' performances, interest, and engagement were higher because of involving more interactions, activity, and attractive materials (like cake or animation) in the context of these lessons. Additionally, while both students and teachers enjoyed the lessons, students started to understand the integrations of the disciplines.

Although making the team teaching were more productive compared to individual instruction, some problems regarding the way of implementation of the interdisciplinary lessons were discovered. Since we had to do the activity design workshop after half of the first term, we barely had time for the planning and implementation of these lessons. Thus, we conducted seven lessons in nearly one month. Teachers also had a busy teaching schedule owing to preparing for the school exams and the MİS exam. Therefore, in one of the interdisciplinary lessons with individual teaching, we had to conduct the lecture and practice parts separately. Besides, teachers sometimes could not find time for team teaching. All of these increased the number of interdisciplinary lessons. We also conducted all the lessons in the visual arts or English speaking lessons owing to the flexibility of these lessons. However, these sometimes created a wrong impression on students because we were seemed to take these lessons for making the interdisciplinary lessons. Besides, all the weight of these lessons was on the visual arts and English speaking teachers; the other teachers could not make enough contributions.

Additionally, while there were no reactions from some students, we confronted others' responses at the beginning or end of the lesson. They were not significant reactions that prevented the lesson process and were mostly stated by the same students. Although, as a researcher, I discovered some of the problems during the implementation of these lessons, the intensity of the lessons, the necessity of preparing for the STEM activity, and teachers' busy teaching schedule prevented us from making significant changes in the implementation of the interdisciplinary lessons.

These lessons were one of the steps to implement STEM education at school since they were expected to build the perception of interdisciplinary education before the implementation of the STEM activity. Both teachers and students experienced both types of teaching. Besides, their awareness of the interdisciplinary relationship of the disciplines was created. However, because of confronting some problems in the planning and implementation of the interdisciplinary lessons, it was understood that a proper organization should be made to realize these lessons productively.

6.7 Phase 3: Teachers' implementing the STEM activity in the class with the assistance of the researcher-designer

In Phase 3, it was intended to implement the STEM activity. There were three purposes in this phase. The first one was to make teachers gain experience in the implementation of STEM activity. The second one was to make students experiencing STEM activity with three different types of questions. The last one was trying to find appropriate strategies regarding the implementation of STEM activity to integrate STEM education into the school. For the first time, all teachers, students, and the researcher were actively involved during the implementation of the STEM activity. While the researcher and teachers had the role of guide, the students were the active participants.

6.7.1 Part 1: The implementation of the STEM activity

The STEM activity was implemented on the 9th of January, 2018, in the school library with five teachers and the same 5th-grade class (Table 6.18). There were English speaking, social science, visual arts, science, and math teachers as participants. All teachers could not be able to stay and observe the activity till to the end owing to their other responsibilities and lessons at school. One of the students also had to leave in the last one-hour because of having a workout. The activity took four lessons, and between the first two lessons, we gave 5 minutes break. After the two lessons, students took their 30 minutes lunch break. The last two lessons were conducted as a block to finish the activity. The activity was video-recorded and photographed. In addition to being a guide to students, the researcher was a participant-observer during the implementation of the STEM activity to explore the teacher's interaction with students and students' reactions to the activity. After the STEM activity, between the 11th and 18th January 2018, the individual interviews with teachers were conducted to evaluate the STEM activity and also the implementation of the DT approach in the STEM activity design process. All interviews were conducted in Turkish and voice-recorded; the duration of each interview varied between 20-48 minutes. In this phase, both the observation notes and the individual interviews were evaluated together under each question because of having three questions in the STEM activity and different teachers as participants in each question.

Table 6.18 *Information about the STEM activity*

Phase 3: **Teachers' implementing the STEM activity in the class with the assistance of the researcher-designer**	
STEM Activity	Have three questions under which there are sub-questions.
Participants	5 teachers, researcher, and 16 students (Student L left after making a prototype.)
Duration	4-lesson hours
Theme	Students' conversation at the cafeteria about the flood in Samsun and the served food in the lunchtime (food storage container, melted ice cream)
Data collection methods	Researcher observation (Video recorded), Individual interviews with teachers about the STEM activity (Audio recorded interviews between 11th and 18th January 2018)

The activity was conducted in the library because of being the most suitable place in the school. The area was organized to create an appropriate working space for students. I also brought materials to the students to be used for prototyping during the activity (Figure 6.21).

Figure 6.21. Views from the library where the STEM activity was conducted

I previously prepared a presentation for students to mention what the prototype and sketch are because of students' lack of knowledge about them. The activity started with this presentation; however, owing to the lack of time, I could only mention the sketching. After that, I presented the main theme, which was about a conversation between two students at the cafeteria about the flood in Samsun and the served food (food storage container, melted ice cream) at lunchtime. The activity included three questions under which there were also sub-questions (Appendix Q and Appendix R). At the end of the presentation, I asked the questions to the students one by one by keeping a digital timer. Although the theme of the first question is different from the others, all of the questions had to be asked on the same day because of having two weeks to the end of the term. Before starting the activity, when we wanted to arrange students' seats, they did not want to change their place. In the first and second questions, they also showed resistance to listen to their teachers and other students; however, they showed interest in the materials.

Question 1. The flood that was lived in Samsun. Question 1 was about the flood that was lived in Samsun, and students had 20 minutes to work on this question individually. In this question, the students, the researcher, the math, and visual arts teachers were the participants. This question included the science, social science, math, and English speaking disciplines inside. In this question, the reason for the flood, the ways of protection from it, a math question about the flood, and the English equivalent of the natural disasters were asked to the students (Table 6.19).

Table 6.19 *Information about question 1*

Question 1: The flood that was lived in Samsun (questions-answers)	
Duration	20 minutes
Participants	Math and visual arts teachers, researcher, 16 students
Type of the study	Individual study
Question	The question was about the reasons for the flood, the ways of protection from it, one math question related to the flood, and one question about the English equivalent of the natural disasters.
Disciplines included	Science, Social Science, Math and English speaking

The findings of Question 1. In this question, the first sub-question was related to the reasons for the flood. Its answer should have included information about social science and science disciplines, but students only replied by using their social science knowledge. The social science teacher was pleased with their answers; however, she stated that there was no science information in their responses. As previously stated, upon my request to make a change in this question owing to not involving the science discipline, the science teacher did not need to make it because of considering the reverse. Therefore, the science teacher was surprised by this result, and it was evident that it was not the right question for the STEM activity (Figure 6.22).

Figure 6.22. A view from the first question

In the math sub-question, students had difficulty to notice that the question was about the fraction. Some of the students seemed to understand the question; but, the result showed that the question was hard for them. Although the math teacher had higher expectations from the students due to making multiple lessons, she was surprised by the result. She stated that students felt confusion when confronted with the question as this quote shows:

> **Math teacher:** They got confused. The best students could not even succeed in common activity questions. Many of them could not solve that 150-250 meter question.
> **Researcher:** Did they tell you that they did not understand the question?
> **Math teacher:** They told me that they got confused and they did not know what to do. I remember how many times I repeated it on that day; you told me also. Maybe, they could not solve it when they saw on the paper.[96] (Math teacher)

The visual arts teacher considered the question higher than the students' level since they newly got familiar with STEM education. The social science teacher also pointed out students' lack of interpretation for this question, and she suggested asking similar ones to make them getting familiar with these kinds of questions. Considering other teachers' points of view, I thought that the math teacher was expected to have known the students' level when preparing her question.

> **Visual arts teacher:** Hmm, in my opinion, the question was tough.
> **Researcher:** For the fifth class?
> **Visual arts teacher:** Yes, it was tough for the fifth class.
> **Researcher:** From which point?

> **Visual arts teacher:** Academically, dear teacher. There were fractions in it. Even I could not understand it, at first sight; I was not able to comprehend it. Fractions were given for some periods, but immediately the 9th of January arrived. It was something like this […] There could be something newer. If it had been, there wouldn't have been any problem.[97] (Visual arts teacher)

> **Social science teacher:** Well, this question is a simple one; if we had given it with fractions such as 1/5, 2/5, all of them would have simplified and expanded.
> **Researcher:** So, are we talking about interpretation again?
> **Social science teacher:** Yes, we are.
> **Researcher:** Is the problem in our design?
> **Social science teacher:** Probably the problem is Turkish.
> **Researcher:** Do they lack comprehension knowledge?
> **Social science teacher:** Yes.[98] (Social science teacher)

Students also had difficulty when answering the English equivalent of natural disasters. The English speaking teacher felt disappointed about the result of the question. She could not figure out the reason for the failure since she considered that she had an effective role in the interdisciplinary lessons. She also stated that she could not make the subject repetition because of the MİS exam.

Both the math and social science teachers highlighted some of the students' bad performances who were considered successful in their lessons, such as Student G. However, the math teacher surprised about the success of Student L in this question. The science teacher associated this situation with the students' inexperience about the STEM activity.

> Student X isn't good at individual studies. Student F seems to be silent, but he is good at academically. But the students I rank for individual questions had no success, they could not do anything. For instance, we think Student L drops a bit behind the class as performance, she is a student deserving 80-90 points in my lesson, but she could. For instance, she answered the individual questions.[99] (Math teacher)

> The fact that they were not able to answer individually in Math made me upset because we worked very hard. There was nothing that they did not know, and they could do. But it was their first experience, and they were involved in such an activity for the first time, so they could not. I think we are going to see the improvement in the second term.[100] (Science teacher)

Question 2. Designing the interior of the food storage container considering the chosen food. Question 2 was about creating the interior of the food storage container, and students had 16 minutes to work on this question individually. In this question, the students, the researcher, the math, visual arts, social science, and English speaking teachers were the participants. This question included the visual arts, math, and English speaking disciplines inside. In this question, students were asked to divide the rectangular prism-shaped food storage container according to the chosen food from the given menu. Moreover, the interpretation of these divisions in the fraction expression, painting these divisions with three primary and one secondary color, and the English equivalent of the chosen food were asked to the students (Table 6.20).

Table 6.20 *Information about question 2*

Question 2: Designing the interior of the food storage container considering the chosen food (An activity worksheet)	
Duration	16 minutes
Participants	Math, visual arts, social science and English speaking teachers, researcher, 16 students
Type of the study	Individual study
Question	The question was about dividing the rectangular prism-shaped food storage container considering the chosen food, the interpretation of these divisions in the fraction expression, painting the divisions with three primary and one secondary color, and the English equivalent of the chosen food.
Disciplines included	Visual arts, Math, and English speaking

The findings of Question 2. In this question, students were concerned and confused about the divisions of the perspective of the rectangular prism. While some students only included the side of the prism and divided it into 4, some covered the whole and divided it into 16. They were expected to cover the whole by dividing it into 16 pieces; but, the question was not clear about this issue. Although 12 students took the total point, except the Student N, who divided the prism into 16 pieces, the other students divided it into 4. Student N was previously defined as one of the students who were below the class level by the teachers; however, she was the most successful one in this question. Both the math and visual arts teachers were expected to predict the lack of the question's clarity before the activity; but, they discovered it after the implementation. This issue could also be reasoned from the inexperience of the teachers about implementing the STEM education (Figure 6.23).

Figure 6.23. A view from the second question

The visual arts teacher also correlated this issue by giving this exercise as a problem which had to be solved by the students in the STEM activity. Since in the interdisciplinary lessons, they were directed by the visual arts teacher when dealing with a similar worksheet, and they were not given any activity to figure out the issue by themselves. He also considered students' concerns in the activity normal; according to him, they needed more time to understand the subject better. Consequently, the visual arts teacher found this part of the activity higher for students.

> **Visual arts teacher:** Now let me explain. We are already teaching colors in the lessons; for example, we warn children such as "use one secondary color or two primary colors" when they are painting. That is something caused by these warnings. Two primary colors and one secondary color, we are continuously repeating them. We should repeat it. This time we did not draw those sections for the lesson probably.
> **Researcher:** Yes, you asked us to draw. Afterward, we drew them.
> **Visual arts teacher:** Afterwards, we drew it like a storage box shape. They might have been confused at this point; otherwise, they would have painted in the same way if we had told them again "paint the surfaces on the right and left sides with primary colors". But the depth of the box and the perspective it has causes confusion. And this problem can be solved in a few lessons rather than one lesson.[101] (Visual arts teacher)

Having limited time for this question also caused stress on students during the activity. The math and social science teachers considered that students confused about making the separation between the primary and secondary colors when painting. Contrary to the social science teacher, the visual arts teacher perceived no problem since he valued the students' process of improvement in education.

However, he highlighted students' problems with transferring their knowledge when they painted directly with orange instead of blending the appropriate colors.

> **Researcher:** How did you feel at the end of the activity? Moreover, you probably saw two of the questions.
> **Social science teacher:** Visual arts teacher made a useful study on the design with colors.
> **Researcher:** What did you observe in the second question?
> **Social science teacher:** They could not distinguish primary and secondary colors. Besides, they were not able to paint the proportions demanded of them. (**Researcher:** Fractional expressions?) Yeah, fractional expressions. Why were not they able to do? Indeed I was worrying about this question.[102] (Social science teacher)

> **Researcher:** Then, did they have difficulty in the activity?
> **Visual arts teacher:** No, they did not.
> **Researcher:** How were they finally?
> **Visual arts teacher:** Sure, I had a look at their studies. Some of them were appropriate except a few faults, but they are going to be corrected in time, not in a while. For instance, the harmonization and blending of the colors, two colors at least. I always tell the student, but he/she takes the easy way out. He/she paints with red, then yellow, then orange. He/she paints with the orange color; in fact, I want him/her to blend red and yellow to obtain the orange color.[103] (Visual arts teacher)

Besides, Student N insisted on using white color to represent the yogurt with its original color instead of the primary and secondary colors. Student G also wanted to see a real food storage container image instead of the rectangular prism-shaped in the question. These reactions showed that for some of the students, the real problems were more appropriate than the imaginary ones.

Question 3. Producing a solution to prevent the melting of the ice cream at the cafeteria. Question 3 was about developing a solution to prevent the melting of the ice cream at the cafeteria, and students had 130 minutes (the last three lessons) to work in groups of 2. In this question, the students, the researcher, the math, visual arts, science, social science, and English speaking teachers were the participants. In every part of this question, different teachers were involved owing to having lessons in the other classes. For this question, the English speaking, science, and visual arts teachers were the ones who were most present during the STEM activity. The HPI's DT approach was also integrated into this question to facilitate the problem-solving process of the students. While teachers mentioned the contribution of the STEM activity to the students, they also pointed out the contribution of the DT approach to the students. Thus, the observation and teachers' and students' feedback provided us information about the perceived characteristics and benefits of both STEM and DT approach (Table 6.21).

Table 6.21 *Information about question 3*

Question 3: Producing a solution to prevent the melting of the ice cream in the cafeteria (Including making prototyping, poster, presentation and peer review)	
Duration	130 minutes (last three lessons)
Participants	Science, math, visual arts, social science and English speaking teachers, 16 students (one of them left after prototyping), researcher.
Until the prototyping	Science, math, visual arts, and English speaking teachers
During prototyping	Visual arts and science teachers
During the math question	Math and science teachers
During making a poster	Visual arts and English speaking teachers
During making a presentation	Visual arts, science and English speaking teachers
Type of the study	Teamwork including two people
Question	The question was about producing a solution to prevent the melting of the ice cream in the cafeteria, making their prototypes and a poster in the English language about their solutions, solving a math question related to the problem, and finally making the presentation of their solutions.
Disciplines included	Visual arts, math, science, and English speaking

This question was the only one that included making a prototype, poster, students' presentation, and peer review, and it included the visual arts, math, science, and English speaking disciplines inside. In this question, at first, students were asked questions about the reasons for the melting of the ice cream in the cafeteria. Then, they were required to solve this problem, starting from sketching to making a prototype. Later, they created a poster in the English language to present their designs, and they also answered a math question related to this problem. After the completion of all of these stages, students presented their ideas to the class and got feedback from their classmates about their designs. We also incorporated students' choices in the activity to make students evaluate and select the best project. As a result, students were the center of the activity, and they had the chance to own, manage, and present their projects.

The findings of Question 3. Compared to the other two questions, students worked more enthusiastically in this question owing to including making a prototype. Some of the students considered the activity good, and according to my observation notes, they could connect the disciplines. Thus, the third question was more efficient, and the students were more participative. In the activity, while we were expected a problem from Student B as she did in the interdisciplinary lessons, she and her teammate stated their pleasure from group working. However, Student X caused trouble from the beginning of the activity and interfered with his teammate, Student F. Because of Student X's reactions; Student F made both the idea generation and the prototyping by himself. But, their prototype's quality was better than the others, and they were selected as the best group by their peers. Except for this group, the other students were good at in the group working, and the social science teacher considered students, even the unexpected ones, having good performances in the group working: "They were good at the study with their friends. There was not a problem for the 9th of January. (**Researcher:** Were you expecting something like this?) Yes, I was expecting. But it did not matter; at least Student B was not against."[104] (Social science teacher)

The student-centered environment in the STEM activity provided an opportunity for students' engagement and group working by enabling collaboration, social interaction, communication, and exchange of ideas: "Well, Student X reacted as we did not expect from him. Apart from this, I saw they enjoyed it very much. I saw they were trying to do something. They drew, they wrote. Afterward, they talked to each other and argued how to do it: in this way or that way?"[105] (Science teacher)

The science teacher also considered the students' group working and presentations successful. She surprised some of the students' good and bad performances in group working in terms of taking responsibility. According to my observation during the presentation, Student Z took a word a couple of times, although she was considered shy by their teachers. About this finding, the science teacher thought that this kind of collaborative environment could make students act differently compared to their social relationships in terms of social interaction and self-reflection, similar to Student Z.

> For example, Student X astonished me; Student B astonished me very much. Besides, Student F also because Student F is a silent and calm boy. Very honest and kind then.

> He is not very active, but he is not an unsuccessful student, too. His effort pleased me. He worked very hard. He tried to produce something although his group friend made things difficult for him. At this point, I was astonished by Student F's effort. Student X […] We were expecting several things from Student X. He is a very active student and also very successful. It was exciting his doing nothing. It was again interesting that Student B did not behave disobediently. That is to say; they can be much more different in group work. We have realized that they can be more different than usual when they participate in such an activity.[106] (Science teacher)

> **Researcher:** Can you evaluate their presentations and group work generally?
> **Science teacher:** Positive, precisely positive. They tried very hard. For example, we chose Student Z to make a speech, although she was not able to speak well. She could even express herself; in my opinion, this is amazing. I think we have improved the children.[107] (Science teacher)

The math teacher stated that students were enthusiastic about expressing their projects to her without being asked when she was taking pictures of their prototypes. Therefore, it was apparent that their motivation and ownership of the problem were higher. Additionally, the English speaking teacher considered students' presentation as the most exciting part of the activity (Figure 6.24). She was surprised that students expressed their projects beautifully by using their imagination: "Indeed, they showed their performance but to tell the truth, I was not expecting that they would present what they did in such a beautiful way. Because they magnificently presented the simple works by imaging them."[108] (English speaking teacher)

Figure 6.24. Views from the project presentation

Additionally, students were very active when dealing with their prototypes and the materials. In this question except two of them, the other students' sketches were compatible with their prototypes, and their prototypes' qualities were good. However, students' result-oriented perspective was noticed in their problem-solving process because of developing mostly one or two ideas as a solution. The visual arts teacher also pointed out students' interest in the materials, and he was satisfied with their prototypes and drawing. Furthermore, owing to dealing with a hands-on activity, he considered that students had knowledge about materials and production techniques for making a prototype and developed their model-making skills.

> The children found an opportunity to use both the waste materials and new ones together. The stuff you brought, which included both waste and new ones were quite useful. Colorful materials arouse interest among children. They tried to use them. Beyond my expectations, as I said, then, beyond my expectations, they created several drawings and 3D products according to their class level.[109] (Visual arts teacher)

> "This is the short side, and this is the long side; e.g., the short one is 10 cm, and the long one is 20 cm. Let's draw it on the material. Then cut it with scissors. Put it on it and stick it." A child wants it to stick very quickly. The child in that class may want it. With what kind of adhesive does a material stick to other material? So, the argument begins; there are some types of chemical adhesives, and there are liquid glue, wax glue, solid and liquid adhesives in the classroom. Some adhesives do not glue or stick some materials to another. We also teach this. What kind of materials sticks to each other? Or which material holds this? We give the answers to them, so they learn.[110] (Visual arts teacher)

The science teacher observed that when using the materials, students could develop different ideas (Figure 6.25). Dealing with hands-on activities and materials also increased students' engagement and motivation. Besides, the science teacher made an analogy by saying "working like a bee" when mentioning about students' performances: "When they dealt with the materials, they directed to different ideas, also to different spots, I saw that. So seeing them working like a bee continuously […], I was delighted to see them like that."[111] (Science teacher)



Figure 6.25. Views from the sketching and prototyping part in question 3

There were unexpected students' successes, for instance, Student N and Student K, who was considered below the class level by teachers, got a total point as a group in the math question. Student M and Student L, who were believed to have academic deficiencies by teachers, also had good performances in this question. After Student L left the activity in the last lesson, Student M answered the question by herself and took the second good point from the math question. Student M also repaired her prototype by herself after her prototype fell and shattered. The science teacher considered students successful in this question since students could use their knowledge in the problem-solving process. She also pointed out the creative side of students' ideas, such as putting handle, using dry ice.

> **Science teacher:** I can say that I took the answer I expected. For example, the solutions they found for the problem by themselves were excellent. I mean, there were different ideas. A handle can be made to prevent ice cream from pouring out, for example. Or there can be non-melting ice there; I mean they had good ideas. I told them about the sublimation of dry ice. Thus, they say, 'Dry ice, dry ice!'
> **Researcher:** In other words, did they use their knowledge in a way?
> **Science teacher:** In fact, yes, they did. Of course, they used it. This result pleased me. I took a good result at this point. I think it was a good result for my field of study.[112] (Science teacher)

The findings of the implementation of the STEM activity. In Phase 3, the implementation of the STEM activity was explored by doing individual interviews with teachers to find out its effects both on teachers and students. Moreover, additional questions were asked to learn whether teachers' opinions about using the DT approach in the STEM activity design was changed. The findings of the STEM activity, along with the implementation of the DT approach provided us information about the teachers’ perceptions about the STEM and DT approach and the stakeholders’ perceptions about STEM education and regular education. In this respect, this interview was investigated under six categories: evaluation of the STEM activity-based on the teachers’ reflections and researcher’s observation, parents’ and students’ perceptions about the education and the STEM education from the perspective of the English speaking teacher, teachers’ recommendation about the implementation of the STEM education for the Main Study II and the sustainability of the STEM education at school, the perceived characteristics of the DT approach by teachers and students’ personal growth through STEM and DT approach.

Evaluation of the STEM activity based on the teachers’ reflections and the researcher’s observation. The STEM activity, including three different kinds of questions, was conducted in the Main Study I. According to the teachers’ feedback and the researcher observation, we confronted some problems and failures during the implementation of the activity. For instance, there was a problem with the activity time because the activity was held two weeks before the end of the term. Besides, before the activity, there were MİS and school exams. Thus, students were tired, and no subject repetition could be made before the activity. The announcement of the activity was also made one day before the activity.

> But we did not know when MİS (National Monitoring Exam) would be held. We did not know the exact date. It coincided with our exams. Our exams started, and MİS interrupted them. We usually make examinations having one-day breaks. For example, if an exam is made on Monday, then Tuesday no exam is held, and we make it on Wednesday, then Thursday is free, and again Friday is the exam day. Because of MİS, the students took exams every day in a week. (**Researcher:** As if we pushed their buttons) Therefore, they got bored. I mean, it was a misfortune.[113] (Science teacher)

Moreover, having three different types of questions in the STEM activity caused confusion and tiredness on students. Besides, we had some failures in answer to the first and second questions. For these failures, many reasons were discovered such as asking a question higher than the students’ level, students’ lack of interpretation of the problem, the inability to transfer their knowledge into reality, students’ unfamiliarity with the STEM education, not making changes in the context of the question, the lack of question's clarity, having less time for solving the questions and showing a realistic attitude towards the question's content. According to this, while teachers were expected to know the students' level when preparing the questions, the reverse happened. They discovered the deficiency of the questions related to students' level after the implementation of the STEM activity. These issues could be caused by teachers' inexperience about implementing the STEM activity and having fewer students' insights during the "observe" stage. Although we conducted the interdisciplinary lessons to make the students understand the connection between the subjects of each discipline, after these lessons, we could not make any activity in which they could use this information.

Students' perception of STEM education shaped their reactions to the implementations of the STEM activity. It was discovered that students reacted to a new educational approach owing to not getting familiar with it. According to the science teacher, while students enjoyed the STEM activity, they also had a problem because of experiencing STEM activity for the first time and having multiple exams around the activity time.

> To be honest, it was delightful; for the children, it was enjoyable, too. Our teacher did their best. Just because of their effort, they should have received their products, but they did not. As we talked about before, there were many factors such as exams made one after the other, being unprepared, participating in such an activity for the first time. In other words, the children were going to take part in this activity, but they were unprepared, so they did not know what would happen.[114] (Science teacher)

While both the social science and math teachers stated that students did not want to deal with the first and second questions of the STEM activity, the math teacher also considered that students did not take the STEM activity seriously owing to not being graded. According to my observations, they also had difficulty in solving these questions. While they were participative and thriving in the third question, according to the math and English speaking teachers, students gave more value to creating appealing prototypes: "But they did not like the questions asked before the activity. They gave feedback on this. They told me that doing something in the activity enjoyed them but solving questions before it did not enjoy them."[115] (Math teacher)

> **Researcher:** I wanted to look for the videos again. I noticed that they had been reticent for 15 minutes in the informatics exam. Because they were much focused, I thought they did not take us seriously.
> **Math teacher:** Because why? They once asked me whether it would affect the marks in their report cards or not. In case of the fact that they could panic and get stressed then they could not answer the questions when the report cards become involved in, I told them that it wouldn't affect the marks. At least we can say that your second or third oral examinations would be scored according to it in the second term.[116] (Math teacher)

> **English speaking teacher:** I wondered the opinions of the children, too. I asked them what they thought about the activity and half of them told us that they liked it. On the other hand, the other half said that they never liked it. When I asked, "Why?" some of them said, "Time was too short." some said, "We were going to do it better." and the others said, "It could be more excellent, but we could not." For them, these reasons made them dislike the activity. Indeed, it was not a dislike, in my opinion.
> **Researcher:** Not being able to do a good job?
> **English speaking teacher:** Exactly! I do not know if they were not satisfied with the activity. They think so, but it was enjoyable, in my opinion. Generally, it was lovely.[117] (English speaking teacher)

There was also students' personal growth in the third question, although we had problems or failures in the first and second questions. We also had unexpected successes and failures in some of the questions of the STEM activity. These results showed that students had situated behaviors and success in the collaborative and creative learning environment. After the implementation of the STEM activity, the English speaking teacher wanted to leave the study owing to having concerns about keeping up with the curriculum in the second term.

Parents' and students' perceptions about education and STEM education from the perspective of the English speaking teacher. In this study, while we accepted only teachers as stakeholders at the beginning of the study, it was discovered that students should be taken as stakeholders along with their parents. Since all of them had different expectations and concerns about students' education and they could be affected by each other. For instance, the English speaking teacher pointed out parents' variety of expectations and concerns and how they shaped teachers' attitudes towards the visual arts lesson. She also highlighted parents' worries about exams, grades, and how this could affect their decisions about participating in this study. According to her, this study was perceived as a temporary activity by parents, and they cared about whether it affected their students' success.

> What do they think about my lesson or the visual arts? They think visual arts lessons should be taught, but they ask to borrow this lesson to study times of their lessons at the moments they cannot find any extra time. Indeed, it shouldn't be like this, but we meet very mixed parent types. They all have different opinions; one of them wants his/her child to be happy; one of them demands his/ her child's success, even the most successful. One expects that his/her child will have an average success and have a job or be a teacher. Or some want that their children have an average living standard. Some parents try to teach us our job, although they are not relevant. Therefore, we should appeal to all of them and please everyone.[118] (English speaking teacher)

> **English speaking teacher:** The parents' attitude in such a manner is the point here. 5/B and 5/C classes' parents did not accept this STEM activity. They want their children to participate in such social activities, but they are always keen on academic success on the other hand. They care about high marks taken in the exams, top ranks in the tests, best high schools to go. But they also want their children to be social despite the question in their minds: If we cause our children's academic success to decline? They won't cause, in fact. In my opinion, they won't. But as long as they think like this, a social or sportive activity becomes meaningless.
> **Researcher:** Do you think that it was understood as a social activity?
> **English speaking teacher:** No, never. What I mean is that we generally reached a joint decision only with 5/X class because the others perceived the STEM activity as an extracurricular activity, not as a social one.[119] (English speaking teacher)

According to the English speaking teacher, while students liked the implementation of STEM education, they also perceived it temporary at school owing to not being a natural educational approach in their school. She also stated that the existence of the researcher during the implementations and calling STEM with the name "activity" could make students think that STEM is something fun and temporary because of the students' perception of the activity. She said that they could perceive the interdisciplinary lessons as a presentation since the subjects mentioned in these lessons were not included in their books. Similarly, according to the social science teacher, they perceived the interdisciplinary lessons as a game. Considering the teachers' feedback, students did not take the lessons seriously.

> In my opinion, this activity stroke the children's fancy. But it is entirely a question of perception. It would be better if they thought and accept that this was an education method in the school, and their lessons were taught in this way; I am sure they would have a different approach for the activity. They were probably aware of the fact that

> this was a temporary period. Or I do not know we unconsciously made them think like that. Just because of that …[120] (English speaking teacher)

> I think that we said that this is an activity, STEM activity in 5/A class, the kids perceived this STEM activity like that. In short, it was an activity, and it should be temporary, shouldn't it? Please, do not get me wrong, you're here, as a teacher from outside, might have aroused this perception. As I said before, the children could have accepted what was going on if the school had been running this STEM program and if the teachers were practicing it. In my opinion, they also see STEM as a temporary method.[121] (English speaking teacher)

> **English speaking teacher:** I think that the children listened to it as if it was a presentation. It was about the lesson, but there isn't in our course book.
> **Researcher:** Not stated?
> **English speaking teacher:** It was not stated in the book. I had told you that I was going to give additional information. Except for finding it enjoyable, probably they did not see it as a lesson since I adapted it to other lessons by adding more information. Did not it mean a lesson to them, or did they feel as if it was a presentation?[122] (English speaking teacher)

Some of the students showed reactions to the lessons which took place in the visual arts and English speaking lessons. This reaction could be due to how visual arts and English speaking lessons are perceived by students. According to the English speaking teacher, both visual arts and English lessons are admired by students and considered as a relaxing lesson. Besides, another reason discovered under the students' reactions was the fears of students being left behind from the English speaking curriculum due to STEM being performed in this course.

> Let me tell my own opinion, both English and visual arts are accepted as relaxing lessons in the school and for children. I am sure that they are going to tell the same thing if you ask them. I do not only refer to my lesson; I mean the Main Course lesson and the others also. The students like our lessons; moreover, they become happy when we enter the classroom. Of course, they get stressed because of exams, we get stressed, too. For both groups, my lesson and visual arts lessons are very relaxing, and they like them. Other fields require success academically, and they may not be loved by every child. While a child is very interested in math, the other does not like it or is involved in science more than math. It is not the same in English lessons. Maybe rarely, if a child has a very weak basis for English …[123] (English speaking teacher)

> For example, when I entered the classroom one day, the children said that their lesson had gone. They have repeated this statement many times. I always try to convince them. "I have given the units of this term. I did what I planned. Look, there are 12 units, and six units were already taught. Is there any page that we did not read? No. Is there any subject that I did not cover? No. Did you learn something extra? There are those shapes as extra information; did I inform you about this? Yes, I did. Anything to learn more? Yes. We have time for more!"[124] (English speaking teacher)

It can be concluded that, according to the English speaking teacher, students' perceptions about STEM education shaped their reactions to the implementations of the interdisciplinary lessons and the STEM activity. Therefore, it could be said that there was an alignment about parents' and students' perceptions about considering STEM as a temporary activity and giving more value to regular education.

Teachers' recommendations about the implementation of STEM education for the Main Study II. After Main Study I, teachers made a recommendation for the Main Study II upon my request. For instance, the science teacher suggested making some changes in students' groups to make inactive students actively involved. She also advised making only STEM activity instead of interdisciplinary lessons to make students more active and engaged. Since according to her, the exposure to the interdisciplinary lessons repetitively affected them negatively.

> When we observed, the children were more active in the activity. They were happier. They worked harder and released a product. Instead of asking them questions up to their ears, it will be better if we focus on making activity and releasing a product. Doing an activity seems to be more useful; well, the students become more active. Perhaps they should be taught theoretically before the activity because they should relate the subjects and then they can produce something and solve the problem we give. When we generally think about that now, they've got bored of the fact that other teachers were continuously attending to the class. If we do the same again, this will probably be reflected negatively. I do not think we can avoid this situation, because there are many reactions from the students.[125] (Science teacher)

Similarly, the math teacher suggested making only one activity, including both prototyping and questions, to make students produce something and use their hands-on skills. The other important thing that the math teacher highlighted was the activity time since the STEM activity had to be conducted late because of being back in the math curriculum. Therefore, she suggested making the activity earlier in the second term.

> **Math teacher: [**…] While questions are being prepared, they will be such questions as giving answers while making something.
> **Researcher:** Both they will use their hand skills, and they will produce something.
> **Math teacher:** I'd rather they produce.
> **Researcher:** They will be more participative.
> **Math teacher:** They will be more participative and more pleased. They will do it without getting bored.[126] (Math teacher)

Math teacher: I think that it can be better not to do the activity late in the second term as we did in the first term.
Researcher: Please tell me your advice then.
Math teacher: I am against doing the activity almost at the end of the term. In the first term, there was a significant problem because of me.
Researcher: Not just because of you, generally everyone tried to keep up with …
Math teacher: It was in general, but the most significant problem was because of me. Because I was new, I came to the school, and STEM started. And there was a half and a month gap in the curriculum. I started this newly. And only this week, I am not giving my lesson, I am making my students solve tests. I do not have any lacking in the subjects for the second term. If we do the activity before the third exam, it can be useful for their motivation.[127] (Math teacher)

Moreover, the English speaking teacher pointed out not to integrate all disciplines into one activity and suggested a better ordered, simple activity. As previously stated, I offered to math teacher making a job introduction in the Main Study II owing to students' reactions in the interdisciplinary lessons. At the end of the activity, she wanted to make this to make students aware of the jobs: "We are talking about industry 4.0 revolution and many jobs sunk into oblivion will come to life, and many new jobs will appear. The greatest help of us as their teachers is to encourage them to have a job; moreover, to reveal their interests. As a part of STEM, I want to introduce jobs in the second term."[128] (Math teacher)

What do I think about the other disciplines? I think it will be more rational to simplify it in other disciplines. You also feel in the same way, but much more organized and simplified. That is to say, it is crucial to do it by guessing its result, the product, and by simplifying it.[129] (English speaking teacher)

The English speaking teacher also recommended not making students aware of the STEM activity until the implementation day for the Main Study II since the STEM was perceived temporary by students. The science teacher was also against researcher involvement during the lessons.

Researcher: In your opinion, if I hadn't joined the lessons, would their perceptions have changed?
English speaking teacher: Maybe but we could not know this at the beginning. Of course, we can realize this after the study finished. Maybe it could be because the children know it as STEM, next term, it is essential not to call it as STEM. We shouldn't let it be noticed.[130] (English speaking teacher)

Science teacher: Are you going to join the lessons again?
Researcher: For the activity, I am going to.

Science teacher: No, not for it. For example, you were entering to our lessons, listening to us and taking photos, I mean these.
Researcher: I am going to join if you plan an interdisciplinary lesson. Otherwise, I am not.
Science teacher: In my opinion, we shouldn't plan it in this way. Because the children react negatively to this. Of course, you will come for the activity; you will be here. But we shouldn't give lessons together with two or three teachers because it causes backlash. Of course, it is necessary to be in communication with other teachers. But when you join the lesson, we receive a negative attitude from the class. Therefore, it seems more sensible not to do it.[131] (Science teacher)

Furthermore, the math teacher suggested telling the students the activity being graded to make students taking the STEM activity seriously. She also recommended making group working instead of individual study owing to enabling peer learning and collaboration.

Researcher: What can it be done in the second term then?
Math teacher: For example, the children have a fear of getting low marks.
Researcher: So, what can be done?
Math teacher: They asked, "Teacher, will these marks be written on our school reports?" I told them that they wouldn't be written because of not making them panic. Maybe we can say to them that they will affect their oral examination marks in the second term. We can say, "One of your oral exam marks will be given according to this."[132] (Math teacher)

Researcher: Would you prefer individual or group work in the second term?
Math teacher: I would prefer group work. There shouldn't be individual work because a high failure arises in individual work. I comment in this way by considering the individual questions. When there is a group work, peers get along with each other.
Researcher: And they learn from each other.
Math teacher: Also, they cooperate. Doing something in cooperation is a higher virtue. I am for cooperation.[133] (Math teacher)

Moreover, because of the STEM activity's unsolved questions, I recommended the math teacher to make a trial to understand why students could not solve the questions. After my proposal, she implemented her lesson by asking similar questions. Later, I offered to do the same thing in Main Study II, and she agreed with me (Figure 6.26) and decided to test the students about the questions before asking in the activity.

I got it teacher. Because they were test children. They have difficulty in comprehending long texts. It is better to make a pilot test in the classroom.

Is it essential to make it short the text?

I thought so.

Yes, I want to make a pilot test before the activity not to face the same problem.

Well, it will be very good.

They are used to short and clear answers as they are test students.

We will make the plan according to this.

I agree with you. In the second term, test the class before the activity. According to the result, we make a move.

Figure 6.26. Messages of the math teacher[134] (Original screenshot in Appendix W)

Teachers' recommendations about the sustainability of STEM education at school. Teachers gave reflections about the sustainability of STEM education at school. For instance, the visual arts teacher stated that accepting and adapting to the STEM education needs time and continuity and according to him, students did not get used to the STEM education at school yet. The English speaking teacher found the STEM activity beneficial because it involved the inquiry-based learning that enabled brainstorming and problem-solving. She also considered having a particular department or meeting room to gather teachers to design STEM activities collaboratively in their free time.

> Activity will go on. In the same class, with a different subject in the second term […] It will settle in time, my dear teacher. We started with hope, and we won't give up the struggle as it did not settle down. It is a matter of time. We need time in visual arts, time in social science, again time in English, time in music; it is a matter of time.[135] (Visual arts teacher)

> Mostly, I see this as an evaluation of all things we did. I think it may be so. Because from the beginning we saw all the subjects, we instructed as a whole. We asked questions to the children. We demanded documents. We wanted them to gather what they know by brainstorming. For me, it was an enjoyable activity from the beginning. It is something practical, but time is a question. I think that a particular department is needed for this. For example, a room can be given to us, and we, teachers, can come together and work cooperatively in certain times, in their free time, in common times, and then we can perform more effectively. But the limited times, the lack of communication with you, despite these, it was the best. It was the best of the impossibility. I do not have negative thoughts; in other words, I never think negatively.[136] (English speaking Teacher)

Perceived characteristics of the DT approach by teachers. The teachers' perception of the DT approach was investigated in the STEM activity design process.

Structuring the STEM activity design as a process through the DT approach. The math teacher considered using the DT approach in the STEM activity design for the Main Study II, and she referenced to the significance of the problem-solving characteristic of the DT approach because of customizing the activity design. She stated that she could design a STEM activity herself by using the DT approach and having the assistance of someone: "If I have the information you've already had, I'll say "Yes". But I cannot prepare anything again on my own; I cannot. How can I say? Perhaps I can do it with the help of someone based upon the information you gave before."[137] (Math teacher)

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating teachers' and students' perspectives. DT approach empowered teachers through interdisciplinary collaboration and teamwork in the co-design process, which in turn, facilitated getting to know the other teachers in terms of how to work with each other and enhanced teachers' and students' personal growth.

> **Science teacher:** I never thought that I could agree with the visual arts teacher, but I agree. He is a bit, hot-tempered man. (Giggles …)
> **Researcher:** As a result, you began to know each other.
> **Science teacher:** Yeah. We greet each other in the corridors, maybe at lunch. Except for these, we do not have the opportunity to meet up in the school doing a shared activity. Everyone has a lesson timetable. Lesson times do not interfere with each other. If they interfere, me with the visual arts teacher maybe, he is a bit nervous man, but he is a perfect man on the other hand. At least, we have realized how to study together, with him also. For all of us, for the teachers, this was a different experience.[138] (Science teacher)

The interaction between the teachers contributed to the teachers' personal growth in terms of changing their perceptions related to their teaching practice. For instance, the science teacher said that she could make team teaching with the math teacher for difficult science subjects since she started to be aware of the harmony of the subjects between the curricula. Similar to the science teacher, the math teacher stated how her awareness about the connection between the disciplines increased. She also surprised about the relationship between the visual arts and the math disciplines: “I used to tell I could not connect math with visual arts. I mean the lesson itself, of course, it contributed to me. Thinking differently, another thinking balloon appeared in my mind.”[139] (Math teacher)

> When I was teaching the Forces, I knew that this subject included math inside, but to be honest, I did not realize that it could be taught together with math. This is now more different for me. I can give an example to you: In sixth class, Speed is a subject. Speed subject is entirely math, indeed, and the students do not understand it. His science teacher tells it, but they do not comprehend. So a student goes to the math teacher and asks for help. He/she says, “My teacher, is it already something like math?” He/she says that “We are learning it in a science lesson, but please give me counseling to teach this subject”. Is it clear? Especially some problematic subjects in some fields are related to each other in this way. I now think that lessons can be given more effectively by gathering together with the relevant in-field teachers.[140] (Science teacher)

> We are already practicing STEM education in our lessons without knowing. My awareness of STEM education did not increase very much. Only awareness for following and adapting the curriculum increased. While giving our lessons, every lesson already involves. What comes into our minds is that we can say this is a STEM activity, and we can relate these subjects to the curriculum. Now we know this.[141] (Math teacher)

The social science stated to have an intention of making interdisciplinary lessons with science: “At first, I did not believe its practicability of the combination of lessons, yet I realized they could be combined. I am thinking of using the method to make a relation with other fields in my lessons, but as I said before, with science, not English…”[142] (Social science teacher)

As a result, teachers’ perceptions of teaching practices were changed. They started to make their lessons more consciously compared to before. They were also aware of the harmony of the subjects between the curricula. Besides, they discovered the significance of interdisciplinary collaboration and the interdisciplinary connections between the unpredictable subjects.

Teachers’ collaboration also contributed to students’ personal growth in terms of being aware of the interdisciplinary connections of the disciplines. In addition to demonstrating every discipline included math and science, they were also aware of the interdisciplinary relationship of the other disciplines such as visual arts, English, or social science: “Do you know what I have realized then? Even while I am teaching any subject, it calls their attention. For example, “Oh, here is mathematics.” “Mm, we learned this in social science.” From now on, they are aware; it arouses their interest.”[143] (Science teacher)

Additionally, after completing the Main Study I, according to the math teacher, students discovered that math is related to every discipline as this quote shows:

> For example, the fact that I taught the fractions with the help of the cake in their English speaking lesson and that they did the activity was beneficial for the sake of combining English and math. We already gave worksheets in science and social science lessons. In the visual arts lesson, to relate the perspective with the fractions was very useful again. So the children have realized that mathematics is everywhere. They have seen that all the lessons somehow include mathematics.[144] (Math teacher)

Students’ personal growth through STEM and DT approach. In this study, the researcher intended to make a change in students’ perspectives to implement STEM education and to create their awareness about the interdisciplinary relationship of the disciplines. Therefore, establishing a creative and participative environment for students to generate collaboration during the STEM activity, using the HPI’s DT approach as a problem-solving method, and enabling students’ collaborations in the third question of the STEM activity were significant for facilitating students’ perspectives. As a result, there were students’ personal growth in the DT integrated STEM question, and we perceived unexpected students’ successes in all three questions of the STEM activity.

According to the teachers, the third question of the activity provided many benefits to the students, such as increasing students’ motivation, creating unexpected students’ achievement, and students’ personal growth in terms of improving their model-making skills, self-reflection, teamwork skills and a better comprehension of the course content. Furthermore, students had good performances in group working because of taking responsibility, having excellent communication (social interaction and exchange of ideas), and collaboration. Using attractive materials and making hands-on activity enabled students’ enjoyment, promoted their creativity, and increased their interest and engagement in the activity. Students were also good at turning their drawings into real prototypes. As a result, the third question, which was DT integrated STEM question, provided many contributions to the students, and the DT approach also facilitated the problem-solving process of the activity.

In the STEM activity, students had the chance to own, manage, and present their projects, and students' choices were also incorporated into the activity. Creating a student-centered learning environment caused a human-centered STEM activity. It can be concluded that the STEM activity (particularly the third question of the STEM activity) contributed to students' personal growth.

6.7.2 Discussion of Phase 3

The implementation of the STEM activity was conducted in Phase 3. There were three purposes in this phase. The first one was to make teachers gain experience in the implementation of STEM activity. The second one was to make students experiencing STEM activity with three different types of questions. The last one was trying to find appropriate strategies regarding the implementation of STEM activity to integrate STEM education into the school. In this respect, this interview was investigated under three categories: the perceived role of the researcher in the co-design process, the perceived characteristics of the DT approach by teachers and adopting a holistic thinking mindset through the DT approach for reducing the ambiguities during the problem-solving process.

Perceived role of the researcher in the co-design process considering teachers' feedback and observation notes. During the implementation of the STEM activity, as a researcher, I had two facilitator roles, including guide and participant-observer. For instance, before the implementation of the STEM activity, I established a participative study environment in the library by arranging the place and bringing the materials and documents. During the STEM activity, both the teachers and I acted as a guide to manage the implementation of the activity. I also assisted the teachers in guiding the STEM activity if needed.

I also observed the students' reactions, their interaction between themselves, and with teachers for collecting the data about the activity and evaluating the efficiency of the STEM activity. According to this, the facilitator roles of the researcher and using the DT approach as a tool had three impacts on the study:

- Facilitating teachers' perspectives by changing their mindsets and creating awareness about collaborative lesson preparation and teaching practices to teach the STEM and DT approach and to integrate STEM education into the institution.
- Facilitating the implementation of STEM activity by establishing a participative environment.
- Facilitating defining strategies after the implementation of STEM activity and interdisciplinary lessons.

Perceived characteristics of the DT approach by teachers. According to the findings, the two attributes of the DT approach were defined: the interdisciplinary collaboration and problem-solving.

Teachers' collaboration enabled getting to know the other teachers in terms of how to work with each other. This benefit contributed to teachers' integration of disciplines since teachers' awareness increased about the connection between the disciplines. They started to think about changes in their teaching practice. The customized DT approach facilitated teachers' collaboration because of presenting a step-by-step guide in the STEM activity design. Observing students' personal growth as a result of the interdisciplinary lessons and the STEM activity also increased teachers' motivation. It directed teachers to collaborate with other teachers in their regular education. HPI's DT approach also facilitated the students' problem-solving process owing to structuring the STEM activity into the stages. As a result, it contributed to students' collaboration and interaction during the implementation of STEM activity.

We had an unexpected students' success and failures in some of the questions of the STEM activity. These results showed that students had situated behaviors and success in the collaborative, creative environment, and different types of educational applications. In this study, while we accepted only teachers as stakeholders at the beginning of the study, it was discovered that both students and parents should be taken as stakeholders. Because both teachers and parents had different expectations and concerns about students' education, and they could affect the result of the study. Therefore, the revision should be conducted in the DT approach to define the stakeholders' understanding when developing a STEM activity.

Adopting a holistic thinking mindset through the DT approach for reducing the ambiguities during the problem-solving process. The structured DT approach enabled teachers to discover the significance of a holistic thinking mindset in the STEM activity design process. In the STEM activity, students' result-oriented perspective was also noticed in their problem-solving process because of developing mostly one or two ideas as a solution.

Holistic thinking means perceiving the systems from different perspectives to build information by synthesizing all aspects into a single comprehensive one (Sibo-Ingrid, Celis-David A. & Liou, 2018). Holistic thinking is part of the systems thinking and DT approach, while systems thinking is also one of the characteristics of the DT approach (ibid). According to these findings, adopting a holistic thinking mindset through the DT approach was considered significant for teachers during the design of STEM education to develop ideas for synthesizing the disciplines. Since developing many ideas by considering all human and non-human factors could increase the opportunity to create the right STEM activity. It was also valuable for students in the problem-solving process of STEM activity to generate several ideas.

6.8 Phase 4: Focus group with students

After the implementation of the STEM activity, a focus group interview with six students was conducted to evaluate the Main Study I on the 18th of January 2018. The primary purpose of this focus group was to learn students' opinions about interdisciplinary lessons and STEM activity. To achieve my goal, I prepared my questions under four main groups: the evaluation of the STEM activity and the interdisciplinary lessons and their suggestions about the STEM activity and the interdisciplinary lessons (Appendix G). The interviews were all conducted in Turkish and voice and video-recorded. The duration of the conversation was 41 minutes. There were six students, the science teacher, and the researcher during the interview. The students were selected by the science teacher and the researcher considering their situation in the interdisciplinary lessons and the STEM activity.

6.8.1 The findings of the focus group with students

The findings of the focus group interview with students provided us information about students' perceptions about the STEM and DT approach. In this respect, this interview was investigated under four categories: students' perceptions and concerns about the interdisciplinary lessons, students' problems and concerns about the STEM activity, students' recommendation about the implementation of the STEM education, and students' personal growth through STEM and DT approach.

Students' perceptions and concerns about interdisciplinary lessons. Some of the students showed reactions to the interdisciplinary lessons in the Main Study I. According to the findings, the reasons for their reactions were related to how they perceived STEM education at school. Students also reacted to a new educational approach due to not getting familiar with it. As previously stated by English speaking teacher, calling the STEM with the name "activity" (STEM activity) made students think that STEM education is something fun and temporary owing to the perception of the activity by students. Student E and Student D supported this idea since they perceived the interdisciplinary lessons with activity entertaining. However, in these lessons, it was intended to teach the interdisciplinary connections of the subjects with the activities:

> I did not like STEM very much, but there is an aspect in which I love it. […] For example, we are routinely taught a lesson, but STEM is more joyful. (**Student D** nods and says “There are activities.”) You see, lessons are not anymore intensive when an activity involves in. This is a little bit more joyful.[145] (Student E and Student D)

Student F stated that he had confusion when learning some lessons differently because of not getting familiar with STEM education. Student A also had a concern about making the interdisciplinary lessons in the English speaking lesson owing to having only two lessons in a week: “The activity we did last week was much more joyful. But afterward, I am getting confused when some lessons are taught differently.”[146] (Student F)

> **Student A:** Because we often do it in English speaking lessons, not in the English lessons …
> **Researcher:** What disturbed you is the fact that it was done in the English speaking lesson?
> **Student A:** Mm, we already have only two lessons in a week, and they went for nothing.[147] (Student A)

Some of the students also caused problems in interdisciplinary lessons, which included math. For example, Student C felt uncomfortable about including math in most of these lessons since they also conducted intense math lessons due to being back in the math curriculum.

> **Student C:** It is nice, but I get bored of the fact that mathematics is in every lesson. Although I scarcely like math, I like learning it. But it makes me bored when it is involved in every lesson.
> **Researcher:** Is this in question for this year? I know your teachers had changed one by one. Moreover, you were pinched for time to learn the curriculum. (**Student C** nods and **Student A** says “Yes”). Did you get bored because of those factors this year?
> **Student A:** For example, let me tell you what happened this year. -Wait a minute!- Sadık teacher left, and Tuğba teacher came. Then, Tuğba teacher went, and our teacher came.
> **Researcher:** Is that right? Some new teachers came to school from time to time, do you mean it?
> **Student A:** There are already five teachers in the schools, and four of them teach us. Just that.[148] (Student C and Student A)

In the interdisciplinary lessons, we tried to show students that every discipline includes math, science, and can also include the other disciplines. About this issue, Student C, Student A, and Student E stated that before the interdisciplinary lessons, they only considered that math and science are included in everything. However, they did not think the same thing for the other disciplines. Therefore, with these lessons, they became aware of the interdisciplinary relationships of the other lessons with each other.

> **Researcher:** You see, mathematics is in everything. What do you think about science and others? For example, was the visual arts lesson involved in math, science, or social science lessons?
> **Student G:** To me, it was.
> **Student E:** It was very much involved in science indeed.
> **Researcher:** Then, did you use to think like that formerly, or did you begin to think this from now on?
> **Student E:** I used to think like that formerly.
> **Student C:** I used to think that science and math were involved. But I never thought that the other lessons could be related to each other.
> **Student E:** Only science and math.
> **Student A:** But there is something to say. Mountains, lowlands, and earthquakes are all related to science. Then we do a calculation in science, and it becomes related to math.
> **Researcher:** Ok, is it something that you have recently understood?
> **Student A:** Yes.
> **Researcher:** Did you use to think like that formerly?
> **Student A:** No.[149] (Student A, Student C, and Student E)

Student D and others also stated that the interdisciplinary lessons were necessary because of getting familiar with STEM education. Besides, Student G said his astonishment about making these lessons and the activity couple of times. Although students had problems and concerns about the interdisciplinary lessons, they had benefited from the implementation of them in terms of getting used to STEM education and discovering the interdisciplinary relationships of the disciplines other than science and math.

> **Researcher:** If there hadn’t been lessons, could you have done the activity last week?
> **Student A:** There was no science lesson already. (The others nod to confirm.)
> **Researcher:** No, no. If we hadn’t given all the lessons, if I had put the materials in front of you, then, could you have done it if the teacher had asked the same things?
> **All students:** No, never.
> **Student D:** No, we could not because we did not know how to do it, and we were not used to doing it.[150] (Student A and Student D)

> **Student G:** I wouldn't have imagined such activity if I had thought for ages.
> **Student G:** For example, what if I tried to make someone practice it one day? I think that it is useful.
> **Student G:** For example, what if I designed something like that? Then I made some people try it? I think that it would be nice. I mean, I liked this activity.[151] (Student G)

Students' problems and concerns about STEM activity. Some of the students did not want to deal with some of the questions of the STEM activity in the Main Study I. According to the findings, the reasons for this problem were related to how they perceived STEM education at school. For instance, most of the students stated their difficulty in math and English questions since they could not interpret it to find the result as a fraction. About this issue, the science teacher pointed out the weakness of students' ability to interpret the questions as follows:

> **Researcher:** You remember that your teacher believed you could solve that question, but most of you could not. Well, was it difficult for you?
> **Student A:** A little bit. (**Student C** nods.)
> **Researcher:** In which aspect was it difficult? Because it was not directly given you as a fraction question? (**Student D** nods, **Student C**: Yes.) Because you needed to find out the way on your own?
> **Student A:** Yes.
> **Student C:** If it had been given with the fractions, it would have been easier.
> **Student A:** Yeah, just about the fractions. They usually give fractional questions and tell to add, subtract …
> **Student C:** Everybody found the standard answer, not the fractional one.
> **Student A:** Indeed, the child would have gotten drowned if the water had been 1 cm. over his head.
> **Student C:** We thought like this.
> **Researcher:** You could not make a proportion then.
> **Science teacher:** Teacher, we see how weak the children's interpretation ability is.[152] (Student A and Student C)

Most of the students also could not find the English equivalent of the asked words in the activity. For this issue, while the English speaking teacher previously stated that she could not find time to make a subject repetition, Student A also pointed out the same problem for the reason of the failure in this question. Student G expressed his excitement in the STEM activity as a reason for not giving a proper answer to these questions. Students also had difficulty in the second problem of the activity, and they had confusion about the division of the rectangular prism. They further had a problem with the painting of the rectangular prism, and according to Student G, the visual arts teacher could not guide students well in this issue.

Student G: But, my teacher, the problem is the teacher; "Where are we going to paint in full?" was I asking Ahmet teacher.
Researcher: What did he say?
Student G: I said that I paint there with this. I asked whether there was somewhere else to paint. He said, "Yes, there is." And then he again showed me the same place I painted before.[153] (Student G)

Student E also stated that they could not make an appealing prototype owing to the visual arts teacher's stress on finishing the prototype faster. It was understood that the inexperience of the teacher to guide the activity could cause problems in the STEM activity. About this issue, having limited time in the activity could also affect the visual arts teacher reversely. Additionally, Student E and his teammate complained about not able to transfer their ideas into a prototype by using the materials.

Researcher: Let's talk about the activity we did last week […] Were not you pleased with the question?
Student D: No, it pleased us. Although we imagined we could not do it. We could not use the materials as necessary.
Student E: Teacher, if you had put there a shoebox, we could have done a beautiful thing.[154] (Student D and Student E)

In the third question, students were asked to provide a solution to prevent the melting of the ice cream and, some of them produced a lunch box as a solution to this problem. In this respect, students tried to make a prototype of a box because of having stereotypical images in their minds about the lunch box. Therefore, Student E wanted a shoebox to use it in the prototyping. These problems can be reasoned from having education based on memorizing and not leaving room for creativity. Besides, the reality of education can cause a challenge for the application of STEM education.

Some students stated that they wanted to spend more time and effort on the prototype instead of dealing with the questions. Besides, Student A confessed that she did not want to make an effort for the questions owing to not being graded.

Researcher: Well, my teacher, the answer to science seems unclear.
Science teacher: They could not even give a clear answer to social science. They told it very shortly.
Researcher: Why did you answer in such a way, friends?
Student A: We tried to separate more time into the prototype.

Researcher: Then you did not care about the questions only for starting to make the prototype, is that right?
Student A: No, it was not a disregard for questions; we were very keen on making the prototypes. Already I have a great interest in creating prototypes.[155] (Student A)

STEM activity enabled a collaborative learning environment for students due to including a group working in the third question. For instance, we discovered unexpected performances of Student K in their group work, although she was considered below the class level by their teachers. While the math teacher gave credits to her partner, Student G, about solving the questions, contrary to the math teacher, Student G stated their collaboration with Student K in terms of problem-solving and exchanging of ideas. Student D also pointed out the sharing of the responsibility with his partner, Student E, in the problem-solving process. Student A referred to making good cooperation with her teammate in terms of exchanging ideas and excellent communication.

Researcher: What happened in your activity, Student G? Did you or Student K answer the questions? Or together?
Student G: We answered them together.
Science teacher: Did she also answer some questions?
Student G: Yes.
Researcher: Or did she give any opinion to you?
Student G: For instance, we had an idea for a circulating fan. I only mentioned about making a fan but never thought how to operate it. Student K told me how to do and run it.[156] (Student G)

Student A: I was getting along with Student M. We had no problems. We did the activity with Student M, and we had a way with each other, so it was easy.
Science teacher: Exchange of ideas?
Student A: I drew something, and Student M wrote down. Then I wrote down, and she drew something. We did it in turn.[157] (Student A)

Student D: Teacher, we exchanged our ideas with Student E for the short questions. We thought together, and then Student E wrote down. Sometimes I wrote down.
Science teacher: Exchange of ideas […] It is nice.[158] (Student D)

As a result, because of creating a collaborative learning environment, students have a chance of collaborating to solve the problems. That enabled to exchange of ideas, the share of the responsibility, and good communication among students. Some students were not pleased with their partners. For instance, Student F and Student C complained about their partners in terms of not sharing responsibility in the group work. Therefore, there was an unequal responsibility of the teammates within these groups.

Students' recommendations about the implementation of STEM education. After completing the Main Study I, students gave their suggestions about the application of STEM education for the Main Study II. According to their feedback, some preferred a STEM activity with a prototype, while others requested an activity with both questions and a prototype. Thus, they did not want to make interdisciplinary lessons in the second study. However, some of them wanted to make both the interdisciplinary lessons and the activity similar to the Main Study I without making any changes.

> **Student E:** I want a prototype.
> **Researcher:** Something like a prototype. Would you prefer to do just the activity, not the lesson?
> **Student E:** Yes, I want an activity.
> **Student D:** Concise questions can be better perhaps but (**Student G:** Yes, concise ones) except for this, it is an activity.[159] (Student E and Student D)
>
> **Student G:** So it can be the same again. I think that was nice.
> **Researcher:** Lessons plus activity? Or is it just activity?
> **Student G:** Lesson plus activity.[160] (Student G)

Since some of the students wanted to have both questions and prototypes in the STEM activity, the science teacher wanted to get a specific answer from them. Upon her question, they favored both having a prototype and questions similar to the third question of the implemented STEM activity:

> **Science teacher:** Please forgive me, I interrupt here. It was a three-stage study like your teacher said. A question was asked, and an answer was expected. Then another was asked, and you were supposed to answer. You all want to make designs and prototypes, but questions are necessary at the beginning. Only an activity should be made, or some questions should be asked to measure the information we gave you a priority? Those questions were for measuring information and providing you use your knowledge. As a result, you made design according to what you knew about the states of matter as you answered that question in science. Should questions be asked in this way? Should the answers be expected? Or should it be only making a prototype?
> **All students:** The questions should be asked, too.
> **Student G:** When one only makes a prototype, no ideas can be put forward.
> **Student A:** We cannot tell for what the prototype is made.
> **Science teacher:** Perfect! It is good.[161] (All students)

It was understood from their answers that students cared to have the purpose of developing an idea instead of making an ordinary prototype. Moreover, they favored hands-on activities and suggested including materials and themes that can attract them to the activity.

> **Student D:** We had made some shapes with those cakes in the English speaking lesson. I think it can be better to do something like that.
> **Science teacher:** Sorry to interrupt you, my teacher. Did they eat that cake?
> **Researcher:** Yes, they did.
> **Science teacher:** Mm, I got it.
> **Researcher:** Which did you like most among the activities done for one and a half months?
> **Student E:** The one with the cake.[162] (Student D and Student E)

> **Student D:** If it's something that concerns us, for example.
> **Researcher:** Like what?
> **Student A:** Cake
> **Student D:** Toy, for example. Like that.
> **Student G:** It is addressing children.[163] (Student D, Student A, and Student G)

Student A also recommended making a subject repetition before the activity. Furthermore, Student C requested more time for making a prototype and a change in team members since she had difficulty with her teammate: "Everything can stay the same, only increase time and please change the partners."[164] (Student C)

Similar to Student C, most of the students also complained about the activity time and order and requested a better arrangement. For instance, they proposed to make the activity in a week in the separate lessons to have more time for questions. Student A also suggested the interdisciplinary lesson and proposed making it in the social activity time instead of the English speaking lesson. Besides, she recommended lesson plans to prevent making math often in the lessons.

> **Student A:** Let me say something. What about doing all the activities on different days?
> **Researcher:** Would it be better if we did it by spreading it day by day?
> **Student A, E, and C:** Yes, it would be much better.
> **Researcher:** What about doing them in separate lessons?
> **Student E:** Oh, yes, it would be amazing.
> **Student D:** It would be perfect.[165] (Student A, Student E, Student C, Student D)

> **Student A:** In my opinion, we can practice math in social activity time instead of making in the English speaking lessons every week. Our brains are clanging as "math,

math, math" I think social science and science are more related to each other, so, for one week, we can practice social science and science together, then math for another week, and then social science along with math.
Researcher: What do you think about Student A's opinion?
Student D: To me, maybe.[166] (Student A and Student D)

Students' personal growth through STEM and DT approach. Students discovered the interdisciplinary relationships of the disciplines other than science and math because of the implementation of the interdisciplinary lessons. They also got familiar with STEM education. For instance, Student C stated that making activity and the interdisciplinary lessons benefited them in terms of learning the interdisciplinary relationship of the disciplines and developing model-making skills: "This was useful for reinforcing our making the prototypes. We learned the relationship between the lessons with each other. For example, the relation between math and English or social science and science, etc."[167] (Student C)

The DT integrated STEM question provided many contributions to the students based on their feedbacks. Both teachers and students considered that students had good performances in model making, the group working in terms of taking responsibility, having excellent communication (social interaction), and collaboration. According to this, students and teachers had a similarity about the perceived benefits of the interdisciplinary lessons (Table 6.22).

Table 6.22. *Benefits of the interdisciplinary lessons and STEM activity based on students' reflections*

Benefits	**The benefits of the interdisciplinary lessons**	**The benefits of the STEM & DT approaches during the STEM activity**
Students' personal growth in terms of raising awareness about interdisciplinary relationships, comprehending the STEM education	✓	
Students' personal growth in terms of model-making skills and teamwork skills (taking responsibility, communication (exchange of ideas), collaboration)		✓
Increasing students' engagement	✓	
increasing students' interest	✓	

6.8.2 Discussion of Phase 4

A focus group interview with six students was conducted to evaluate the Main Study I. The primary purpose of this focus group was to learn students' opinions about the interdisciplinary lessons and STEM activity. They also made some suggestions for the implementation of STEM education at school. In this respect, this interview was investigated under two categories: the perceived characteristics of STEM and DT approach by students and adopting a prototyping mindset through the DT approach for facilitating STEM activity design and implementation.

Perceived characteristics of STEM and DT approach by students. The findings indicated that students connected the STEM and DT approach with interdisciplinary, collaboration and hands-on activity including a prototype (making a production). The defined characteristics were similar to teachers' feedback about the STEM and DT approach. Moreover, these findings showed that they could make good collaboration with their peers, and this collaboration could affect some students positively about their performances in the problem-solving process. It was discovered that students gave more significance to hands-on activity and making a prototype in the activity. According to teachers, all STEM, DT, and education are creative processes and include prototyping (production); in this respect, students' inclination in STEM education had consistency with teachers' vision.

Adopting a prototyping mindset through the DT approach for facilitating STEM activity design and implementation. In the STEM activity, the lack of problem's clarity and asking a question higher than the students' level was discovered in teachers' and students' reflections. According to this, while in the "observe" stage, teachers were expected to get insights about the students' academic level for preparing the questions, they discovered it after the implementations. Consequently, adopting a prototyping mindset by teachers was considered as a solution for preparing the activity questions to students' level.

The prototyping mindset was also utilized by the researcher-designer to evaluate and improve the DT approach and to define strategies for the realization of the Main Study II. Thus, adopting the prototyping mindset through the DT approach was considered significant for both the researcher and teachers in the application of STEM education to deal with the challenges and problems by creating solutions and strategies and to create STEM activity appropriate to the students' level.

6.9 Discussion of Main Study I

The findings of the Main Study I provided us information about the perceived common characteristics between STEM and DT approach, teachers' and students' holistic view of education through STEM and the DT approach, the roles and contributions of the researcher-designer, teachers, and students in Main Study I and the strategies developed for the Main study II and the interdisciplinary lessons.

Perceived common characteristics between STEM and DT approach. According to the findings, the characteristics of STEM education includes interdisciplinary collaboration, hands-on activity including a prototype (production), learning by living, and inquiry-based learning owing to involving thinking, planning, and idea generation. The characteristics and mindsets of the DT approach involve human-centeredness, interdisciplinary collaboration, inquiry-based learning, aesthetics, prototype, hands-on activity, creativity along with holistic thinking, and prototyping mindsets. Based on the DT approach integrated STEM activity, several characteristics of the STEM and DT approach are discovered, such as collaboration, interdisciplinary, hands-on activity, prototype, student-centered learning, inquiry-based learning, and self-reflection. According to this, four common characteristics of STEM and DT approach are found: interdisciplinary collaboration, inquiry-based learning and hands-on activity including a prototype (Table 6.23).

As previously stated, the STEM and DT approach have shared characteristics, and this result verifies that both approaches include a problem-solving process and hands-on activity. In this respect, the DT approach can serve to purpose of the STEM activity about inquiry-based and hands-on learning to provide students' active participation (Moore et al., 2014; Reinking, & Martin, 2018). While implementing the STEM education needs teachers' interdisciplinary collaboration (STEM Education Policy Statement 2017–2026, 2017), the DT approach also encourages dealing with multiple disciplines to develop innovative ideas (Grácio & Rijo, 2017). According to this table, the DT approach can make a significant contribution to STEM education in terms of facilitating teachers' collaboration.

Table 6.23. *The comparison of the characteristics and mindsets among STEM and DT approach inside the STEM activity, STEM education, and the DT approach*

Characteristics of STEM and DT approach inside the STEM activity	Characteristics of STEM education	Characteristics and mindsets of DT approach
interdisciplinary	interdisciplinary collaboration	interdisciplinary collaboration
collaboration		
student-centered learning	learning by living	human-centeredness
inquiry-based learning (problem-solving, idea generation)	inquiry-based learning	inquiry-based learning (problem-solving, idea generation)
prototype	prototype	prototype
hands-on activity	hands-on activity	hands-on activity
self-reflection		creativity
		aesthetics
		holistic thinking mindset
		prototyping mindset (resiliency)

Teachers' and students' holistic view of education through STEM and the DT approach. The DT approach facilitated the design and the implementation of the interdisciplinary lessons and the STEM activity. According to this, teachers discovered the scope and benefits of STEM education. They also gained a holistic view of education and understood teaching and learning as a creative process and having full of ambiguity. This study also increased teachers' awareness about collaborative lesson preparation and teaching practices. They further discovered the significance of making collaboration with other teachers when planning and conducting the lessons. This finding was a significant improvement for the study since the researcher hoped to cultivate an interdisciplinary collaborative culture between the teachers for the integration of STEM education. This study also developed students' and teachers' personal growth (Table 6.24). Through the DT approach and the researcher-designer's facilitation, teachers were able to perform various roles such as a facilitator or a guide for students in STEM education.

One of the profits of applying the DT approach for teachers in the STEM activity design was to enable and accelerate getting familiar with the teachers first and then the students by using empathy as a tool in teachers' collaboration. The literature also supports these findings that one of the most distinctive features of the DT approach is stated to identify and focus on every possible stakeholder with empathy to understand their needs with the requirement of the human-centered mindset (Camacho, 2018). In this study, these were valuable contributions for teachers since they were new to the class in which there were also new students.

Two mindset changes were defined in this study. Teachers discovered the significance of holistic thinking mindset in the problem-solving process. Besides, after learning this mindset, the visual arts teacher applied the DT approach in his teaching practices by making a plan concerning the materials and the production *before* starting the implementation. The math teacher also adopted the prototyping mindset under the researcher's guidance for testing the questions before asking in the STEM activity in the Main Study II. Finding these two DT mindsets among others are related to teachers' changing roles from "implementer" to "doer" in the current education to design the learning environment and experiences for students (Kalantzis & Cope, 2010).

Mainly, the interdisciplinary lessons with team teaching and the DT integrated STEM question provided more students' benefits compared to others. Considering Martin-Paez et al. (2019) approach, these benefits could be divided into three categories: cognitive, procedural, and attitudinal benefits. Both lessons and the activity fostered students' cognitive benefits about raising their awareness about the interdisciplinary relationship of the disciplines. Students' performance and comprehension of the course content also improved. Since the DT approach was integrated into STEM activity, this created interactive and collaborative teaching and learning environment to foster and apply students’ disciplinary knowledge into the problem-solving process. For procedural benefits, they promoted students’ creativity because of enabling independence in students’ decision-making process. They also improved their model-making skills due to engaging students’ with hands-on activity and prototyping. For attitudinal benefits, they increased students’ motivation and self-reflection. According to teachers, making hands-on activity in the lessons through the DT approach increased students’ interest and engagement in the lessons. They also developed students’ teamwork skills in terms of taking responsibility, having good communication, and collaboration. Because of incorporated students’ choices in the third question of the STEM activity, students also owned their learning during the activity. Accordingly, the implementation of the STEM education provided many benefits to students, and these findings verified the literature in terms of the expected benefits from the STEM and DT approach. Considering teachers’ feedback, students met three teachers’ expectations, such as raising students’ awareness about the interdisciplinary relationship, a better comprehension of the course content, and increasing students’ interest in the courses.

Table 6.24. *The teachers' and students' personal growth and mindset adoption in Main Study I*

	Phase of Main Study I			
	Phase 1	Phase 2	Phase 3	Phase 4
Mindset adoption and personal growth	**Teachers' personal growth:** Teachers' awareness about collaborative lesson preparation and teaching practices and having interdisciplinary knowledge. **Mindset adoption:** DT approach mindset: Teachers' awareness about holistic thinking in the problem-solving process.	**Teachers' personal growth:** Making changes in teaching practices. Comprehending the STEM education. Teachers' awareness about the benefits of making collaboration with the other teachers, the interdisciplinary relationships, and different material opportunities. **Mindset adoption:** DT approach mindset: The change in visual arts teacher's teaching practice by adopting a holistic thinking. **Students' personal growth:** A better comprehension of the course content, raising awareness about interdisciplinary relationships.	**Teachers' personal growth:** Comprehending the STEM education. Teachers' awareness about collaborative lesson preparation and teaching practices, and the interdisciplinary relationships. **Mindset adoption:** DT approach mindsets: Adopting a prototyping mindset by math teacher to test the questions before asking in the activity. **Students' personal growth:** A better comprehension of the course content, raising awareness about interdisciplinary relationships, improving students' teamwork skills, model-making skills, and self-reflection.	**Students' personal growth:** Raising awareness about interdisciplinary relationships (specifically the ones other than science and math), comprehending the STEM education, and improving students' model-making skills and teamwork skills.

The roles and contributions of the researcher-designer, teachers, and students in Main Study I. In the educational setting, the position of the researcher is important in the co-design process, and its determination is based on teachers' expertise and the previous collaboration tradition (Causo, 2016, as cited in Pivot, 2018). In this study, except for one teacher, teachers had no collaboration experiences, and all of them did not know the STEM and DT approach. Because of that, they had some difficulties in designing STEM activity and interdisciplinary lessons and managing the implementation of them. Thus, the researcher-designer had to intervene to overcome these challenges and to enable the implementation of STEM education. From this perspective, how the researcher facilitated was explored from two aspects: the different facilitator roles and the impact of the roles on the integration of STEM education.

The researcher-designer facilitated the preparation of the co-design workshop, the co-design workshop and STEM activity design process, the preparation and the implementation of the interdisciplinary lessons and the STEM activity, and creating mindset changes on students and teachers for the integration of the STEM education. In the execution of STEM education, the researcher-designer generated strategies for the implementation of STEM education at school, considering the students' behaviors, stakeholders' reflections, and recommendations. The literature also supports this finding that the design facilitator is expected to have a strategic, human-centered, and design perspectives (Body, Terrey & Tergas, 2010). While I, as a researcher, had the participant-observer role for evaluating the effectiveness of the interdisciplinary lessons and the STEM activity, I also had three different facilitator roles. In this respect, the researcher-designer had a co-designer role in the STEM activity co-design workshop and a guide role in the implementation of the STEM activity. The co-design process among teachers and the researcher-designer in the STEM activity design workshop also enabled teachers to discover the scope and benefits of STEM education and DT approach because of the contribution of the researcher-designer's educator and guide roles. As a result, along with having a researcher role, I had an expert facilitator and participant-observer roles in this study.

In the educational setting, the co-design process accepts teachers as professionals who share their experiences, expertise, and ideas with the other teachers (Potvin, 2018). In this respect, teachers were present in the STEM activity co-design process as expert co-designers to support teachers' collaborative engagement and the researcher with their knowledge. Teachers also acted as a mediator between the students and the researcher for transferring the students' data in the STEM activity co-design process, a collaborator in teachers' collaboration in the co-design workshop and team teaching process, an educator in the interdisciplinary lessons and a guide for students in the implementation of the STEM activity. Teachers considered the co-design workshop efficient because of the facilitation of the researcher-designer, the productive workshop design process including the execution of wallet design exercise, and the benefit of applying the developed DT approach as a tool in the STEM activity design process.

Teachers facilitated the STEM activity co-design process, the preparation and the implementation of the interdisciplinary lessons, and the STEM activity. The researcher and teachers worked together in the design of the STEM activity and interdisciplinary lessons, preparing for them and the implementation of the STEM activity. Both sides owned the implementation of the interdisciplinary lessons and the STEM activity commonly. In this study, the strangest topics faced by the researcher are communicating with students and students' perceptions about the courses. Since while they mostly reacted to the lessons, including visual arts and math, they barely showed a reaction to the lessons, including English speaking. The researcher also had difficulty setting the workshop date because of teachers' busy teaching schedule, and doing the workshop late caused implementing the lessons and the STEM activity in a short time.

Since teachers could observe the changes in students' academic performances and social interactions, they intervened in the context of the questions and students' groups in the STEM activity. They also canceled one of the lessons and turned it into common evaluation questions to prepare for the STEM activity. They created a new interdisciplinary lesson with team teaching by integrating two lessons. However, they had difficulty in developing ideas and perceiving the interdisciplinary relationship of the disciplines in the STEM activity co-design process. Consequently, the researcher assisted teachers in the idea-development, owing to having an interdisciplinary viewpoint. They also had a deficiency about making collaboration before the interdisciplinary lessons, and this caused more responsibility for some teachers. During the STEM activity co-design process, teachers mostly cared about the harmony in the students' group and the students who could create a problem in the activity. They also valued students' feedback about the lessons and STEM activity.

In this study, students were accepted as users at the beginning of the study. However, due to the students' reactions to some lessons and their impact on teachers, they were later considered as indirect stakeholders. Students had difficulty in this study owing to not knowing the STEM and DT approach and team teaching and not able to solve problems that needed interpretation. As previously stated that this study enabled teachers' and students' personal growth in many points. The researcher also discovered the challenges, stakeholders, and the ways for working in the educational context, and revised the DT approach for the STEM activity design and implementation considering these findings.

The strategies developed for the Main study II. Strategies for the implementation of the STEM education in Main Study II were developed considering teachers' and students' feedback and suggestions and the result of the study. According to this, the strategies were developed under three main categories as follows;

<u>Strategies for STEM activity design</u>

- Identify an activity theme which attracts students' attention to the STEM activity.
- Integrate the DT approach into STEM activity with a special emphasis on prototyping.
- Include team working for students in STEM activity. However, make a change in the existing group members.
- If appropriate, include a job introduction into the STEM activity design.
- Do not place any more questions after the prototyping part.

<u>Strategies for teachers</u>

- Test similar questions in class before implementing the STEM activity.

- Review the relevant subjects in class before implementing the STEM activity.
- Inform the students of the activity subjects before the STEM activity date.
- Grade the STEM activity in order to make students take the activity seriously.
- In grading, give more points to the “answering the questions” part than the prototyping part.

Strategy for the researcher

- Determine the date of the STEM activity in accordance with the collaborating teachers’ schedule and students’ exam schedule.
- Ensure not to students be aware of STEM activity until the day of implementation.
- Inform collaborating teachers about the necessary points of the activity to enable successful guidance in the STEM activity.

The strategies developed for the interdisciplinary lessons. General strategies for the design and implementation of the interdisciplinary lessons were developed considering teachers’ and students’ feedback and suggestions and the result of the study.

- Students should be introduced to the STEM education before conducting the interdisciplinary lessons and the STEM activity itself.
- In planning the interdisciplinary lessons, the teaching order and timing of particular subjects and their interdisciplinary compatibility with each other should be taken into account.
- Integrating the visual arts and English disciplines into the interdisciplinary lessons would be advantageous due to their interdisciplinary curricula and activity based natures.

- Conducting interdisciplinary lessons through individual teaching may be preferred when team teaching requirements concerning collaborating and scheduling cannot be met.
- In interdisciplinary lessons through team teaching, the workload of collaborating teachers should be equally distributed.
- When conducting a series of interdisciplinary lessons through individual teaching, making them consecutively would be more efficient for students' interdisciplinary learning.

The interdisciplinary lessons can be concluded with short or introductory STEM activities for increasing students' familiarity with STEM activities.

6.9.1 The revision in the design thinking approach

A revision was executed at some stages of the DT approach owing to some difficulties in applying the DT approach in Main Study I (Table 6.25).

The first stage: Understand. This study was constructed on the co-design process with the stakeholders. There was an implementation to the real stakeholders instead of an imagined user. To prevent the fuzzy front end in the study, understanding the stakeholders should be constructed in the early stages of the study to understand their latent needs or concerns. According to this, starting from the bottom up to the top is needed for system thinking to understand human interactions, needs, expectations, and to figure out the problem (Camacho, 2018). Therefore, it would be significant to start from the students, the bottom-up stakeholder, to the top and by considering all stakeholders to figure out the actual problem or opportunities for implementing a new educational approach in the school.

Considering the findings, instead of defining the target group, defining the stakeholders were included in the "understand" stage to discover all stakeholders and their concerns to implement STEM education at school. Identifying the stakeholders could also assist the researcher in understanding the setting where the DT approach was executed since the settings were situated. In this way, the problems or reactions could be predicted and prevented before making the implementations by developing the necessary strategies. Defining the stakeholder instead of a user could also show both limitations and the opportunities for the STEM activity design. As a result, defining the stakeholders, their degree of involvement, understanding their explicit and latent needs in the STEM activity design and implementation was considered crucial in the Main Study II. When all stakeholders were defined, the targeted stakeholder/stakeholders were expected to be explored by teachers to focus on the most effective stakeholder/stakeholders, to get familiar with their expectations, and to convince or motivate them to be successful in the implementations. After selecting the targeted stakeholder/stakeholders, the main point was choosing the "extreme users" as a target group from the targeted stakeholders to make the data collection easier in the "observe" stage. As a result, the "understand" stage has three parts as follows;

1- Defining the stakeholders.
2- Choosing the most effective target stakeholder/stakeholders of the study.
3- If needed, select the "extreme users" as a target group (maximum eight people) from the targeted stakeholder/stakeholders to make the data collection easier in the "observe" stage.

The second stage: Observe. Teachers had the difficulty of getting familiar with the students owing to having problems with making observations and interviews and compiling the information about the students for the next "POV" stage. Because of the changes in the "understand" stage, at this stage for obtaining the data, two ways were followed. The first one was about students who were expected to be a stakeholder; the second one was related to the other stakeholders. Since students were supposed to be one of the stakeholders of the study, to get familiar with the students, the ready-made questions were prepared for teachers to enable students' contribution to the STEM activity design as a stakeholder. Teachers could also make additions or subtractions to these questions, if needed. In these questions, there were multiple themes that were popular in the STEM activities to make students a selection among these themes. Additions or subtractions could also be made to these themes by teachers considering the subjects selected in the "problem definition" stage. In these questions, students were asked about their problems or the problems around themselves to find a real-world problem that could be appropriate for the STEM activity design. This way of approach could also make students own the problem. Since teachers previously had issues with making interviews and observations and evaluating the data, the interviews could be done with the previously selected students (the extreme users) that represent the whole class.

Other than students, there could be other stakeholders that are determined for the STEM activity design. If needed, to get more familiar with them, similar to the process in the Main Study I, teachers were expected to prepare questions (maximum seven questions) by brainstorming. Later, they were expected to do interviews with them or with the previously selected stakeholders that represent the whole.

The third stage: Point of view. After the Main Study I, the way of creating an empathy map was changed because of the addition of the stakeholders. In this respect, the empathy map was realized in four parts. At first, teachers were needed to group the information collected in the previous stages. At this part, they could gather the information on a piece of paper by arranging their answers under each interview question. They could also group their observation notes on the paper. Then, to identify the needs, conduct an analysis, and define a problem statement, teachers explored the procedure of empathy map that was created considering the data of the Main Study I. According to this, teachers were given five headings related to students to assist them in defining students' needs.

- How do students learn? (with the game, presentation, activity)
- How do students reflect themselves? (making a presentation, dealing with the project, etc.)

- What are students' interests? (sport, visual arts, music, reading science fiction books, etc.)
- What kinds of questions should be asked to students? (test, open-ended, etc.)
- How are the activities designed? (including the DT approach, prototyping, worksheet, including an exhibition, involving other stakeholders, etc.)

On the empathy map, there were options created under these headings. Teachers could make additions to the empathy map by taking the collected data into account. As a result, in the "POV" stage, the creation of empathy map had five parts;

1- Grouping the collected data of the stakeholders.
2- Exploring the procedure of empathy map to select from the options to identify the needs.
3- Exploring the limitations along with the needs originated from the stakeholders for conducting an analysis.
4- Creating a persona considering the findings of the students.
5- Identify the problem statement.

The fourth stage: Ideate. In the "ideate" stage, a couple of changes was executed, such as the addition of the *hot potato* as a brainstorming method, giving detailed directions for brainstorming, revising the evaluation part by removing the itemised response and PMI method and finally students' involvement in the brainstorming session. According to this, a print-out ideate procedure was prepared for teachers to brainstorm. It includes the below items:

- How are the disciplines integrated into the STEM activity design?
- Find the theme/problem statement for the STEM activity design.
- Create an activity plan (the process of the activity, the way to present the theme, the types of the questions, the activity time and date, who attend and guide the activity, the grades of the activity stages).

- Create mini activity or lessons to support the STEM activity (interdisciplinary lessons or conducting regular lessons covering a common theme).

After discovering the effect of the students as a stakeholder, if needed, the students' involvement could be considered for developing ideas about the theme or problem statement. In this respect, one or two students could be selected to represent the whole students.

Table 6.25 *The revised DT approach for STEM activity design for Main Study II*

	Problem Definition	**Understand**	**Observe**	**Point of view**	**Ideate**	**Prototype**	**Test**
What is it?	Identify the subjects which will be included in the STEM activity design	Identify the stakeholders, choose the most effective target stakeholder(s) and define a focus group among the target stakeholder(s), if needed	Conduct interviews with and make observations about the target stakeholders	Compile and group all data from the previous stages to identify the needs, conduct an analysis, and define a problem statement	Generate ideas for the STEM activity design	Create a prototype of the STEM activity plan through multiple prototyping methods	Implement the STEM activity in the class and revise the STEM activity plan
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	Empathy Map, brainstorming	Brainstorming, mind map, hot potato	Planning, journey map, diagram, model making	Peer review
Revisions in the DT approach	No change	Remove “Define the Target Group” Add “Define the Stakeholders”	Add an interview guide for teachers’ conducting interviews with students	Develop a structured procedure for creating an Empathy Map	Add Hot Potato as a brainstorming method Develop a structured procedure for generating ideas Revise the evaluation part by removing the itemised response and PMI method	No change	No change

CHAPTER 7

MAIN STUDY II

7.1 Goal of the study

In Main Study II, it was intended to test the revised DT approach for the STEM activity design and implementation. For this reason, co-developing and implementing a STEM activity and regular lessons through the DT approach was realized with 5th-grade teachers in the spring term of the 2017-2018 academic year (between 27.02.2018 and 05.06.2018). The study was conducted in the same private school in Samsun, where the Main Study I was held.

7.2 Data collection and analysis

Main study II utilized a case study, and qualitative research method and data were obtained through focus group interviews, individual interviews, observation and meeting notes, and mobile instant messaging (SMS and WhatsApp). All interviews were audio-recorded by the researcher after taking written consent from the participants. A video camera was used to gather data both in the STEM activity and in the workshop. Besides, photographs were taken to document the study. Videos were not shared with any institution/person, and when photographs were used in prints, the faces were blurred. Before conducting the study, all participants were informed about the aim of the study. Consent forms were obtained from the participants.

To start the analysis of the data, the digital audio files of all interviews were organized into individual folders under the name of each teacher. Then separate folders were created for students' and teachers' focus group interviews. All interviews were fully transcribed in Turkish. To save the files, I first gave codes to the collected data in accordance with the realization date from the beginning of the Main Study II. Then I gave codes to the messages and the observation notes separately (Table 7.1).

In the Main Study II, there were a total of five teachers, including mathematics, visual arts, social science, science, and the English skills teachers. As a result, the sample of the study is comprised of 16 5th-grade students and five teachers who lectured in the targeted 5th-grade class. I abbreviated teachers' and students' names to state them in the data (Table 7.2). Moreover, students' names were coded as "Öğrenci A" and "Student A" to hide their real names.

Table 7.1 *The codes related to the phases of the Main Study II and file names*

Description	Code
Main Study II	S2
Post-workshop focus group interview	P1
Post-workshop individual interviews	P2
Making interviews with teachers after the regular lessons	P3
Making interviews with teachers after the STEM activity	P4
Focus group interview with teachers after the STEM activity	P5
Focus group interview with students after the STEM activity	P6
SMS or WhatsApp communication	MSJ
Observation	Observe

Table 7.2 *The participants' abbreviations used in the Main Study II*

Participants	Abbreviation
Visual arts teacher	Art
Mathematics teacher	Math
Science teacher	Science
Social science teacher	SocialS
English skills teacher	English1
Student	ST

I saved the data as separate word processing files in MS Word, and I assigned a number to each paragraph to make it easier to locate the quotes if needed. In this study, to understand, compare, and evaluate the study, I analyzed the phases and parts of the Main Study II separately by making a comparison of the similarities and differences between the phases. The collected data was analyzed based on the template analysis method by using the same initial template of the Main Study I (See section 6.1 for data analysis). In the Main Study II, transcriptions of interview data (129 pages), observation and meeting notes (42 pages) and mobile instant messaging (SMS and WhatsApp) (58 pages) were coded through a computer-assisted qualitative data analysis software, MaxQDA.

7.3 Context of the Study

The Main Study II had five phases: co-designing a STEM activity with teachers, regular lessons conducted by teachers through individual teaching covering shared STEM activity themes, teachers' implementing the STEM activity in the class with the assistance of the researcher-designer, the focus group with students and exhibiting the outcomes of the STEM activity at the school's science fair (Table 7.3).

Table 7.3 *The five phases of Main Study II*

Phase 1: Co-designing a STEM activity with teachers
Part 1: A two-day co-design workshop with teachers Part 2: Post-workshop focus group with teachers Part 3: Post-workshop individual interviews with teachers
Phase 2: Regular lessons conducted by teachers through individual teaching covering shared STEM activity themes
Part 1: Social science lesson conducted by the teacher Part 2: Visual Arts lessons I conducted by the teacher Part 3: Visual Arts lessons II conducted by the teacher
Phase 3: Teachers' implementing the STEM activity in the class with the assistance of the researcher-designer
Part 1: The implementation of STEM Activity Part 2: Post-STEM activity focus group with three teachers to evaluate the STEM activity and the overall study Part 3: Post-STEM activity interview with the visual arts teacher to evaluate the STEM activity and the overall study
Phase 4: Focus group with students
Phase 5: Exhibiting the outcomes of the STEM activity at the school's science fair

7.4 Phase 1: Co-designing a STEM activity with teachers

In Phase 1, it was intended to collaboratively design STEM activities with teachers by using a DT approach. Phase 1 included three parts: a two-day co-design workshop with teachers, post-workshop focus group with teachers and post-workshop individual interviews with teachers. In this phase, both the researcher and teachers were actively involved in the study (Table 7.3).

Preparing before the STEM activity design workshop. We gathered with teachers three times (16th, 23th, and 27th of February 2018) for preparing for the STEM activity design workshop. Before the first meeting, I requested from teachers to bring their curriculum and their weekly schedules to learn their subjects, their day of the lessons with the targeted class, and their spare time to plan the workshop. After getting all of these documents, I prepared a list of the subjects and the example about themes to make teachers aware of each other's curricula and to make them prepared for the "problem definition" stage of the STEM activity design process before the workshop.

We gathered with teachers on the 16th of February 2018 to decide the date of the workshop. Teachers wanted to do the workshop on the weekdays. Therefore, we decided to do the workshop on the 28th of February and the 01st of March 2018. Later, I gave them a list of the subjects and the example of themes. Then, we discussed them to be more familiar with the other teachers' curriculum and the context of the subjects. Furthermore, I wanted to create the teachers' groups before the workshop. I suggested creating two groups since teachers wanted to include fewer disciplines in a STEM activity. However, the math and science teachers did not find the proposed grouping appropriate; thus, they wanted to be in one group. I also requested them to bring their weekly schedule and curricula to the workshop.

After the English speaking teacher left, the English skills teacher joined us in the Main Study II. Consequently, except for the visual arts teacher, all other teachers gathered together on the 23rd of February. In this meeting, the social science teacher stated that she could not be able to join the workshop, and we decided to meet her before the workshop. They also offered to make the STEM activity at the end of April or at the beginning of May between the two exam dates. The math teacher further requested to have group work in the STEM activity, and she did not want to make interdisciplinary lessons because of having concerns about students' reactions.

On the 27th of February, I met the social science teacher to brainstorm for defining the subjects and themes that could be used in the STEM activity. In this meeting, she connected the English skills' subject "animal farm" with the science subject of the "animals in danger of extinction". She also related this science subject with the social science subject of the "professions around me" by proposing activities such as "designing a living space for these animals to survive". On the 27th of February, I also met with the English skills teacher to explain the Main Study I, STEM, and DT approach since she could not experience the previous study. We discussed her subjects for a STEM activity. As a result, by gathering with the teachers, we made preparation for the activity subjects and themes and grouping of teachers.

7.4.1 Part 1: A two-day co-design workshop with teachers

A two-day co-design workshop was realized on the 28th of February and 01st of March 2018 to design STEM activity with five teachers by using the DT approach. The participants were the English skills, social science (partly involved in the second day), visual arts, science, and math teachers. The workshop was led and guided by the researcher-designer. The data was obtained from the observation notes. Since the workshop was video-recorded, the script of the video recordings was also used to illustrate the discussions in the workshop. The previous workshop plan was changed owing to teachers' familiarity with the STEM and DT approach (Table 7.4).

Table 7.4. *A two-day STEM activity design workshop with teachers*

A two-day STEM activity design workshop with teachers (28th of February and 01st of March 2018)	
Video recorded Duration: 17.30-20.30 Participants: 4 teachers (The math, science, English skills and visual arts teachers)	Video recorded Duration: 16.00-20.30 Participants: 5 teachers (The math, science, English skills, social science (partly involved) and visual arts teachers)
• Problem definition (40 min.) • Understand (10 min.) • Point of view (50 min.) **Interval: 10 min.** • Ideate (70 min.)	• Ideate (60 min.) • Prototype (70 min.) **Interval: 10 min.** • Test (10 min.) • Evaluation of the workshop (60 min.)

In the workshop, I created a collaborative and participative co-design workshop experience with the necessary supplies. I brought many materials (paper, sticky notes, mock-up materials, etc.) to be used in the STEM activity design process. Additionally, handouts about the stages of the DT approach and the workshop program were provided to the participants (Figure 7.1).

Figure 7.1. A view from the room where the workshop was conducted

The first day of the workshop started at 17.30, and one teacher group, including all teachers, was formed owing to teachers' requests. On the first day of the workshop, we followed the DT approach to the "ideate" stage in order to test the revised seven-stage DT approach for STEM activity design process (Table 7.5), and the STEM activity design process started with the execution of the "problem definition" stage.

Table 7.5. *The revised DT approach implemented in STEM activity design process in Main study II*

Stage	Methods	The purpose of the methods
Problem Definition	Brainstorming	Brainstorming for subject selection
Understand	Brainstorming	Brainstorming for defining the stakeholders
Observe	Brainstorming	Preparing interview questions for stakeholders other than students
	Interview	Conducting interviews with stakeholders
	Observation	Conducting observations
Point of View	Brainstorming	Compiling and grouping collected data, identifying the needs, conducting an analysis and writing the problem statement
	Empathy Map	
Ideate	Brainstorming	Ideate for STEM activity design by following ideate procedure
	Mind map	A brainstorming method which is a graphical representation of the ideas and the point of view surrounding a central theme, and it shows how they are related to each other
	Hot potato	A brainstorming method which is used to develop quick ideas
Prototype	Planning	Filling the STEM Activity Plan template about the process of STEM activity by using prototyping methods
	Journey Map	Drawing a route map to think systematically about the steps of a process
	Diagram	Venn diagram: explain some important themes and their relations with each other
		Diagrams: a process map related to the structure or the process of the idea
	Model Making	Prototyping with digital model making: Building a simple model of your idea by using digital tools
		Prototyping with physical model making (mock-ups): A three-dimensional made by using various materials (paperboard, styrofoam, paper, etc.)
		Prototyping with paper: Prototyping with large index cards to show the step-by-step process of your ideas
Test	Peer review	Sharing STEM activity designs between the groups to get feedback

Under the stage of “problem definition” of the STEM activity design process, teachers were expected to identify the appropriate subjects for the STEM activity by brainstorming. In this respect, they were first told the brainstorming rules and learned how to brainstorm. Later, based on their curricula and the given document about the subjects and the example themes, teachers were expected to brainstorm to decide the subjects of the STEM activity.

In this study, I decided to create regular lessons covering a common theme to serve the STEM activity since teachers did not want to make the interdisciplinary lessons. Therefore, while I guided teachers in that way, teachers also cared about the dates their subjects were to be taught, the possible activity problem, and the type of prototype when deciding the subjects of the STEM activity. According to the discussion based on the video recording, in the brainstorming session, the English skills teacher offered to use the “animal shelter” to be compatible with the “biodiversity” subject in science. While the visual arts teacher mentioned creating an invitation card for the “party time” subject of English skills lesson, I told him: “you can make students design cards in the class and bring them to the activity” by linking designing a card to the STEM activity. At the end of the “problem definition” stage, for the English skills lesson, the “my town” and “animal shelter” subjects, for the math, the “data analysis” and “graphics” subjects, for the visual arts, the “welcome cards’ design”, for the science, the “biodiversity” subject and for the social science “professions around me” subject were decided to be included by teachers (Figure 7.2). As a result, teachers decided the subjects together and the prepared documents about subjects and the propositions of the example themes assisted and guided them in their brainstorming session.

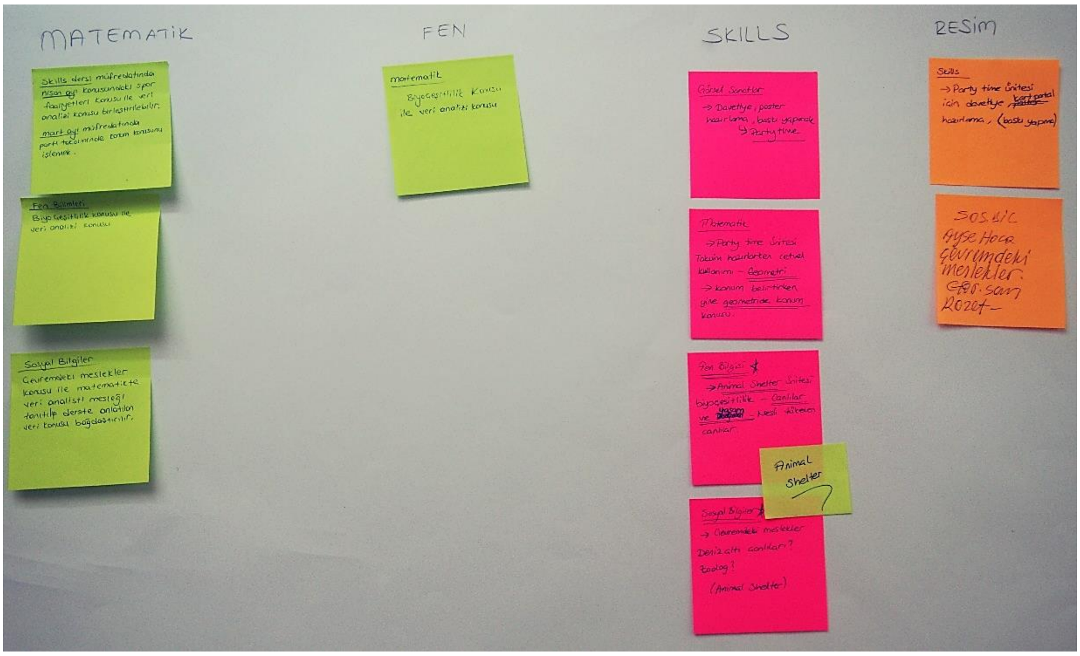


Figure 7.2. A poster from the “Problem definition” session (Original size: 50×70 cm)

In the Main Study I, we discovered the students as one of the stakeholders of this study, mainly, the students were the target stakeholder since teachers, and the parents acted according to their reactions and behaviors. Consequently, at the “understand” stage of the STEM activity design process, teachers were asked to define the target group or “extreme users” among the students. In this respect, the visual arts teacher wanted to continue with the whole class instead of selecting a target group among the students. After the visual arts teacher's proposition, the other teachers also wanted to keep with the entire class. They did not need to define the target group among the students since they had experience with the students' reactions and problems, and students also explained their problems with STEM education and group working. As a result, in the "understand" stage, they wanted to continue with the whole class as the target stakeholder of this study.

At the "POV" stage of the STEM activity design process, teachers were expected to identify the needs and conduct an analysis for the STEM activity design after collecting the data from the previous stages.[3] This stage aimed to develop a point of view to identify a problem statement. This part included two methods: brainstorming, and empathy map. Teachers first explored the print-out procedure of empathy that was created by considering the data of the Main Study I. According to this, they were given five headings that put the students in the center as being the stakeholder to guide the teachers in the creation of the empathy map (See section 6.8.1). On the empathy map, there were options created under these headings. Teachers could also make additions to the empathy map, taking into the collected data account.

In this respect, teachers looked at these options and selected among them to define what was needed to design a STEM activity. For example, when we talked about how the activities should be, while teachers favored including the DT approach in the problem-solving process of the STEM activity, the math teacher wanted to make a group. Upon the science teacher's suggestion about rewarding Student F for his accomplishment in the first STEM activity, the math teacher suggested giving a prize in the new STEM activity to make students more enthusiastic. After discovering the needs, teachers explored the limitations along with the needs

[3] "Observe" stage was not conducted in the Main Study II owing to collecting data about the students in the Main Study I.

originated from the students for conducting an analysis. Lastly, they wrote all the defined needs and insights on the sticky notes and stuck those on to the print-out ideate procedure. Later, teachers were expected to create personas considering their findings of the students. Therefore, they first examined the "persona" lists that were created in the Main Study I to decide whether there was a change and decided to make no changes in the students' lists. Finally, they created a problem statement considering the selected subjects, needs, insights, and requirements for the STEM activity (Figure 7.3).

Figure 7.3. Views from the "POV" stage

In the "ideate" stage of the STEM activity design process, the participants were asked to develop ideas for the STEM activity by brainstorming. This part included three methods, which are brainstorming, mind map, and hot potato. During this stage, first of all, the preparation for brainstorming was explained. After that, the hot potato and the mind map method were presented to be used in the brainstorming session. Then, the detailed directions were given for assisting the brainstorming session on the print-out ideate procedure. Later, the brainstorming session was conducted to develop ideas about the theme/problem statement of the activity, the activity materials, the general content of the activity, the students' research questions and the evaluation part of the activity. In the brainstorming session, teachers followed the print-out ideate procedure (See section 6.8.1).

In the “ideate” stage of the STEM activity design process, we first started to the brainstorming session about finding the theme of the STEM activity. Based on the video recordings, the science teacher favored the theme of the space. According to her experience based on students’ previous performances about the solar system subject, students could like the space theme. Upon her proposition, the other teachers accepted her offer. Then, we explored the problem and the prototype of the activity related to this theme. The visual arts teacher warned us about thinking of materials along with the problem at the same time since the material selection would be critical owing to requesting a prototype in a short time. Later, we talked about the propositions for defining the problem statement and decided to make students design a living environment in the space, including the “animals in danger of extinction” and the “future of the jobs” in the problem of the STEM activity. The visual arts teacher also proposed to make students a drawing of their imagined living place in the space to make them brainstorming before the STEM activity. Then, we continued with a discussion on a material that represents the space to be used in the STEM activity when students presented their prototypes. Later, we decided on the story of the theme and the materials that could be used during the prototyping. By remembering the visual arts teachers’ invitation card proposition, upon my offer, teachers agreed to request from students to create “welcome cards” for the STEM activity, which will represent a present of the students for the children living in one of the planets. Then, we discussed the questions’ types. Since teachers previously decided to integrate the HPI’s DT approach into the STEM activity, instead of integrating all the six stages, we decided to use the “understand”, “ideate”, “prototype”, and “test” stages for making the problem-solving process easier for students. Later, we discussed the activity process, and the English skills and math teachers decided how the activity proceeded (Figure 7.4).

The first day of the workshop has ended at 20.30; but, some details should be discussed. Therefore, we continued to the “ideate” stage of the STEM activity design process on the second day of the workshop. On the first day, the English skills teacher found the some points in the activity design process difficult to understand since this was her first time in this study. Making the workshop in the evening also made the teachers inefficient owing to their tiredness. They held on the details or the same ideas many times. Thus, I had to be involved in drawing their directions. At the end of the workshop, while teachers pleased with the progress, the math teacher stated that “this would be more efficient due to understanding the issue better. We did more things in less time.”

Figure 7.4. Participants discussing the ideas during the “ideate” stage

The science and visual arts teachers also mentioned the reactions of Student B and Student X, who stated their objection by saying, “Are we doing STEM in this term? We do not. I wish my family did not sign the form for the second term.” Teachers also stated that students in the 5th or 6th class have changeable behaviors, and thus, they can manipulate each other. Moreover, the science and visual arts teachers told us that whenever students saw three or four teachers together, they asked, “Are we doing STEM?” to us. For this issue, the visual arts teacher highlighted students’ reactions by saying, “Students want to learn the art as art, music as music and math as math.” Consequently, having situated students’ behaviors, not implementing STEM education as a regular education approach at school, and students’ perception of STEM education caused some students to have less ownership of the study.

The second day of the workshop started at 16.00 and we continued to the “ideate” stage. On the second day, for one hour, the social science teacher joined the workshop, and we made a selection of the jobs under the theme of the space from the document about the "future of the jobs" (Figure 7.5). We also discussed the type of social science questions in the STEM activity. Then, the other three teachers came to the workshop, and we finalized together our latest decision about the jobs' selection. Later, the social science teacher left to be meet with her again on the 2nd of March (the next day of the workshop) to review the activity. After that, the English skills and science teachers chose from the "animals in danger of extinction" since both of them were going to mention this subject in their lessons. Later, teachers tried to decide the date of the STEM activity, and in this part, one of the challenges was the unknown date of the MİS exam. We agreed on the date of the activity as the 4th of May 2018. It was left to May between the MİS and the last exams of the school since the subjects could not be finished in April. Furthermore, since most of the teachers had lessons on the 4th of May, they had to arrange their lessons to be able to attend the activity.

Figure 7.5. Participants made a selection from the list of the "future of the jobs"

Later, we started to deal with the details of the activity. For instance, I asked teachers to make an exhibition after the STEM activity since we intended to make it in the Main study I. The science teacher favored the idea and stated that "The school principal liked these kinds of things." Then, they decided the way of presenting the theme of the activity to attract the students' attention. We also scheduled the date of the material preparation with the visual arts teacher. Because there were national holidays ahead on us, and he had a busy teaching schedule owing to being the only visual arts teacher at school. Then, I asked to include the drawing of the poster and peer-review as we previously did in the STEM activity, and they accepted this offer. Later, we decided on the points of the questions, and I recommended giving the least point to the prototype to direct students' focus to the questions. Lastly, the time that will be given to the questions, and the last version of the activity process was decided. We decided to make the activity in four lessons, and the math teacher proposed to prepare an answer key for the STEM activity.

Along with the STEM activity, three lessons were also decided to be taught for the STEM activity. The first one belonged to the social science teacher in which she taught "the future of the jobs". The second and third ones belonged to the visual arts teacher in which students designed "welcome cards" and made "the picture of the living environment in the space". After deciding the details of the STEM activity, the "ideate" stage of the STEM activity design process was completed (Figure 7.6).

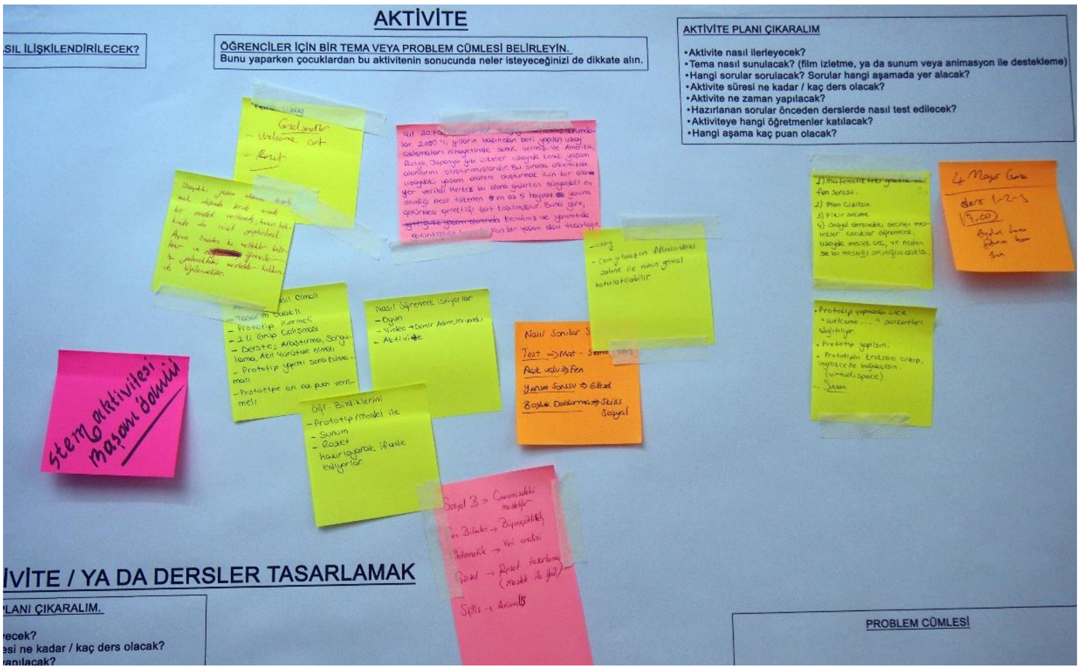


Figure 7.6. A poster from the brainstorming session on the print-out ideate procedure (Original size: 50×70 cm)

In the “prototype” stage of the STEM activity design process, teachers were asked to fill the STEM activity plan template. This part included six prototyping methods: journey map, Venn diagram, diagram, model making including mock-up and paper prototyping. At this stage, teachers got information about the prototyping and the ways for its realization. Later, teachers filled out their STEM activity plan template about STEM activity and the lessons. While creating the STEM activity plans, teachers also used the journey map (Figure 7.7).

The “test” stage of the STEM activity design process was the last stage of the DT approach, and this stage included the implementation of the STEM activity on students. In this section, some suggestions for the implementation of the STEM activity and the points to be considered for the preparation of the activity were presented to the teachers. In this section, one of the most critical challenges was how, when, and by whom students would be informed about STEM activity since, according to the teachers, students did not want to deal with the STEM. We decided to wait to explore ways to tell the STEM activity to the students owing to students’ situated behaviors. The second day of the workshop finished with the “test” stage at 19.30, and later, I conducted a one-hour focus group interview with teachers.

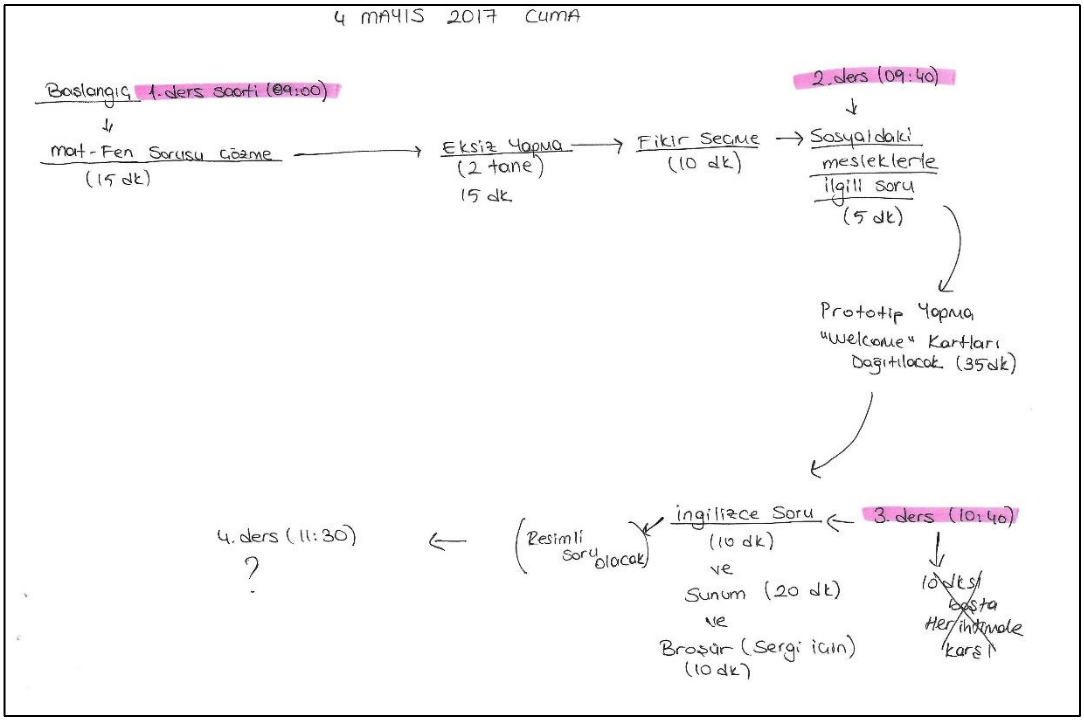


Figure 7.7. A journey map for the activity implementation procedure (Original size: 21×29 cm)

The findings of the two-day co-design workshop with teachers. A two-day workshop was realized with teachers to design a STEM activity by using a DT approach. The observation and meeting notes taken before and during the workshop were analyzed from two points; the researcher's role in the workshop and the teachers' experiences about the design thinking approach. Because of teachers' involvement as a stakeholder, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and researcher-designer in the STEM activity design. According to the findings, the co-design process among teachers and the researcher enabled teachers to develop ideas for synthesizing disciplines. Moreover, in the workshop, the English skills teacher mentioned her previous term-experience with the students about their inability to use the ruler in the activity, and she learned from the math teacher that they would learn using the ruler in that term. That was the information she did not know until making collaboration with the other teachers. Therefore, with this workshop, experiencing interdisciplinary collaboration enabled teachers to get familiar with the other teachers in terms of their disciplines. The interdisciplinary collaboration also enabled idea sharing between the teachers in the "problem definition" and "ideate" stages when selecting subjects and developing ideas for the STEM activity design. Besides, the interdisciplinary collaboration and the co-design process were found significant for the lesson and activity creation. Since teachers and the researcher collaborated for the context of the lessons and the STEM activity.

Before the workshop, I, as a researcher, organized and guided three meetings to prepare for the workshop with teachers. I also met with the social science teacher before the workshop to discuss her subjects since she could not be able to join the workshop. Besides, I transferred her ideas to the workshop to inform the other teachers. I further met the English skills teacher to explain the Main Study I, STEM, and DT approach. In the workshop, teachers were guided by me in the STEM activity design process. As a researcher, I was also a mediator during the "problem definition" and "ideate" stages between the teachers to facilitate their exchange of ideas.

In this workshop, the DT approach was applied in the two places; it was executed to facilitate the STEM activity design process and integrated into the STEM activity to simplify the problem-solving process. At the end of the workshop, teachers considered the workshop efficient. They stated their satisfaction with understanding the STEM and DT approach and finishing most of the stages of the DT approach in a short time. Before and during the workshop, teachers mentioned students' reactions and situated behaviors about the STEM education, parents' concern about students' grades, and both parents' and students' concerns about following the exact curriculum. These issues led the researcher to find strategies about not making students aware of the STEM activity until the implementation day.

7.4.2 Part 2: Post-workshop focus group with teachers

After the workshop, a focus group interview was conducted with four teachers to evaluate the workshop. I made changes in the focus group interview questions considering the data of the Main Study I. According to this, I prepared my questions under eight main groups (Appendix H): the evaluation of the workshop, the role of the DT approach in the STEM activity design, the role of the researcher in the workshop, teachers' perception about the design, the teachers' and students' expectations from the STEM education, the teachers' plans about implementing the STEM education, the collaboration among teachers and their suggestions about the workshop and the DT approach. The interview was conducted in Turkish and voice and video-recorded; the duration of the conversation was 65 minutes. There are five purposes of the focus group interview: The first one was to learn teachers' opinions about the workshop process. The second one was to find out the efficiency of the DT approach in the STEM activity design process. The third one was to get an evaluation of the role of the researcher-designer in the workshop from the teachers' perspective. The fourth one was to learn the requirements about the implementation of STEM education from the teachers' perspectives. The last one was to discover teachers' and students' expectations about STEM education from the teachers' perspective.

The findings of the post-workshop focus group interview. The findings of the focus group interview provided us information about the researcher roles, the workshop process and the teachers' perceptions about the STEM and DT approach. In this respect, this interview was investigated under seven categories:

- Teachers' higher expectations about the study originated from their familiarity with STEM, and the DT approach and motivation reasoned from activity theme.
- The perceived characteristics of the DT approach by teachers.
- Perceiving students as creative agents through the DT approach in the STEM implementation.

- The need for STEM education in the current education system based on the findings of the Main Study I and II.
- The perceived role of the researcher in the co-design process.
- Teachers' and students' personal growth through STEM and the DT approach.
- The perceived qualities of STEM education by teachers.

Teachers' higher expectations about the study originated from their familiarity with STEM, and the DT approach and motivation reasoned from an activity theme. After the workshop, teachers gave positive feedback about the result of Main Study II. They had higher expectations from this study owing to understanding both the STEM and DT approach and finding the activity theme and subjects enjoyable and exciting.

> **Science teacher:** But of course, I do not know if there is an advantage of our suffering at that time (She meant Main Study I). But naturally, we spent a very long time, and we were working in an area we did not know. We were trying to figure something out. That's why that work became a base for us. It was like we were putting it on. It was more comfortable. For example, in my way, my perception was much more comfortable.
> **Math teacher:** We were able to develop ideas more comfortably.
> **Science teacher:** Exactly.
> **Math teacher:** For example, we were less tired than the first period. I think the subjects of this period are more suitable for STEM, and at least it is pleasurable well. Space, this that, this is what we all wonder. I think it'll be more fun.
> **Researcher:** You were also interested in the theme.
> **Math teacher:** Let's say we were interested in the theme, and we learned STEM. That's why it was fun.
> **Researcher:** You, teacher?
> **Visual arts teacher:** Dear teacher, it is essential to grasp the event in a study. In the first term, we have understood it, and because of that, it became easy.[168] (Math, science and visual arts teachers)

Furthermore, the math teacher considered the academic success unimportant after discovering the unexpected students' progress and failure while she previously evaluated the students based on their current success. Therefore, she had a change in her perspective about students' success after the Main Study I. This result also showed how success is situated and isn't dependent on academic achievement.

That also implied the significance of considering students' changeable behaviors when evaluating the activity.

> **Math teacher:** I also understood that success is not very important. For example, Student K was an academically weak student, but she gave the best answers.
> **Science teacher**: Yes.
> **Researcher:** Yes, there were Student M and Student L.
> **Science teacher:** Really, there were Student M and also Student L.
> **Math teacher:** Student M and Student L are together the weaker group actually, but we have learned that they were better. Student C, Student D, and Student G disappointed me much, while we waited for them to answer those questions.
> **Science teacher**: Yes.
> **Visual arts teacher:** I agree with friends, the student is situated.
> **Science teacher:** Of course, isn't it, teacher?[169] (Science, visual arts and math teachers)

Perceived characteristics of the DT approach by teachers. This interview was investigated about the teachers' perception of the DT approach in the STEM activity design process.

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating the STEM activity design process. DT approach empowered teachers through interdisciplinary collaboration and teamwork in the co-design process, which in turn, facilitated the integration of disciplines and enhanced teachers' educational perspectives. Besides, the interdisciplinary collaboration among teachers provided raising awareness about the interdisciplinary relationship of the subjects, and getting familiar with the other teachers in terms of learning their curriculum and teaching experiences. For instance, the visual arts teacher astonished about the English skills curriculum and it's relation to the visual arts lesson.

> **Researcher:** We worked interdisciplinary. Not only me and you, but you are also teachers from different disciplines. Have you had any issues in which you have agreed or disagreed within two days?
> **Math teacher**: It did not, well I did not see a discrepancy, no difference. Not in the first term.
> **Science teacher:** Exactly, well, an idea came upon an idea, and different things, different products came out.
> **Visual arts teacher:** Yes.
> **Math teacher:** Yes, well, at least different things came to my mind from the word of others.
> **Researcher:** You mean you triggered each other?

Math teacher and Science teacher: Yes, yes.
Math teacher: So it was harmonious.
Science teacher: I think there is no discrepancy.[170] (All teachers)

Visual arts teacher: Even though I am a visual arts teacher, apparently, there is an invitation system in English, and I never thought this could happen.
English skills teacher: So you did not think you could have a party, prepare a brochure for that party and send an invitation?
Visual arts teacher: Well, one day in another event.
English skills teacher: That's what I mean by being aware. (**Science teacher:** Yes) In fact, if we had some knowledge of each other's curriculum, such as "they are very relevant to each other".
Visual arts teacher: The group of teachers, the matter is the group of teachers.[171] (Visual arts and English skills teachers)

With this study, teachers experienced the beneficiary points of working together since most of them had no previous experience with interdisciplinary collaboration. Therefore, the teachers stated their requests about making collaboration with each other after the study.

Visual arts teacher: I am especially open to this. Well, I want friends to come and ask me anything.
Science teacher: Let's help each other, right?
Visual arts teacher: Yes
Science teacher: Actually, with this, we have seen that we can do it.
Visual arts teacher: Yes, yes.[172] (Visual arts and science teachers)

Structuring the STEM activity design as a process through the DT approach. In this workshop, one of my purposes was to find out the efficiency of the DT approach applied in the STEM activity design. According to teachers, DT approach structured the STEM activity design as a process by dividing it into meaningful steps to solve the activity design problem and synthesized the disciplines. For instance, according to the English skills teacher, having five disciplines inside the STEM activity made the problem complex, and the DT approach could synthesize these disciplines, although she doubted that before. Moreover, both the math and science teachers pointed out the guide role of the DT approach in the STEM activity design due to making the activity design tangible for teachers.

English skills teacher: At first, I thought a lot about how to adapt the curriculum, programs, and subjects of 5 people. I thought it would be tough. I was scared, so I had a prejudice.
Science teacher: Yea, at first I thought of that too.

English skills teacher: But it happened, it was pretty good.[173] (English skills and science teachers)

Researcher: So, you worked as five disciplines together by using the design thinking approach, what did the method give you in terms of ease or difficulty in bringing together these five disciplines?
Science teacher: Because it was step by step because there was a row.
Math teacher: Because it has a rule.
Science teacher: Because it has a rule, naturally, before it became complex, what we should think about, then what steps we should move on to was given to us by you.
Math teacher: Well, when we worked, we did not think what we did or what we were going to do. We said we did it; we did it, now we're going to do this.
Science teacher: There was a guiding system. Do you know what I mean?[174]
(Science and math teachers)

They also considered the documents in the "POV" and "ideate" stages useful because of making progress faster in the activity design. While the math and science teachers found following the DT approach easier in this workshop, they stated their difficulty in the Main Study I due to meeting the STEM and DT approach for the first time. They emphasized the necessity of learning and following the DT approach when learning the design of the STEM activity for the first time. They also highlighted the need for the DT approach and the researcher-designer to design a STEM activity for the second time owing to providing a guide in the activity design.

Math teacher: Well, for the first time, yes, we needed those steps because we did not know what was what and we learned in the first term.
Science teacher: I am interrupting your word; for example, the name of the steps, even the name, in general, was making me scared.
Math teacher: Yes, yes.
Science teacher: For example, it is perfect for us to go by step by step since the beginning of the first period.
Math teacher: To learn for the first time, everyone must study these steps one by one.
Science teacher: Yes, it needs to be implemented.[175] (Math and science teachers)
Researcher: So if I brought 4 or 5 teachers here and say sit down friends, and if I made you spend a day together, would you can design and create an activity and get out of it like this?
Science teacher: I think it would have missing parts.
English skills teacher: There would be deficiencies because your contribution is too much.
Researcher: I'm not giving anything, and I'm not in it as well.
Math teacher and science teacher: Then we could not handle it in a day.
Visual arts teacher: We could not have done it in a day; only if we had printed plans ... (He meant the documents related to DT approach)

> **Math teacher:** You know, you come with this kind of paper (She meant the documents related to DT approach) in your hand, or even if there are similar ones, still in a day…
> **Visual arts teacher:** But we manage from that (He showed the documents I handed out them)[176] (All teachers)

Perceiving students as creative agents through the DT approach in the STEM implementations. In the Main Study I, we confronted some unexpected problems caused by students, and teachers could not predict them before the executions. Both the science and math teachers related this issue with the student's changeable behaviors which affected the result of the Main Study I as this quote shows:

> **Researcher:** We had expectations in the first period, and later we realized that there were points that did not match with the students. What can you say about it?
> **Science teacher**: Now I say children are situated (**Math teacher:** Yes), it is very relevant to the changeability of the children.
> **Math teacher:** We've too much -I'm talking for the first term-, we've dreamed too much. Our expectation was very high, but we did not think they could change, or anything negative at all. We thought they would solve it and do it.
> **Science teacher**: The negative ones we thought threw us a curveball.
> **Math teacher:** Yes, that's what I'm saying. We dreamed a lot.
> **Science teacher:** Well, I'm really linking it to the student. We thought the student-centered as a result; we have always made plans through them. Groupings, etc. Their relationship with each other, their success situations [...] But it is so variable that it can change so much in a short period, which affected us a lot. Of course, this affected the results we received very much.[177] (Science and math teachers)

In the Main Study II, teachers stated that being familiar with the students in one term and having experiences about the students in the implementation of the STEM education made the activity design easier in the workshop. As a result, the experiences gained in the Main Study I impacted the activity design of the second study.

> **Researcher:** Well, you've known the class since the first term. Did this make it easier for you to plan the activity?
> **English skills teacher and Math teacher**: Yes.
> **Researcher:** In what way?
> **Visual arts teacher:** Personalities.
> **Math teacher:** We discovered what their interests are as children's dream worlds.
> **English skills teacher:** For example, we said that in choosing a profession, we should select that. For instance, Student L wanted to be a tailor. I mean, we're more or less able to figure out who is going to be a lawyer, who might wish to what.
> **Math teacher:** Doctor, space doctor. Of course, there were benefits to it.
> **Science teacher:** For example, if we start from groupings, after that activity, we can say that this grouping should not be like this, we should change it.

> **Math teacher:** So we saw that the child we see as a problem is not a problem; the child we do not realize is the biggest problem.
> **Science teacher:** Exactly.[178] (All teachers)

After their discovery about the importance of getting familiar with the students, I wanted to investigate how teachers make a STEM activity in another 5th class for the next year. For instance, because of the changeable behavior of the students, the English skills teacher preferred to make the same activity that we designed to get familiar with the students instead of creating a new one. If needed, she considered making changes to the same activity after the implementation. However, according to Akgündüz et al. (2015), "learning through trial and error is time-consuming for individuals" (p. 23). Besides, the math teacher preferred to get familiar with the students in the first term and to make the STEM activity in the second term. She also stated that she could think to make the STEM activities in both terms by not making students aware of the STEM activity until the implementation day.

> **Researcher**: Would you apply this activity in the same way for a different class next year?
> **English skills teacher:** I would do the same again, so trial and error is a method.
> **Researcher:** So the first term is a try, and after that, in the second term, you may make changes.
> **Visual arts teacher and English skills teacher**: Sure.
> **English skills teacher:** Even the students we know, we cannot predict how they will react. (**Science teacher:** We cannot predict, correctly.)
> **English skills teacher:** So we can take into account that we can be surprised, this time when doing the second activity.
> **Visual arts teacher:** Each time is an experience.[179] (Visual arts and English skills teachers)

> **Researcher:** Well, if you wanted to do what you did to the 5th class this year to another 5th class next year, would you do these activities in the same way, or would you make changes?
> **Math teacher:** At least, I would do a single activity in the second term, so that I could analyze them in the first term. So I won't be disappointed as we did the first term.
> **Math teacher:** Well, I would do it every two terms, but I would do it without going into the lessons, without making them realize. Now I'm saying that they're aware of everything when they see three or five people together, they do STEM. [180] (Math teacher)

In the Main Study I, teachers discovered that one of the most prominent ambiguities in this study was students' situated behaviors. Teachers also learned that students were the creative agents in the STEM education, and implementing the creative process similar to STEM and DT approach included ambiguity in teaching and learning. From the point of DT approach, this meant following students' behaviors until the implementation of STEM activity to develop the necessary strategies if needed since students' insights based on the collected data could be changed throughout the process.

The need for STEM education in the current education system based on the findings of the Main Study I and II. After executing the Main Study I and conducting two co-design workshops, teachers discovered the necessities to implement STEM education at school. Students also expressed what they expected from STEM education. In this respect, the science teacher pointed out the importance of including the prototype along with the game-based activities to engage students with hands-on learning through STEM and the DT approach.

> **Researcher:** How would you like to do STEM?
> **Science teacher:** Well, yes, these are children, of course, they will want games, of course, there should be games on it, and they should have fun and learn. There is no point in doing this if we are just going to teach a lesson or if the children will see no difference at all. But what is STEM's purpose anyway? In fact, what do they in STEM? It is putting the things we give in theory into practice.
> **Researcher:** We already call the use of information.
> **Math teacher:** Yes, yes, is that information available?
> **Science teacher:** Exactly, for example, we made them a prototype, did not we? How they liked it. That should be done and absolutely done.
> **Math teacher:** They loved it.
> **Science teacher:** Well, one-to-one continuously theoretical explaining, etc. there should be games, and they should have fun.[181] (Math and science teachers)

The science and math teachers highlighted the need for the interdisciplinary curriculum to make quick teachers' and students' adaptation to STEM and to prevent students' reactions. The visual arts teacher also pointed out the significance of teachers' collaboration in STEM education since, as previously stated, after experiencing the interdisciplinary lessons, their perceptions about teaching have changed. The math teacher noted that this type of education should be designed to enable teachers' collaboration and interdisciplinary lessons.

Math teacher: But this has to be modeled systematically from the first grade on to education.
Researcher: Well, if we give it at once, it is natural for them to react.
Science teacher: Exactly.
Math teacher: In other words, if the child grows up in this system, the teacher tells the lesson by making them fun with the game, it becomes more permanent, and the child would not object because he will understand that the education is like this.
Science teacher: And you are teaching physics to the student, “Where do I use it in my life, my teacher?” he says, while it is in life. For example, I am teaching science, then a student asks, “how is this going to be useful” while it is in life. If this STEM was introduced from the beginning, the child would be in this system. If he continues to receive his education, it will be put in his head, and there will be no such question.[182] (Math and science teachers)

Visual arts teacher: What should my new teacher friend do? He should come to me and for two minutes, three minutes he should go into my class or we should arrange opportunities for each other.
English skills teacher and Math teacher: Yes, yes.
Visual arts teacher: Or, even comes into class and says, “Guys, the ruler is like this, there is something like that, let's attach them.” Very quickly.
Math teacher: This education needs to be modeled.
Visual arts teacher: It needs to be comprehended. Otherwise, I do not get involved in the English skills teacher's job, nor does she interferes in my business.
Science teacher: Of course, exactly. (English skills teacher shook her head for approval.)[183] (All teachers)

There was a lack of collaboration culture and interdisciplinary curriculum at school. According to this, the following conversation between the researcher, English skills and math teachers demonstrated how collaborative culture is vital in designing a STEM activity in terms of finding the relationship of subjects.

Researcher: I would like to ask if you would choose the subjects in this way.
English skills teacher: I could have made this distinction if I had noticed that it was related to my subject. But if I knew about it.
Math teacher: Yes, at least at the beginning of the term, it is said that this is my subject.[184] (English skills and math teachers)

It was discovered that teachers used their past experiences when designing STEM activities. In this respect, the familiarity with the students had a significant place since students had changeable and unpredictable behaviors. For instance, the science teacher wanted to include the space theme in the STEM activity due to her experience with students in the first term about the subject “solar system”.

Science teacher: For example, this is entirely related to my first unit, well in general, creating the living space, being in the space. Students were very interested in the first unit; students like to research. And also they have an interest, and some have more

interest. For example, in other classes, we have very interested students. If only they could be in this activity, believe me, different things will come out.
Researcher: A few children in the library came to me and asked if they were going to do it as well, and I said no.
Math teacher: Because they saw something different there than the book.
Science teacher: Well, for instance, because I taught in the first unit, I thought about different things naturally because I knew how children react and want. So it makes you wonder whether or not this can happen. So it helped me a lot. In other words, I have benefited from the unit of the first period.[185] (Science teacher)

Furthermore, one of the limitations of this study was that none of the teachers had experience with STEM education; this constraint affected teachers' idea development negatively in the Main Study I.

Math teacher: I think the same goes for you. For example, we all know that it came from Bahçeşehir. For instance, I met someone who worked there by chance, and they regularly go to İstanbul for STEM training. Perhaps if you had teachers who were routinely trained, it would have made things much different. The same goes for you.
Science teacher: Sure, exactly.
Researcher: I could have asked for different products and things.
Math teacher: Yes, something different, more creative, more original, would have come out.[186] (Math and science teachers)

It was discovered after both workshops that collaborating with experienced teachers could be beneficial to take advantage of their past experiences, to guide the other teachers while developing ideas during the STEM activity design. For instance, both the visual arts and English speaking teachers developed ideas more quickly, and they were more aware of the interdisciplinary relationship of the subjects compared to the other teachers. The visual arts teacher's past experience about collaboration and team teaching with the community of the teachers also made his adaption to the STEM education easier.

Perceived role of the researcher by teachers in the co-design process. In the focus group interview, the role of the researcher-designer was explored to discover her contribution to the STEM activity design. The findings suggested that as a researcher, I had many facilitator roles, such as facilitating the workshop process by having a holistic viewpoint, guiding teachers, developing ideas by being a co-creator, and educating teachers about the STEM and DT approach.

Researcher: What if I asked you to describe my role in the workshop?

Visual arts teacher: A must.
Science teacher: Definitely, a must.
Math teacher: Instructive.
Researcher: What if you give an adjective?
Math teacher: Everything, idea developer, instructive.
Science teacher: Expert, instructive, all.
Math teacher: Expert, instructor, planner.
Visual arts teacher: To be able to see a broader range, not through glasses.
Math teacher: Yes. So your contribution to us is excellent.
Researcher: I thought you would say one adjective.
Science teacher: Because now I see that if we were on our own, you prepare everything, you lead.
Math teacher: You lead us.
Science teacher: You have already tried to teach us this system from the beginning, so I think one adjective is unfair to me.[187] (Math, science and visual arts teachers)

The math teacher associated this study by making design in education. She also favored working with a designer in the two main studies and considered that an educator could not manage this study. Besides, she stated their need for the designer until they fully understand what they should do. According to the science teacher, while teachers know how to give knowledge to the students, the researcher-designer knows how to design activity by planning and providing materials or documents.

Researcher: You come together with me again, so you are all teachers, but you are teachers from different disciplines, and I am not a teacher. What was it like?
Math teacher: Well, you remember the things that I said at the beginning. How will a designer contribute to education? I was not able to reconcile education with the designer in my mind, not personally. (**Science teacher:** Exactly.) But now I think that this is supposed to be the case because we are designing in education. Because this is STEM, I learned, I understand, I know. Not even with an educator, we wouldn't even be able to do this with someone from the Faculty of Education. At the time, I thought so, but now the person in front of me must definitely be a designer. Because I think I'm very impressed by your design thinking idea, so much.[188] (Math teacher)

Science teacher: In other words, when a teacher and a designer come together, the teacher knows how the teacher can give the student what he can provide, but the designer makes the design part. Well, as I said, in this sense, you have professionalism in which your job has brought it in you (**Math teacher:** Yes.). So as I said most things we cannot do, for example, template, etc. you've done everything.
Math teacher: You brought everything in front of us. It has ease.
Science teacher: Yes, so we learned it. How do we transfer it there? Of course, by putting our knowledge in terms of the subject, we have transferred this to children in this way. I do not think it'll ever be without you.
Math teacher: No, no, it would not work without a designer. So at least 5-6 years after working together with the designer, maybe we can say, “Okay, we can handle it now, we do not need the designer.”[189] (Science and math teachers)

Additionally, the visual arts teacher stated his view about accepting the researcher as a creator and educator because of being an instructive, having knowledge about the curriculum, and making the STEM education tangible and understandable. The English skills teacher also found the researcher-designer creative and having a holistic viewpoint; however, she also referred to her lack of creativity due to their education.

> **Visual arts teacher:** You are in perfect with education and training (**Math teacher:** Yes), you saved the STEM from the abstraction and made it concrete. It was a lot for all of us. (**Science teacher:** Aaa, of course). So I felt your knowledge of education and your command of the curriculum. The study went in the same parallel as much as possible. Well, a designer is like a teacher. I think like that. In other words, to find the difference and to create the difference, you saved it from abstraction and made it concrete for both the students and us.[190] (Visual arts, math and science teachers)

> **English skills teacher**: As a designer, your ideas can be broader. You can imagine and design something more. For example, I am not good at creating things. But I'm good at presenting something designed. I guess this is something that being a teacher has given me. I do not know or maybe the education I received. I teach the existed thing perfectly and imitate the existed thing very well. But to create something that does not exist (**Math teacher:** Like to create.) I think until the idea comes to my mind, I would go through a lot. It will take too long till I get a new idea.
> **Researcher:** You are saying the creativity part.
> **Science teacher:** Exactly.[191] (English skills and science teachers)

In this part, it was understood that teachers rediscovered how education is a creative process in which students and teachers are active agents. Consequently, according to them, an educator could not manage this study. The English skills and science teachers found themselves not creative owing to their profession or education, and instead, they found the researcher-designer as creative. According to the previous comments of the visual arts teacher, creativity in education means how you teach a subject, what materials you use in your circumstances; in other words, how you present the subject in a creative way to the students. If both STEM education and regular education require an innovative approach, how we can expect this education from teachers is questionable. In this respect, because of the researcher-designer's perceived qualities, designers or the DT approach can support teachers in this gap.

Teachers' and students' personal growth through STEM and the DT approach. After conducting the Main Study I, there was teachers' personal growth about changing their teaching practice. For instance, the science teacher stated that she discovered the possibility of interdisciplinary education with the DT approach and started to think about the ways of implementing STEM education in the science lessons. She also pointed out the significance of making collaboration with other teachers when planning and conducting the lessons. Besides, the math teacher mentioned her surprise about the unpredictable relationship between the visual arts and math disciplines, and this showed the necessity of having interdisciplinary knowledge to implement STEM education. The math teacher also considered making collaboration with the visual arts teacher to teach a geometry subject.

> **Science teacher**: What I have said since the beginning of the first term is that when I entered this study, I saw that the disciplines are connected clearly, and the interdisciplinary education could be possible with the design thinking method. Well, as I am saying, for example, when I enter the class, this is very simple. Maybe, I taught the subject force; this is thoroughly mathematics. I mean, I could really go in and explain it with my teacher. So this way of planning can be made.
> **Math teacher:** Yes.
> **Science teacher:** Since today and yesterday, the subjects that we have designed and thought can be connected? I'm starting to think about it now. It made a significant contribution.[192] (Science and math teachers)

> **Math teacher:** So I could never reconcile perspective with fractions.
> **Visual arts teacher:** Yeaa.
> **Math teacher:** So I was saying, "what is art got to do with it?" I said, "What is the relevance for", it is very relevant. In fact, we say there is mathematics in everything, there is mathematics, but it is a little hard to put into reality.[193] (Math and visual arts teachers)

> **Researcher:** It is not going to be me next term; we are finishing the study this term. Do you plan to use all or part of anything you have learned from this work in the future?
> **Science teacher:** I say yes, I personally do.
> **Math teacher:** Yes.
> **Visual arts teacher:** Of course, yes, the cooperation with the group teachers, we definitely need to use it, when you are on foot or on the way to class.
> **Math teacher:** 5 minutes.
> **Visual arts teacher:** Such as, I have a unit like this.
> **Math teacher:** For example, I am going into geometry subject, I will ask the visual arts teacher or prepare the material. So the geometry is all related to the visual arts, isn't it, teacher?
> **Visual arts teacher:** Yes, it has something to do with visual arts.
> **Science teacher:** Exactly, exactly. Of course, we plan to continue.[194] (Math, science and visual arts teachers)

Moreover, with this study, the English skills teacher's awareness about needing an interdisciplinary curriculum was created. Discovering the STEM and DT approach also affected the visual arts teacher positively since he changed his implementation and teaching practices. He started with making a plan before the application and considered the materials and the production by using his previous experiences.

> **English skills teacher:** No, it opened my mind. For example, I started to question why this is not the case. I wish the units were compatible in the curriculum, right?
> **Math teacher and Science teacher:** Sure, sure.
> **English skills teacher**: I wish it was easier, though.[195] (All teachers)

> **Visual arts teacher:** First of all research, sketch, design, the suitability of equipment and production.
> **Researcher:** That's right; that is all for you.
> **Visual arts teacher:** Yes, I mean, they've driven me into more. Previously from practice (**Researcher:** Direct practice.) yes, we were going directly into practice. But now, at home and even when I put my head on the pillow, I think, "I wonder if that glue fits into this?
> **Researcher:** But it is a very nice thing (**Math teacher:** Yes).
> **Visual arts teacher:** Let me give you another simple example. I use silicone for bonding styrofoam. Last year, I painted the styrofoam in white when I was building the monument to Çanakkale, but there were burrs on the points where I would use silicone, and it did not stick firmly. It did not hold, but it stuck very weakly, and then tearing and cracking happened. Look, I did not do it this year, this year I brought the styrofoam directly into the shape of a prism.
> **Researcher:** You test it and saw it did not.
> **Visual arts teacher:** Look, I say the suitability of equipment, production. So the production was weak there, this year is stronger.[196] (Visual arts teacher)

The English skills teacher also discovered the importance of making collaboration with the experienced teachers in order to be mentored in the first's years of their professions. This was also one of the significant contributions of making interdisciplinary collaboration among teachers. Since the collaboration not only contributed to implementing a STEM education, it caused personal growth, particularly for the new teachers in terms of their teaching practices and discovering the interdisciplinary relationship of the subjects. That is also an important finding for the profession of teachers because the mentoring system can be applied in schools to help new teachers adapt to the education system.

> **English skills teacher:** I think it should not only be gathered when there is a problem at school, when something happened or when a parent says something.
> **Math teacher:** Like how to teach this lesson.

English skills teacher: Yes, yes, see my curriculum; this is my subject. Like this or that, we have more inexperienced teachers than experienced ones. Some are in 1st year, 2nd year, 3rd year, even in their 5th year, I think also they are inexperienced.
Math teacher: Exactly, according to our visual arts teacher.
English skills teacher: I think it could have been like showing the way of the procedure. But it did not happen, so we went straight into the fire. As we have seen, I started to teach using the ruler in my classroom when I was teaching the curriculum.
Visual arts teacher: In the first five years, you learn the teaching profession by making a mess of it.[197] (English skills, math, and visual arts teachers)

According to the teachers, this study contributed to the students' personal growth because they generated ideas about the STEM activity subjects and their integration into the interdisciplinary lessons. Therefore, as a result of implementing STEM education through the DT approach, students acted as active agents in education, and this created a co-learning and co-teaching environment at school. The math teacher also stated that the interdisciplinary lessons with team teaching caused students' engagement, enjoyment from the lesson, and increased their interest in the lesson.

Science teacher: Believe me; students are aware of this too, I'm saying it sincerely. When we go to class if they see a piece of another lesson …
Math teacher: They connect it straight away.
Science teacher: They say, "Here is STEM, here is STEM". Really.
Math teacher: Or he says, did we talk to you?
Researcher: It is something good.
Science teacher: Well, it is something good.
Math teacher: Children's awareness increased.
Science teacher: It's a good thing that they're aware of my teacher. Of course.
Math teacher: No, they are aware of the fact that the disciplines are related to each other.
Science teacher: For example, we thought about the dissolution of the matter, for example, in the first term, Student D or Student G said in my lesson "Teacher, there was something about electricity rather than the dissolution of the matter; it would have been connected to this subject." They develop ideas, pay attention to what we do not think.[198] (Science and math teachers)

Perceived qualities of STEM education by teachers. One of the researcher roles was an educator owing to teaching the STEM and DT approach. According to this, the change or improvement in the perception of STEM education became essential to test the researcher role. In the focus group interview, teachers stated their understanding of STEM education. For instance, as previously noted that the visual arts teacher made changes in his profession since, according to him, the STEM and

DT approach involve research, plan, and prototyping (production) process. He further stated that the STEM education based on design, creativity and hands-on practices as follows:

> I will now state that design thinking, constructive and creative aspects are predominant in STEM. At the activities, of course, we do a pre-work involving the constructive, creative side, dealing with something, but now we are doing something more practical. As far as I understand, that is entirely based on the design.[199] (Visual arts teacher)

As previously mentioned, the math teacher highlighted the interdisciplinary side of STEM education by pointing out the unpredictable relationship between the visual arts and math disciplines. They also favored the significance of the teachers' collaboration in STEM education to be aware of the other teachers' curriculum. According to the science teacher, the STEM education should include hands-on activity including a prototype in other words, production, along with the game-based activities in the design of the activities, as previously stated.

7.4.3 Part 3: Post-workshop individual interviews with teachers

After the workshop, the focus group interview with teachers was fully transcribed, and it was discovered that there were remaining questions. Some of the answers also were not clear to be understood. Moreover, the social science teacher could not fully attend to the workshop; therefore, she was not in the focus group interview. Consequently, the individual interviews were conducted to complete the missing parts of the focus group interview with the four teachers. Besides, to evaluate the STEM activity design process of the Main Study II and the overall study, an individual interview with the social science teacher was conducted by asking similar questions to the focus group interview. All of the interviews were executed on the 8th and 13th March 2018 and were held in Turkish. The interviews were voice-recorded, and the duration of the conversations was between 14-32 minutes.

The findings of the post-workshop individual interviews with teachers. The findings of the individual interviews provided us information about the researcher roles, the teachers' perceptions about the design thinking approach, and STEM education. In this respect, this interview was investigated under four categories: the perceived characteristics of the DT approach in the STEM activity design, the perceived characteristics of the STEM and DT approach from the point of education, the perceived role of the researcher by teachers in the co-design process and teachers' and students' personal growth through STEM and the DT approach.

Perceived characteristics of the DT approach in the STEM activity design. The individual interviews were investigated about the teachers' perception of the DT approach in the STEM activity design process.

Structuring the STEM activity design as a process through the DT approach. According to teachers, DT approach structured the STEM activity design as a process to solve the activity design problem and facilitated getting to know the students. For example, the visual arts teacher pointed out both the problem-solving and interdisciplinary collaboration characteristics of the DT approach as a reason for using it when designing a STEM activity due to enabling the discussion between the teachers and getting familiar with the students. Furthermore, the stages of the DT approach set the English skills teacher an example about deciding the problem-solving process of her activity about designing a calendar.

> We went step by step; it was actually better. Because, when you do something unplanned, you can miss things accidentally. But we even thought who will be with whom while grouping students. I consider these were essential and necessary things, and these were done.[200] (English skills teacher)

> Yes, we follow it, my teacher. The titles you give us (He means DT approach), lead us to new things, that is, to collaboration. It leads us to the discussion; get familiar with children, so, does not it? I see it in that way. If it isn't, or if it's not those titles, you do not present us those titles, this work remains somewhat abstract. I mean, these things that you give make it concrete. We understand what it means in there, and according to it, by being in mutual dialogue with teachers; we cooperate with the community of teachers.[201] (Visual arts teacher)

> **Researcher:** How did the use of the design method contribute to STEM teaching?

English skills teacher: For a little bit, the idea of design thinking was created in my mind, so I thought I might design something. You know, we talked about the calendar, for example, now I'm going to ask children to create a calendar in my "party time" unit. When they create this calendar, I am going to ask them to mark each other's birthdays or something on it. It made such a contribution to me.
Researcher: What was in your mind before?
English skills teacher: I did not think of designing a calendar before. In my party time unit, I was going to prepare my materials and create a party environment in the classroom to show them how to make a party and invite friends. But the idea of designing a calendar that might be related to our subject came to my mind with STEM, and I will have it done in class. I will make it designed.[202] (English skills teacher)

After the implementation of the STEM education in the Main Study I, teachers were surprised about the students' unexpected performances and reactions. About this issue, the math teacher stated that being a new teacher in the class and the class's academic success misled her about the students in the Main Study I. The science teacher also emphasized the students' situated behaviors and the manipulator ones, such as Student B among the girls. This finding also made us question the reliability of the students' feedback or reactions when evaluating their approach to STEM. Because of the problems in the Main Study I, the effectiveness of the "observe" stage was explored. The math teacher suggested the interview questions be asked by only one teacher to hide STEM education from the students and to get reliable and productive answers.

Researcher: You said there were objections, but who else was there other than this 3?
Science teacher: Well, do you know what is it about? In fact, Student B reacts that way, or when you talk to her, she's actually affected by her other friends. She says, "It had actually been beautiful." In fact, what she says does not coincide with the things she later says.
Researcher: Do you remember how many people?
Science teacher: When Student B says something, the other students gather around her. Well, because girls do something, that is why I cannot give a specific number.[203] (Science teacher)

Researcher: If you remember, we made observations for a week to get to know the children in the first term. Do not you think that's necessary?
Math teacher: Now it worked, but it was a problem because of doing it simultaneously by teachers, so the child gave the same answer to every teacher. Maybe it could have misled us to do it simultaneously. Whether it was done at different times or done without being felt, or if it was done like a single general survey as a guide survey, maybe we could get more real results. Because we asked questions one after another, they wrote the same thing to all of them.

Researcher: I understand that instead of 5 people, maybe only one person should do this.
Math teacher: Yes, yes, if we had offered more general, more professional questions, maybe we could have gotten more efficient answers. So we drew much attention.[204] (Math teacher)

I also wanted to investigate the teachers' ways of getting familiar with the students since this question was remained incomplete in the focus group interview. For example, the math teacher preferred to get familiar with the students in the first term and to make both the pilot and main activities in the second term to fix the problems. However, the visual arts teacher wanted to make interviews or observations about the students, and after getting familiar with the students, he wanted to make changes to the activity.

Researcher: Was it necessary to get familiar with the students in the class, or would you carry out activities directly?
Visual arts teacher: It is essential to get familiar with the class.
Researcher: Is this the way to get familiar as a method?
Visual arts teacher: Yes, to get to know this way, get familiar correctly, I mean, like the things that you gave in those forms. I got to know the students better after the form.
Researcher: Is that so? In what way?
Visual arts teacher: For example, I did not know which profession they wanted; I did not ask such a question in my class. Actually, we used to hand out such forms in the years when there were no guide teachers in the previous years.
Researcher: Did this help us in designing activity?
Visual arts teacher: Of course, at least I understood the moods of the children, their professions, and their approaches.
Researcher: My question is when the different 5th grade arrived, would you do something like that before you gave the activity? Or wouldn't you?
Visual arts teacher: In terms of recognition? (**Researcher:** In terms of applying or not applying the same activity.) Sure, of course, I would, it does not happen without doing it. As I said, after understanding their physical features, capacity, where they came from, from what kind of environment they come from, their location, I would switch to my subject.[205] (Visual arts teacher)

Similar to the visual arts teacher, the science teacher stated that making interview and observation was necessary to collect the data about the students to discover their interests to design a STEM activity. She also preferred to make the pilot activity in the first term and to make the main activity in the 2nd term.

Researcher: I asked if you would apply the STEM activity to other 5th-grade students next year. There, mathematics teacher said she would try to recognize the class in the first term, and in the second term, she would do it. The English skills teacher said that I would implement both first and second terms.

> **Science teacher:** Now that, in our first term, we suffered from our inexperience, we started to learn something we did not know slowly. We saw some of the responses of the children during the activity. We learned, and the second term we try to be more cautious compared to it, we are trying to take the precautions we will take. I think it would be the same thing next year if I were to do this to the 5th grade. The first term we did was a bit like pilot activity; maybe a little pilot activity can be done before-hand and then make the real application, I think.
> **Researcher:** You know, we did observations and interviews to get to know the class first term, isn't it necessary to do these or should we do trial and fail?
> **Science teacher:** No, no, we asked questions to the children, we tried to get to know the children, or with the observations we have done in the class we had ideas about this child has an interest in that. Then it would be useful to collect ideas like that; after that, I think we should design activity on the collected ideas.[206] (Science teacher)

Although teachers considered using the DT approach in the STEM activity design necessary, while the math and English skills teachers preferred to implement the STEM activity instead of using the DT approach to get familiar with the students, the visual arts and science teachers favored implementing the “observe” stage. However, the data from the “observe” stage enabled the activity design in the Main Study II. According to the math teacher’s offer, a change in the “observe” stage of the DT approach was considered. It was decided to execute the interview questions under the management of one of the teachers or the school’s counselor teacher instead of all teachers to make collecting and analyzing the students’ data more comfortable and to prevent collecting multiple data from the same students. While collecting the data, it was also significant to not inform students until the implementation of the STEM activity to get reliable feedback and to show this process as a regular school implementation.

Furthermore, making students accept STEM education was one of the crucial points to implement STEM education since students perceived this study as a temporary study at school. However, the reliability of students' feedback is controversial because of their changing decisions and manipulation of each other. Consequently, it was decided to observe the students until the implementation of the STEM activity to discover the changes in their attitudes towards STEM. We also had the same approach to the students in the Main Study I since the students’ group were continued to be discussed until the implementation of the STEM activity, and we conducted a change before the STEM activity. Besides, it was agreed to disguise the STEM activity from the students to prevent their reactions before the implementation. For future implementations, these issues should be considered mainly for the 5th or 6th classes since, according to the teachers, they were the ones who had more changeable behaviors.

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating the STEM activity design process. In the interviews, teachers stated the exchange of ideas between the researcher and the teachers for developing ideas. The math teacher also highlighted learning the other teachers' experiences owing to the productive interaction between the teachers. As a result, DT approach empowered teachers through interdisciplinary collaboration and teamwork in the co-design process, which in turn, facilitated the integration of disciplines. Besides, the interdisciplinary collaboration among teachers provided getting familiar with the other teachers in terms of learning their teaching experiences.

> It was good because it was nice to take advantage of the experiences of experienced teachers. One year, or even in the same year, men are not all alike. We definitely have gained experience differently from each teacher. This interaction was pleasant.[207] (Math teacher)

> Well, at least in the activity when setting the theme, at least, a sentence you said brought another sentence to my mind. As we said, let's do this; let's do that in space. That idea has opened up my horizon more.[208] (Math teacher)

Perceived characteristics of the STEM and DT approach from the point of education. According to findings, the visual arts teacher pointed out the significance of the DT knowledge along with other disciplines for teachers to have interdisciplinary expertise for the execution of their lessons and to collaborate with the other disciplines.

> **Researcher:** We came together for a collective study. There are two different professions, but they work together. There is a teacher, there is a designer, there is a perspective of the teacher, and there is a perspective of the designer, what would you say about this?
> **Visual arts teacher:** The teacher's mutual communication should be excellent. As I said before, "God always uses geometry" look, the words again comes to my mind, I know what I'm talking about. While God uses geometry, a visual arts teacher and a designer use geometry in the cooperation with the group teachers. As a visual arts teacher, I have to introduce geometric shapes in mathematics to children, that's where

the geometry comes in. A teacher must be complete: must be a designer, an artist. That's what they told us in educational psychology, he/she should dramatize, mathematics teacher should also dramatize.
Researcher: Should a teacher think like a designer?
Visual arts teacher: Of course he/she should think. Otherwise, it is not possible to get out of it.[209] (Visual arts teacher)

Moreover, most of the teachers related the DT with the material design in education. For instance, the social science teacher perceived this study as the design of an educational model. The design meant a material design for her, but her perception of the material design has been changed. Since she previously prepared the materials for the students, at the moment, students designed the material by themselves in the STEM activity. According to her, this made students actively involved in the process. Her expression also indicated that she related both the STEM and DT approach with hands-on activity and prototype when talking about the material design.

Researcher: After all this work, have your perspective on the concept of design be changed?
Social science teacher: The concept of design […] I made the material myself and presented it to them in class, but in this, children designed it themselves.
Researcher: Which activities, do you mean the last period?
Social science teacher: Yes, activity, there was a change for me there.
Researcher: So theirs …
Social science teacher: I was either preparing the material before or finding it and bringing it to the class, but now they did something themselves, and they were actively involved.[210] (Social science teacher)

Both the English skills and the math teacher related the DT with the material design in the STEM activity. Similar to the social science teacher, the English skills teacher valued the preparation of the material by the students for a purpose. With this answer, she also related both the STEM and DT approach with inquiry-based learning and learning by living. Besides, the connection between the DT and education disciplines in the material design showed that teachers related the education, STEM, and DT approach with hands-on activity including a prototype.

The overlapping points are, for example, that the child is preparing a material according to the subject, and that the material should be relevant to the subject and then learning while preparing this is what my overlapping point is. Because I am in favor of children to learn by doing or living, not by giving the direct knowledge in such a simple way, by verbally, by writing, by drawing, I am in favor of making an application. In this respect, it overlaps in my mind. For example, designing something, questioning how something happens during this stage, putting a product in the middle, once, anyway having his/her effort, well, all of them overlap.[211] (English skills teacher)

Additionally, the science teacher related the DT with the creativity, holistic and complex thinking, which she considered she did not possess. She also stated that not all people could design. As with the English skills teacher, she thought not having creative ideas similar to the researcher-designer due to her education. From her sentences, it was also considered that creativity in DT requires experimental work, and consequently, it includes risk and ambiguity.

Science teacher: Design already sounds like a word a lot to me, so it's definitely something that not everyone can do it. For example, my English skills teacher says give me something, I will do it, but I cannot think. Yeah, so am I, I do not know if it's lazy.
Researcher: What is the reason for that, my teacher? Do not misunderstand but is the reason based on education. (**Science Teacher:** No, it is correct, it is education based) Is it like being given ready information and asking for the same?
Science teacher: Yeah, exactly like that, you're absolutely right, that way, but for example, I'm going to do an experiment before I scan the article. I think about how people have done, what they have done, how I can do it. I get my starting point from the previous studies. That is also preparation.
Researcher: But it's the right thing.
Science teacher: Of course. It's definitely not wrong, but I do not know the design, well we need to look a bit holistic, I cannot do that much, for example. How can I say, I cannot think complicated. I think this is probably related to my personality, certainly very relevant to education. You're in this now, and it is seen from your practicality, even your speech, your comprehension of something is fast. For example, I say, I cannot perceive at first. For instance, in the first term, I had difficulty; I was struggling to comprehend. Because you're very practical, you're very fast. Naturally, you're master. We cannot be expected to be practical because we are not a master. But you're a master, naturally. Admittedly I think there may be steps. The design is not something to say, “Let me design this”. So you need to think about many things.[212] (Science teacher)

Perceived role of the researcher by teachers in the co-design process. In the focus group interview, the role of the researcher-designer was discussed; but, teachers stated general comments and did not give specific details about that question. Therefore, similar questions were asked to the teachers to get a detailed description. Accordingly, the science teacher pointed out that researcher-designer carried the role of educator, facilitator, and guidance in the workshop, as she taught the STEM and DT approach and how teachers should think in the Main Study I.

She also stated that the experience in the Main Study I made teachers knowledgeable about STEM education, and they used these experiences in the second workshop while designing the STEM activity.

> About your management of the workshop, we need to make a little empathy for the first term because you have people who do not have knowledge. Are we professionals? Of course, we are not professionals, but you are an expert. That is how I see; in the end, this is your profession. In the first term, you also gave an effort to teach us. Of course, you taught us how to do in each step, how to progress, and how to think. Of course, you are more tired because of teaching them, like us. In the second term, you got to know us, we got to know you, and we got more or less what we should do from the first term and progressed a little faster than that. Of course, because we knew each other, we saw the children, how the activity progressed, where did we make mistakes, where we did not; you took all of your precautions and came to us because you saw them all from the beginning. In this sense, our time saving was huge. Again, you have always supported what we should think about and how to relate.[213] (Science teacher)

Furthermore, the English skills teacher stated that the researcher acted as a mediator between the teachers to connect the ideas in the STEM activity design. The math teacher also found the prepared list of the subjects significant in terms of its benefits for selecting and integrating the appropriate subjects for the STEM activity and saving time during the workshop. All teachers were pleased to work with a researcher because of her contribution to the idea generation and the documents and materials she prepared.

> **Math teacher:** Once, you separated them lesson by lesson, subject by subject. You gave us options, and at that moment, we created a combination of these options. Hence we have selected from what we have. If otherwise, at least we'd have lost a lot of time to separate one by one and list them.
> **Researcher:** If I hadn’t created this template, had you have a hardship?
> **Math teacher:** We could have difficulty from time; otherwise, we wouldn't have a problem. It would be a waste of time; this has shortened our time by at least 1.5 hours.[214] (Math teacher)

Teachers’ and students’ personal growth through STEM and the DT approach. This study contributed to both the teachers’ and students’ personal growth. As previously stated, all teachers comprehended the significance of collaboration about which most of them did not have experience before. According to this, I wanted to get detailed information about how they planned to use STEM education in their lessons. For instance, the math teacher decided to take the other teachers’ assistance in terms of preparing a lesson or material. She also stated that she taught her subjects by citing their interdisciplinary connections with the other disciplines in the classes who were not involved in this study. This finding also showed that since the school presented a social experience, the interaction among actors in the school caused transferring the knowledge to other students and teachers. Therefore, the impact of this study did not affect only the participants but also the other teachers and students.

> **Researcher:** I asked you what design thinking has added to you, and you said it created a different experience; can we open it up a bit?
> **Math teacher:** When I say a different experience that I did not know we could use all these disciplines together; at least the awareness of it increased. For example, when I'm working on the subject, especially in other classes, "Oh teacher, we can combine this with this course," I hear the phrase now. That means that we are unconsciously combining the lessons not only for the 5X class but also for the other classes so that even in groups we do not do STEM, we have created STEM subconsciously. At least, at least personally, it has made a small contribution to my lecture, even if I do not realize, without knowing that there are things that are settled.[215] (Math teacher)

As previously stated, the English skills teacher who newly joined the study decided to create a mini STEM activity for her lesson. She also wanted to apply the STEM education after the study; however, she was hopeless about making collaboration with the other teachers due to their reluctance about it.

> I would like to do it, but to come together with other teachers and implement this, to adapt our leisure times to each other or to plan our compatible teaching hours or our appropriate subjects. I mean, I do not think it's unlikely for anyone will do it.[216] (English skills teacher)

As previously stated, teachers surprised about the unexpected students' performances in the STEM activity of the Main Study I. About this issue, the science teacher highlighted how group working benefited the students in terms of engagement and collaboration while developing solutions for the problem. These improvements in some of the students also made the math teacher think that these students need different ways of learning based on inquiry-based methods instead of traditional ways. Besides, these findings indicated that the STEM and the DT approach could address students that have different learning needs.

So for these children, not the traditional education, more diverse, we need to approach them with learning through discovery method. So, those kids are special. I observed we need to teach those subjects with special programs; they can be more successful with different approaches.[217] (Math teacher)

Researcher: Student K, Student M, and Student L, they were a little ahead of the class on January 9th, was it a coincidence or what is your determination?
Science teacher: This is what I got out of here, so we have seen that they are very prone to group work. If I talk to Student K, Student G is a very hardworking and intelligent student. Student K also has an illness, so, of course, she has a downturn, but perhaps because Student G was too diligent, I think this may have been triggered her. Student L's friend was Student A, right?
Researcher: Student L was with Student N, Student A was with Student M.
Science teacher: Student A and Student M get along well, but when we look at both, Student A is better in academics. But when we look at, Student M did his best.
Researcher: Student L was the person who made the math problem in the first question the most correct one individually. And that's an interesting point; she was with all the people who have done it wrong, that is there's no one who she can copy from, which is surprising. Student L left early that day. Student N continued alone.
Science teacher: I do not think it's a coincidence, but maybe we've seen one of the things we did not know.
Researcher: Are they more prone to do that?
Science teacher: I think they are more prone, because not so much during the class, so Student L is very quiet, does not participate, and not very well at success. She cannot be compared to Student G.[218] (Science teacher)

7.4.4 Discussion of Phase 1

In Phase 1, it was intended to collaboratively design STEM activities with teachers by using a design thinking approach. Phase 1 included three parts: a two-day STEM activity design workshop with teachers, a post-workshop focus group with teachers, and individual interviews with the teachers about the workshop. The overall findings of Phase 1 provided us information about the perceived role of the researcher by teachers, the perceived characteristics of the design thinking approach, teachers' and students' personal growth through STEM and the DT approach after conducting Main Study I and the challenges concerning the workshop plan, education system and stakeholders' expectations and abilities.

Perceived role of the researcher in the co-design process. In this phase, the researcher-designer has four facilitator roles, including a guide, educator, mediator, and co-designer, before and during the workshop and the STEM activity design process. Teachers also performed co-designer, mediator, and collaborator roles during the STEM activity design process. According to this, the facilitator roles of the researcher and using the DT approach as a tool had four impacts on the study:

- Facilitating teachers' perspectives by changing their mindsets and teaching habits to teach the STEM and DT approach and to integrate STEM education into the institution.
- Facilitating the preparation for the STEM activity design before the workshop.
- Facilitating the workshop process by establishing a participative workshop environment.
- Facilitating the STEM activity design process between the teachers who were empowered as stakeholders in the co-design process.

Perceived characteristics of the DT approach. In this phase, the DT approach was executed for two different purposes; it was applied as a tool in the development of the STEM activity design and integrated into the STEM activity to facilitate the problem-solving process of the students. In light of the findings, the DT approach enabled teachers' collaboration and getting familiar with the students in the STEM activity design process since the DT approach provided a step-by-step guide and made the STEM activity design process tangible for teachers. The customized DT approach also enabled to develop ideas for synthesizing the disciplines due to teachers' collaboration. Since the interdisciplinary collaboration among teachers facilitated to get familiar with the other teachers in terms of raising awareness about the interdisciplinary relationship of the disciplines and, in return, assisted teachers' idea development and the lesson and activity creation.

According to the science teacher, the DT approach needs creativity, holistic, and complex thinking. Thus, she proposed that not all people could design. As previously stated, education and STEM education are creative processes, and creativity in education brings along ambiguity and risk. Consequently, it was discovered that adopting risk-taking and embracing ambiguity mindsets of the DT approach is significant for teachers to conduct creative education similar to STEM and DT approach and to deal with the ambiguity originated from students' situated behaviors.

Teachers' and students' personal growth through STEM and the DT approach after conducting Main Study I. After conducting the Main Study I, there were concrete changes and improvements in teachers' practices and also students' perceptions. In that study, both teachers and students observed and experienced a holistic view of education through STEM and the DT approach. As a result, teachers changed their views about teaching and searched for ways to conduct interdisciplinary lessons. According to this, there was teachers' personal growth about improving their teaching practice, raising awareness about the connections among the disciplines (particularly the unpredictable ones), needing an interdisciplinary curriculum and the significance of making collaboration for STEM education. They also understood the necessity of having interdisciplinary knowledge to implement STEM education.

Teachers also stated the study increased students' personal growth in terms of a better comprehension of the course content, a better engagement in the activity, raising their awareness about interdisciplinary relationships and developing their teamwork skills. According to them, this study further increased students' interest in the courses, created unexpected students' achievement, and addressed students' different learning needs.

While applying the STEM education through the DT approach created more social interaction and experience among actors, this also caused co-learning and co-teaching environment between students and teachers. Because students started to generate ideas about interdisciplinary lessons, and teachers transferred their knowledge to the other classes. Therefore, the impact of this study did not affect only the participants but also the other students. According to this, the STEM and DT approach can create more democratic educational environments at school by giving rights to every actor in the design of teaching and learning experiences owing to their human-centered and student-centered nature. If an opportunity is given for making collaboration between students and teachers, this can result in creating a more engaging environment for teachers and students and increasing the ownership of learning and teaching. For instance, in a design thinking-based school, Design39 Campus, teachers have been using the DT approach to create a personalized learning experience for students from 2013 by working with parents, students and other stakeholders and adopting collaboration and reflection culture. During these collaborations, they realized that each team member contributed their perspectives, skills, and this enabled team professional growth (Power, 2019).

Challenges concerning the workshop plan, education system and stakeholders' expectations and abilities. In the workshop, some challenges were defined, such as the Ministry of National Education curriculum, the school exams and the MİS exam, and teachers' busy teaching schedules. For instance, the English skills and the social science teachers intervened in their curricula to change the places of their subjects to create a STEM activity. However, this was not a possible act for all lessons. Therefore, it was discovered that the current curricula and the order of the subjects might cause a limitation when creating STEM activities in this educational system. Furthermore, it was observed that the English skills teacher in this workshop and the other teachers in the previous workshop could not comprehend the STEM education totally at their first attempts. In this respect, similar to one of the schools' approaches in the exploratory research, the STEM activity similar to the wallet design exercise can be executed to the teachers to make them experience the STEM education personally.

Other challenges originated from the students' and parents' expectations; these are students' reactions to the STEM education before the workshop, their situated behaviors, parents' concern about students' grades and both parents' and students' concerns about following the exact curriculum. Although students stated negative comments about STEM, the students' reliability of the feedback was questionable owing to their manipulation with each other, and their changeable decisions. As we previously stated, both parents and students could affect each other about their decisions. Thus, observing the students until the implementation of the STEM activity was decided. Besides, it was agreed to disguise the STEM activity from the students to prevent their reactions before the execution. However, strategies were needed to ensure that students were not aware of STEM activity until the day of implementation.

It was discovered from teachers' statements that making collaboration with teachers and having interdisciplinary knowledge were needed in the application of STEM education. Mainly, making collaboration with the experienced teachers had multiple advantages in the design of the STEM activity. Collaborating with the experienced teachers was also found significant by the English skills teacher to be mentored in their first's years of their professions. Therefore, creating and managing the collaboration culture in the school is significant for the orientation of the novice or less experienced teachers to the education system and the application of STEM education. However, teachers forwarded the other teachers' reluctance and their busy teaching schedule as an excuse for teachers' collaboration and implementing STEM education. One of the common characteristics between STEM and the DT approach was interdisciplinary collaboration. The visual arts teacher also stated that teachers should know the design discipline to have an interdisciplinary knowledge for the execution of their lessons and to collaborate with other disciplines. According to this, using the DT approach through the designer's facilitation as a time-saving process can support teachers' collaboration and serve to discover the interdisciplinary connections.

Another challenge was related to the teachers' creativity since similar to the English skills teacher, the science teacher found herself not creative because of her education, and instead, they found the researcher-designer creative and having a holistic viewpoint. Although both of them aren't graduated from the Faculty of Education, many teachers have pedagogical formations to be a teacher similar to them. It was also previously discovered that education, the STEM, and the DT approach require a creative approach. In both studies, researcher-designer's facilitation through the DT approach assisted teachers' integration of the disciplines due to having an interdisciplinary knowledge and creativity since teachers could not be expected to be creative in their first attempts. Furthermore, because of its perceived qualities, the DT approach supported teachers in this gap. However, more experiences about STEM education and taking advantage of the students as a stakeholder when creating a STEM activity can be a solution to this issue.

7.5 Phase 2: Regular lessons conducted by teachers through individual teaching covering shared STEM activity themes

In Phase 2, it was intended to conduct the regular lessons covering common themes with the other teachers to serve the STEM activity. Phase 2 included three parts: the social science lesson conducted by the teacher, the visual arts lessons I conducted by the teacher and the visual arts lessons II conducted by the teacher. In this phase, the researcher, teachers, and students were actively involved in the study (Table 7.3).

7.5.1 Part 1: Social science lesson conducted by the teacher

On the 29th of March 2018, it was intended to teach the “future of the jobs” as a part of the STEM activity in the social science lesson. The lesson was conducted in two-lesson hours and involved the social science teacher and one of the 5th-grade classes as participants. The data was collected from the meeting notes, Whats-App and SMS communication during the preparation for the lesson. An audio-recorded, non-structured, 13 min. interview was also conducted with the social science teacher in the 19th of April, 2018.

The social science teacher could not able to attend the whole workshop; therefore, the general outline of the lesson was created during the workshop. We had a meeting on the 02nd of March to discuss the ways of teaching the lesson. Thus, the co-design process between the researcher and the social science teacher continued about preparing for the lesson. On the 29th of March, 2018, the social science teacher conducted two lessons in the 5X class. After the lesson, she sent me a Whats-App message regarding the execution of the lesson. Later in the individual interview, she gave the details about the lesson.

In the first lesson, she conducted a presentation of eight jobs. Then, she pointed out the "animals in danger of extinction" and the space to explain some of the jobs. Later, they watched a video about the space concerning this subject. In the second lesson, she made an oral exam by asking students questions about which jobs they would select and the reason behind this selection. In the end, she asked questions about all jobs to test students' knowledge about the subject.

The findings of the social science lesson conducted for the "future of jobs". According to findings, students enjoyed the lesson, showed a great interest in the subject, and they were successful in the oral exam. Therefore, because of the subject, students' engagement and motivation to the lesson, and their course understanding were high. She also understood that students learned the subject of the lesson in the other lessons. For example, when she mentioned the "animals in danger of extinction" to explain one of the jobs, they said having the same subject in the science lesson without being asked. They also said they were drawing the picture of the space when she mentioned the jobs related to space. On that occasion, they could comprehend the connection between the subjects in the regular lessons. After seeing the effect of the lesson on students, the social science teacher considered that there wouldn't be a problem in the activity. For the STEM activity, she also prepared similar questions that she asked in the lesson. Thus, by adopting a prototyping mindset, she tested the questions in the lesson before implementing them in the STEM activity.

She also wanted to teach the same subject in the other two 5th classes; but, they did not like the subject as 5X did. She stated that they did not believe that there could be a life in the space owing to the absence of gravity and oxygen. According to her, it was an unexpected reaction from these classes because they had never reacted like this before. All of these students' responses also showed that some students could have stereotypes in their minds and could not imagine beyond their learning. She also stated that the other classes' interest was different from the 5X class, which meant not all the 5th classes were the same and appropriate to apply the same STEM activity. Besides, this finding showed the significance of getting familiar with the students before the implementation of STEM activity.

> **Social Science teacher:** Yes, they found the animal migration expertise very different. There, I mentioned Noah's ark as an example to kids.
> **Researcher:** What did they say?
> **Social Science teacher:** They were surprised. I mean, when they meet the information they never know, their reactions are a bit of a surprise.
> **Researcher:** Have you had a lot of questioning?
> **Social Science teacher:** No, 5X did not question, but, as I said, the other classes asked a lot.
> **Researcher:** What did they say? Did they find it unreasonable?
> **Social Science teacher:** Yes, they found it unreasonable. They said, there is no oxygen in space, how these people live, or there is no gravity, they asked they will fly in the air.[219] (Social science teacher)

7.5.2 Part 2: Visual Arts lessons I conducted by the teacher

On the 26th March, 2nd and 9th April 2018, in the visual arts lesson, it was intended to make students design the "welcome cards" as a part of the STEM activity. The lesson was conducted in three lessons and involved the visual arts teacher and one of the 5th-grade classes as participants. The data was collected from the individual interview and the meeting notes based on the phone call, SMS and Whats-App communication.

On the 26th of March, the visual arts teacher started the lesson by giving information about the space and the planets. Then, he requested the students to design a "welcome cards" as a gift to present to the children living in one of the planets. According to him, students liked the subject and tried to create their cards immediately. They completed their "welcome cards" on the 9th of April.

7.5.3 Part 3: Visual Arts lessons II conducted by the teacher

It is aimed to make students brainstorm before the STEM activity by creating a "picture of the living environment in the space" on April 16 and 30, 2018, in the visual arts lesson. The lesson was conducted in two lessons and involved the visual arts teacher and one of the 5th-grade classes as participants. The data was collected from the individual interview and the meeting notes based on the phone call, SMS and Whats-App communication. The non-structured interview was voice-recorded and included the evaluation of his both lessons. It was conducted in the 19th of April, 2018 and the duration of the conversation was 14 minute.

On the 16th of April, the visual arts teacher started to the subject by referring to the "welcome cards" to remind them about space. Then, he requested them to select one of the jobs that could be employed on the new planet. Later, students started to discuss the "future of the jobs" with the visual arts teacher, and they were very enthusiastic about talking about the jobs. They also mentioned their lessons that were executed in the social science lesson. The visual arts teacher was surprised by these reactions and their interest in the subject. Later, he wanted them to create a new living environment considering their new jobs on the new planet, and students started to draw their drawings immediately. They completed their pictures on the 30th of April.

The findings of the visual arts lessons conducted for the "welcome cards" and "the picture of the living environment in the space". During the implementation of these lessons, the visual arts teacher called me several times to cooperate with the problems he faced and the final status of his lessons. The visual arts teacher and I also communicated from the Whats-App and with SMS for the details of these lessons. As a result, the co-design process among the researcher and the visual arts teacher continued during the implementation of these lessons. After the completion of all lessons, the audio-recorded non-structured interview was conducted with the visual arts teacher. He stated his reflections about the lessons conducted for the “welcome cards” and “the picture of the living environment in the space”. Therefore, the findings of both lessons were presented here together.

According to his feedback, the students showed no reaction to him and enjoyed the subjects in all lessons. They started to work enthusiastically after the subject was presented to them. Thus, it was apparent that themes attracted the students’ attention, and made them motivated in the lesson. It also increased their interest in the lesson. When they were talking about the “future of jobs” in the lesson, students were very eager to transfer their knowledge about what they learned in the social science lesson to the visual arts lesson. Therefore, similar to the social science lesson, they showed their awareness about the connection of the lessons.

The visual arts teacher also stated that teachers would need the researcher as a guide in the Main Study I when conducting the interdisciplinary lessons owing to learning the STEM education for the first time. However, he stated the reverse for these lessons because of knowing STEM education. Furthermore, according to him, seeing another person in the class other than the teacher could make students behave differently. Since there was no reaction from the students in these lessons, he related this result to presenting the subjects similar to his regular lessons and students’ familiarity with him as a teacher. According to him, no student understood that some parts of the STEM activity were practiced in these lessons.

7.5.4 Discussion of Phase 2

In Phase 2, it was intended to conduct the regular lessons covering common themes with the other teachers to serve the STEM activity. For this reason, three individual lessons were executed: the social science lesson conducted by teacher, the visual arts lessons I conducted by teacher and the visual arts lessons II conducted by teacher. In this phase, the researcher, teachers, and students were actively involved in the study. After the workshop, the co-design process between the researcher and teachers continued about the implementation of these lessons.

According to the result, in social science and visual arts lessons, students were motivated and participative in the lessons because of the attraction of the themes. Besides, they enjoyed the lessons. The lessons contributed to students' personal growth in terms of a better comprehension of the course content and raising awareness about interdisciplinary relationships. None of the students understood that one of the parts of the STEM activity was employed in these lessons. Therefore, not making students aware of the STEM activity until the implementation day, students' familiarity with the teacher, and the non-existence of the researcher and the other teachers in the class affected the students positively during the implementation of these lessons. That also indicated that depending on the context, when applying the STEM education as a temporary activity at school, the regular lessons that served the STEM activity and are connected under the same theme can be implemented easily.

As a result, none of the teachers had a concern about the STEM activity since the theme of the subjects and students' interest originated from the theme created higher motivation for teachers. Besides, while teachers had an educator role in this phase, how the researcher-designer facilitates was explored from two aspects; the different facilitator roles and the impact of the roles on the integration of STEM education. Accordingly, in the co-design process, the researcher guided the social science teacher for preparing the lesson, and she also supervised the visual arts teacher for dealing with the issues that he confronted during the lessons. As a result, the facilitator roles of the researcher had two impacts on the study: Facilitating the preparation for the social science lesson and facilitating the implementation of the visual arts lessons.

Adopting a prototyping mindset through the DT approach for facilitating STEM activity design and implementation. In the Main Study I, teachers discovered the ambiguity of the creative processes and understood that one of the most prominent ambiguities in this study was students' situated behaviors. That also meant that students' insights based on the collected data could be changed throughout the process. Therefore, in the Main Study II, teachers adopted the prototyping mindset in the design of the STEM activity by researcher-designer's facilitation. For instance, while teachers changed the students' groups and offered not making interdisciplinary lessons considering the previous study experiences, the math and social science teachers tested the questions before preparing the new ones for the STEM activity. Since this mindset was previously considered crucial in the Main Study I, adopting the prototyping mindset through the DT approach was significant for teachers in the application of STEM education to deal with the challenges by developing strategies and to create STEM activity appropriate to the students' level.

7.6 Phase 3: Teachers' implementing the STEM activity in the class with the assistance of the researcher-designer

In Phase 3, it was intended to implement the STEM activity by collaboratively working with teachers. This phase had three parts: the implementation of STEM activity, post-STEM activity focus group with three teachers, and post-STEM activity interview with the visual arts teacher to evaluate the STEM activity and the overall study. At this stage, it was intended to make teachers and students gain experience about the STEM activity, and all of the teachers, students, and the researcher were actively involved during the implementation of the STEM activity. Before the STEM activity, some preparation was conducted with teachers (Table 7.3).

Preparing for the STEM activity. Before the implementation of the STEM activity, we conducted four meetings with teachers on the 13th March, 19th, 24th, and 26th of April to be prepared for the STEM activity. The data was collected from the meeting notes, SMS and Whats-App communication. Therefore, the co-design process between the researcher and the teachers continued about the preparation of the STEM activity. While teachers acted as a co-creator during the preparation for the STEM activity, as a researcher, I facilitated and guided the preparation.

In the workshop, the general outline of the STEM activity was completed, and teachers wanted to prepare their questions later. After the workshop, I checked the students' groups with teachers and directed them when creating their questions. The math teacher also wanted to give a study paper to test the students before preparing the questions not to have problems in the STEM activity. Besides, I collaboratively developed material with the visual arts teacher for STEM activity (Figure 7.8).

Figure 7.8. An image from the material that was prepared for the STEM activity

On the 24th of April, we gathered with the English skills and social science teachers. I offered to make the "answering the questions" part in the first lesson and then, the prototyping part in the other lessons to make students not aware of the STEM activity until the last point. Teachers accepted my offer, and later, we discussed how to tell the STEM activity to the students. Then, we decided to be told the "answering the questions" part by the social science teacher and the prototyping part by the math teacher.

On the 26th of April, we gathered with the math and visual arts teachers. For announcing the STEM activity, the math teacher offered not to tell the name "STEM" to the students and proposed only telling "an activity with a prototype" to the students. To motivate students before the STEM activity, it was planned to give medals to the previous winner in front of the class and to inform the students about the exhibition at the Science Fair. Besides, she was expected to say that the activity was graded to the students to make them more responsible during the STEM activity. The math teacher also offered to bring chocolates to the activity to motivate students, and to give both medals and chocolates as presents for the winner of the STEM activity. In the meantime, I had problems with one of the teachers for not attending the meetings and not responding to my messages. She also had the responsibility to arrange the STEM activity day, and she stated that the management did not agree to arrange the lessons for the STEM activity. Later, the assistant manager solved this issue instead of her, and then, this teacher left the study. Thus, we rescheduled the activity on the 3rd of May in which there were two math and social science lessons in a sequence. All of these problems showed that when implementing an educational approach outside the school, along with teachers, parents, and students, the school management also affected the integration of STEM education due to giving priority for sustaining the school order. Besides, it was apparent that the stakeholders' motivation and ownership of the study could affect the process and the result of the study. Consequently, some motivational factors should be considered to increase the stakeholders' bonds with the project.

7.6.1 Part 1: The implementation of STEM activity

The STEM activity (Appendix S and Appendix T) was implemented on the 3rd of May 2018 with four teachers and the same 5th-grade class (Table 7.6). There were English skills, social science, visual arts and math teachers as participants. The breaks in the activity were arranged according to the students' requests. In addition to being a guide during the STEM activity with teachers, I was a participant-observer to explore the teacher's interaction with the students, teachers' opinions about the students' projects and the reaction of students to the activity. The activity was video-recorded and photographed, and the researcher also used the activity video to complete the missing points in her observation notes. After the STEM activity, the focus group interview with three teachers and students and an individual interview with the visual arts teacher were conducted to evaluate the STEM activity and the overall study. The HPI's DT approach was also integrated into the STEM activity to facilitate the problem-solving process. Therefore, the observation notes and feedback of the teachers and students related to this activity provided us information about the perceived characteristics and benefits of both STEM and DT approach.

Table 7.6 *Information about the STEM activity*

Part 1: STEM Activity	
Participants	Math, visual arts, social science, and English skills teachers, 16 students, researcher.
Duration	Four-lesson hour
Theme	New settlement in Space
Data collection methods	Researcher observation (Video recorded)

The STEM activity started at 9.00 am and ended at 12.10 pm, and thus, it was conducted in the four lessons. The activity had two parts. The first part, also called as “answering the questions” part, was answering the scaffolding questions about math, social science, and English skills disciplines, and it was conducted under the management of the math teacher in the math lesson between 09.00 am and 09.20 am. Then, the students came to the library for the execution of the second part. The second part, also called as prototyping part, was answering the question about creating a new settlement in the space by considering three animals in danger of extinction and choosing a new job. This part included making a prototype, poster, presentation and peer review respectively. The prototyping part started at 9.30 am and ended at 12.10 pm, and it included the visual arts, math, social science, science, and English skills disciplines inside. In this question, the math, visual arts, social science, and English skills teachers, in addition to the 16 students and me as a researcher, were the participants. (Table 7.7)

Table 7.7 *The structure of the STEM activity*

Part 1: The "answering the questions" part: Answering the scaffolding questions about math, social science, and English skills.	
Participants	Math teacher and 16 students
Duration	Between 09.00-09.20
Type of the study	Individual study
Disciplines included	Math, English skills and Social science
Part 2: The prototyping part: Making a prototype, poster, presentation and peer review	
Participants	Math, visual arts, social science, and English skills teachers, 16 students and the researcher
Duration	Between 09.30-12.10
Type of the study	Teamwork including two students
Disciplines included	Visual arts, Math, Science, English skills and Social science
Question	Creating a new settlement in the space by considering three animals in danger of extinction and choosing a new job

Different teachers were involved in different phases of the prototyping part because of their lessons in the other classes. The math, social science, and the visual arts teachers were the ones who were most present during this part. In this part, the activity started with the presentation of the theme, and then students were divided into groups that had two students. Before beginning the activity, I gave students chocolate for motivation, and the "welcome cards" were distributed to the students by the visual arts teacher (Figure 7.9).

Figure 7.9. An image from the "welcome cards"

Later, they were asked to solve the problem starting from sketching to making a making prototype, and then they created a poster to present their designs. After these stages, students presented their ideas to the class, answered their peers' questions, and got feedback and critiques about their designs. We also incorporated students' choices in the activity to make students evaluate and select the best project, and the new chocolates were given to the owners of the best project as a present. As a result, students were the center of the activity that they had the chance to own, manage and present their projects.

The findings of the implementation of STEM activity. According to my observation notes, the stages of the STEM activity in the Main Study II were successfully implemented, and there was no students' reaction compared to the previous one. It was apparent that not using the name "STEM" when informing students about the STEM activity, and separating the "answering the questions" from the prototyping part made students not discovering having the STEM activity until seeing the researcher and the other teachers in the prototyping part (Figure 7.10). They also considered that the activity was just about making a prototype, and not including any questions, thus, they answered the questions without showing any reactions. At the end of the activity, the visual arts teacher examined the students' prototypes and evaluated them. Later, I assessed the students and calculated their points based on the answer key and the opinions of the teachers during the activity. Besides, I examined the video of the activity to complete the missing points in my observation notes related to the students' projects.

Figure 7.10. Students engaged in making a prototype and a poster

During the activity, it was observed that Student X, Student Y, Student D, and Student E were focused on being the winner of the activity. It was understood from their conversations that the theme of the activity and giving a medal to the last winner were the motivation factors for them. While most of the girls' groups' projects brought forward the "animals in danger of extinction" in their solutions, some of the male groups did not focus on this issue. Furthermore, the most original ideas belonged to Student D' and Student C' groups, and the visual arts teacher liked the craftsmanship of the Student H' group prototype. Students selected Student B's group as the winner of the STEM activity.

As a result, the prototypes were much better compared to the previous STEM activity in terms of craftsmanship, and students enthusiastically worked during the activity. However, some of the students' solutions were incomplete in terms of answering the whole question. Some of them also tried to design a settlement on a new planet, considering the conditions on the earth. For instance, Student H added solar panels to the prototype as if he was creating a settlement for the earth and did not make an effort to solve the problem about the "animals in danger of extinction". According to the teachers, by making a cloning machine, Student D and Student E had an exciting solution for the "animals in danger of extinction". Student C and Student F also chose space engineering as a job for themselves and created a settlement for both animals and people to address the problem. Their design of the settlement was original, and their prototype had a good quality. As a result, half of the students were good at problem-solving due to presenting a complete solution to the question. However, others were unable to identify the problem and its constraints, or they focused on practices in the world in their solutions because of the stereotypical images in their minds. Therefore, it was understood that focusing on the problem definition was needed to enable the productivity of STEM activity. It was also important to make students gain a holistic viewpoint and to show them multiple perspectives in the problem-solving process to reach different solutions and break the stereotypes in their minds.

According to the result, the Student C, Student X, and Student H took the total point from the question part individually. Student C’, Student D’, Student L’, and Student G’ groups took the highest marks from the practice part. While many students took total points in the math and social science questions, there were fewer students in the English questions. Although it was apparent from their presentations that they understood the subjects of the activity, but they again focused on creating a good prototype. They were also much better in the question part compared to the previous STEM activity. According to this, separating the questions from the prototyping part and not making students aware of the STEM activity until the implementation day were the right strategies to show this part as a regular exam.

When creating STEM activity, we focused on some points to develop students’ skills. For instance, we incorporated student choices and peer review in the evaluation of the STEM activity to make it more student-centered. We also included students’ presentations to develop students’ self-reflection, and they were very successful in expressing their projects in the activity (Figure 7.11). According to this, Student L, Student A, Student Z, Student D, Student E, Student F, Student G, Student H, and Student B were more participative to ask questions to the other groups. Student Y further asked the reason behind the project to every student to understand the project purpose; this was one of the essential questions that should be asked to each group. We also included making prototypes to develop their hands-on skills and, as previously stated that they were good at in their prototypes compared to the previous one. However, students used most of the materials when making their prototypes. That was a problem with sustaining the same amount of stuff for all students. Accordingly, to enable equal material usage, limiting material used can be considered in the STEM activity to promote students' creativity in their problem-solving process. There was also a group working in the activity to create a collaborative learning environment. Except for one group, it was observed that students were very good at doing teamwork.

Figure 7.11. A view from the students' presentation

In the activity, we observed that students were very motivated and engaged during the prototyping and presentation; they also showed great interest in the problem. Therefore, it was understood that the theme, materials, and also presents could increase students' attention, motivation, and participation in the STEM activity. From their presentations and their answers to the questions, we discovered that the STEM activity provided students' personal growth in developing model-making skills, teamwork skills, a better comprehension of the course content, and creating unexpected students' achievement. Students generally had good performances in self-reflection when presenting their projects, and group working in terms of responsibility, communication (social interaction, decision-making), and collaboration.

7.6.2 Part 2. Post-STEM activity focus group with three teachers to evaluate the STEM activity and the overall study

After the implementation of the STEM activity, on the 07th of May 2018, a focus group interview was conducted with three teachers to evaluate the STEM activity and the overall study. There are two purposes of the focus group interview. The first one was to learn teachers’ reflections about the STEM and DT approach, along with the comparison of two main studies. The second one was to determine the requirements and the way of implementations of STEM education from the teachers’ perspective. After the implementation of the Main Study I, I made changes in the questions of the teachers. I prepared my questions under three main groups: the evaluation of the implemented STEM activity, teachers’ perceptions about the STEM & DT approach and researcher-designer, and the plans of the teachers about implementing STEM education after the study (Appendix İ). The interview was conducted in Turkish and voice and video-recorded; the duration of the conversation was 46 minutes.

The findings of the post-STEM activity focus group with three teachers to evaluate the STEM activity and the overall study. The findings of the focus group interview provided us information about teachers’ evaluation of the Main Study I and II and the teachers’ perceptions about the STEM and DT approach. In this respect, this interview was investigated under six categories: teachers’ reflections about the implemented STEM activity in the Main Study II, teachers’ reflections about the needs and the way of implementations of the STEM education, teachers’ and students’ personal growth through STEM and the DT approach, the perceived characteristics of the DT approach in the STEM activity design, perceiving students as creative agents through the DT approach in the STEM implementations and adopting a holistic thinking mindset through the DT approach for changing teachers’ and students’ result oriented perspectives in the problem-solving process.

Teachers' reflections about the implemented STEM activity in the Main Study II. According to the teachers' feedback, both teachers and students enjoyed the activity, and there were higher students' motivation, participation, interest, and a better improvement in the course understanding. Considering teachers' opinions, these benefits arose from the theme of the activity and using a variety of materials during prototyping. Students were also motivated because of the given present to the previous STEM activity winner. Besides, the math teacher tried to encourage students by promising the presents to the winner of that activity. According to the teachers, they got familiar with STEM education in the Main Study I, and this made the conduction of this STEM activity easier compared to the previous one.

> If we compare it to the first term, I think it was successful; it was quite successful. We said to the children that would be no STEM, but they said: "it was STEM", "Oh, they tricked us" or something. But anyway the activity was lovely; you know the activity turned out nice as a result. The only troubles were material and silicone gun. If we gave it to them, they'd probably do wonders. But I think it was beautiful; successful products came out compared to the first term.[220] (Math teacher)

> **Math teacher:** Yes, the subjects of this term were also enjoyable for us too (**Social science teacher:** She shook her head). The first term, we had difficulties maybe because it was the first time or we got used to it in the second term, we learned the systematic.
> **Social science teacher:** But the second term was something more. (**Math teacher:** Our subjects were delightful, compatible.) The subjects were lovely; at least there was a concrete product that emerged. For example, the designs, the planning of a city, was charming.[221] (Math and social science teachers)

There were unexpected success and failure of students, and this result showed that STEM education could address students' different learning needs. For the failure of the STEM activity, teachers pointed out two reasons; the lack of reading and students' inability to transfer ideas into the prototype.

> **Math teacher:** In English, Student F is 10, I think because he forgot to mark it onto it.
> **Researcher:** My teacher, actually, most of them have forgotten that.
> **English skills teacher**: Yes, I was going to say that there are some names that I am surprised. For example, Student D and Student B. They are usually outstanding students in English
> **Researcher:** But they failed here, they have really forgotten it.
> **English skills teacher:** I'm surprised at Student Y. Not good but did 14, 14 out of 15.
> **Researcher:** But Student Y remembered. Even Student Y's mistake was this; he wrote the same profession twice; otherwise, usually, Student Y would get a full score.

> **Math teacher:** So this is the educational model of Student Y.[222] (Math and English skills teachers)

> **English skills teacher:** Even I said put a tick on animals in danger of extinction; even I showed the tick to them …
> **Math teacher:** They do not read, not read the question.[223] (Math and English skills teachers)

> **Researcher:** Did you have any questions about the activity?
> **Math teacher:** I was on Student C's side when I looked at the other side, the prototypes, their imagination do not appeal to me. I mean, they cannot imagine what they want to do with materials. Well, they had trouble with that. They had difficulty in implementing what they imagined or thought that they were running out of time, so it was the only difficulty.[224] (Math teacher)

The math teacher further found the Student C' group the most successful one in the STEM activity. Her second choice was Student D' group, and her third choice was Student H' group.

> **Math teacher:** I liked Student F's and Student C's during the activity. (**Researcher:** We gave him 50 points; we found them creative.) Yes, he was my first place winner. […] Student C's and Student F's were good, number two was Student D and Student E, and my third was Student H and Student Z, who had the idea of a hospital.[225] (Math teacher)

Both the social science and math teachers considered telling the STEM education to students due to conducting regular lessons covering common themes instead of the interdisciplinary lessons with team teaching. On the contrary, I thought not making students aware of the STEM activity until the implementation day as the right decision. Since teachers stated the students' negative comments about the STEM before starting the Main Study II, and they continued to give similar feedbacks until the implementation of the STEM activity. The math teacher also favored making regular lessons covering common themes because of not causing an extra responsibility on them and concerning the students about leaving back from their lessons. She further pointed out the continuity of STEM education in the school to make students' adaption easier.

> **Researcher:** From the beginning, we discussed how to say STEM. There was always a question mark in our minds.
> **Math teacher:** Well, if we look at students' concerns, I do not remember where they said it, but I think we talked in class. The children were worried about whether STEM

is going to go on to their report or not. For example, because of the collaboration between the classes, they feared that we would fall behind these lessons. So if STEM is to be integrated into education, it can be a STEM activity hour like a social activity hour. Well, STEM should be told to the children from the beginning. But since there will be STEM activity, maybe if each teacher enters the class interactively as we did in the first term, different results may occur. You know, when you do something like this without showing, there are difficulties, but I think that if we fix it, there will be very different results. According to the children's interpretation, this comes to mind.
Social science teacher: I think it wouldn't be a problem if we have told them as well because we did not enter the lesson as 2-3 teachers or you did not come. No cameras, no pictures. They might have known because they did not exist, but I think they would still be comfortable because each lesson's teacher taught as if it was their regular lessons.
Researcher: Yes, it was a difference during this term. You all talked about your subjects in your lessons, so it did not look like there was any connection. (**Social science teacher:** Yes, **Math teacher:** No, **English skills teacher:** Shook her head).
Social science teacher: We did not create fear in the eyes of the children by entering the class with two or three teachers, and they did not worry about what we are in. Actually, we could have told them.[226] (Math, social science and English skills teachers)

Teachers' reflections about the needs and the way of implementations of STEM education. Teachers stated their opinions about the requirements for the application of STEM at school. Since according to the teachers, STEM education could benefit the students in terms of a better comprehension of the course content. Accordingly, there should be an elective lesson to integrate STEM education into the school. They also stated the need for a STEM atelier, which includes small tables and cushions to create a comfortable atmosphere both for teachers and students. They pointed out needing extra time for teachers to collaborate under the management of a coordinator. Besides, they stated the need for a designer to guide teachers in STEM education owing to having an interdisciplinary viewpoint and creativity. The social science teacher also said that an educator could not manage this study because of having experience with only one discipline.

Social science teacher: It can be a STEM workshop.
Math teacher: Workshop. It is a place in which there are small, small tables, cushions where they can sit comfortably.[227] (Social science and math teachers)

Researcher: Do you think including the STEM approach into the school (**English Skills teacher:** Would it matter?) would it matter?
Math teacher: For example, what I said at the beginning is that if the STEM approach is to be included in the education system on a school basis, yes, I think it should be, but it should be an hour of activity. (**English Skills teacher:** Elective course) Like an elective or social activity course, there should be a STEM group in

social activity.
English skills teacher: It can be a course like technology design or information technology. (**Math teacher:** There must be a lesson.) So something extra should be reserved for it, time should be reserved for it (**Social science teacher**: Yes).
Math teacher: It should be assigned a lesson in a one-week curriculum, and also teachers should again work ...
Social science teacher: I think there should be a coordinator.
Researcher: Who makes us all (**Social science teacher:** Guiding) organize. (**Math teacher:** Of course, he will) He will look at whether they will be involved in doing.
English skills teacher: In other words, when such interdisciplinary harmony or common point is found and given to the child, the child can perceive things better when he/she connects the subjects (**Math teacher:** Something useful for the child). When you make a connection, you can see some things better, like a puzzle, I think.[228] (All teachers)

Researcher: So working with a designer, and using a design method, did it come strange to you or add you something?
Math teacher: Working with a designer has a significant contribution to us in STEM. If it is to be studied, it is a great benefit for a designer to accompany and to guide.
Social science teacher and Skills teacher: Yes
Researcher: Can you tell me what it means? Because it could be an educator here, after all, STEM is an educational approach.
Math teacher: At first, I said that a designer is not an educator. I thought about how to apply design to education; I could not reconcile it in my head. But thinking whether it is an educator or a designer, I think it's a designer because, in the end, it is design thinking.
Social science teacher: The educator also develops himself/herself in one field. Probably, interdisciplinary wouldn't have been this useful.
Math teacher: If our essence is creativity, it should be a designer.
Social science teacher and English skills teacher: Yes
Researcher: What do you say, my teacher?
English skills teacher: I agree.[229] (All teachers)

The math teacher highlighted making the regular lessons covering a common theme instead of making the interdisciplinary lessons with team teaching for the benefits of both students and teachers.

Researcher: The last term, we made team teaching, but we did not do anything like that in this term. Everyone covered their subjects in the class separately. What can you say when you compare this term with the previous one?
Math teacher: Especially, it was exhausting for me to enter each other's lessons in the first term because I enter every lesson. You know, to think, to integrate, to make team teaching with teachers, their burden and weight were on us. But this time, everyone did their job, you know, the children did not see us over and over. Since I've been in their class for weeks, there was such bad luck. This term was very comfortable for me from that point of view, and if it is, it is better to be like that. Everybody should go to their lesson, where interdisciplinary lessons are integrated into the necessary places, but no one enters the others' lessons and scares the children. Children are seriously doing a thing; you know worrying about what is going on, what is happening. The order of the class is differentiated. When you came to class, it caught their attention, the camera, they always become a problem. I mean, that's what the kids say.[230] (Math teacher)

Teachers also mentioned how they could use the STEM at school. For instance, the math teacher wanted to apply STEM education individually by stating the relationship of the disciplines between each other without making an activity. However, the social science teacher found this way of implementation not productive owing to not including a product and pointed out the significance of having a system at school to enable the continuity of the STEM education. From their conversations, having interdisciplinary knowledge and teachers' collaboration was needed to apply STEM education at school. For the 5th class, the social science teacher also wanted to use STEM education in the second term because of having easier and enjoyable subjects compared to the first term. This finding can be another important point for teachers' and students' adaptation to STEM education.

> **Researcher:** According to these works, do you have anything in mind such as workshop, STEM, or design, that I can use one or do something like that? **Math teacher:** At least the first term, we took each other's lessons. But surely in the next step, maybe not in 5th grade, but in the 6th or 7th grade, at least I will have a look at the curriculum and try to apply the interdisciplinary on my own. Of course, if I can find the opportunity or if it comes to my mind, I will use it. **Social science teacher:** But then it does not happen again by making decisions alone. **Math teacher:** You know, of course not, but at least if I do not collaborate with anyone, I say, "Heyy, did you learn that in social class?" and I will connect the mathematics in one hand. For example, I will say, "Look, there is this in science," and I will apply to mathematics. I will tie it up in one hand, myself. **English skills teacher:** Exactly, it reveals the difference between making them do a calendar and making them prepare the curriculum. If I knew in the first term that the children do not know how to use a ruler, I would never attempt such a thing.[231] (All teachers)

> **Social science teacher:** My teacher, the school should have a system. It can be applied in a school without a system but (**Math teacher:** We succeeded the hard.) when the discipline is used alone, no productivity is obtained, it is like a regular subject expression, and no product is made.
> **Math teacher:** Yes, disciplines are necessary for creating a product (**Social science teacher:** Yes) But if the product will not come out, the subject explaining can be applied individually in one hand.[232] (Social science and math teachers)

> **Social science teacher**: Let me talk for my lesson, though it is the same in all disciplines, the subjects of the first term are a bit more academic. (**Math teacher:** Yes, in mathematics as well.) In the second term, the weather gets warmer, and the holidays are approaching. The Ministry of Education makes plans accordingly in the curriculum. (**Researcher:** Is it easier?) The subjects become easier and more fun (**Math teacher:** Yes). So that's why it might be the second term. Since in the first term, we had difficulty in interdisciplinary integration of the subjects in this context. Because the subjects were more difficult, and each subject had significant issues. But in the second term, it was joyful because there were more fun-oriented subjects

(**Math teacher**: Yes) I think, the latter term was more productive (**Math teacher**: Shakes her head).
Math teacher: Because there were easy subjects compared to the first term, really easy subjects. (**Social science teacher:** Yes)[233] (Social science and math teachers)

Teachers' and students' personal growth through STEM and the DT approach. One of the factors that could influence the development of STEM activity was creativity and collaboration. In this respect, while the social science teacher considered herself creative, both the English skills and math teachers stated their inability to turn their ideas into reality. Thus, the English skills teacher indicated her need for collaboration to develop ideas since making interdisciplinary collaboration with the other teachers in the co-design process affected her creative idea development to develop a STEM activity. The English skills and math teachers also considered that this study contributed to their creativity.

Researcher: My teacher, in what way do you not find yourself creative?
English skills teacher: Yes, my imagination is a bit high in material design, but I do not know
(**Researcher**: Is it hard to put into practice?) Yes.
Math teacher: I have it too, put into practice, facilities.
English skills teacher: An idea developer, such an assistant condition, is essential to me. When I am talking to a person, I can see that; actually, I can design something myself, but thinking on my own, no, it does not happen.
Researcher: Did this work contribute to your creativity?
Math teacher: Yes.
English skills teacher: It was, it was, it was to mine. I was very creative when I was making a calendar. Well, I do not know how it came to my mind; I think it's a very original idea. I mean, I wouldn't usually think of an idea like this.[234] (English skills and math teachers)

Teachers pointed out another benefit of making collaboration with the other teachers in terms of being aware of the connections among the disciplines. For instance, while the math teacher discovered that math was related to all disciplines, the English skills teacher also found the unpredictable relationship between the English and science disciplines after the Main Study II. As previously stated, the implementation of the STEM activity enabled some of the students' personal growth in terms of a better improvement in their course understanding. While some of the students performed better in the activity, some of them failed unexpectedly.

This finding showed that STEM education could address students' different learning needs.

> **Math teacher:** When we look at our curricula, in fact, there is math in everything. But how do we apply this to children? But after the first term, no, I mean, there's no discipline I say I cannot work with.
> **English skills teacher:** I was saying what relevance to science before. But, there it was.[235] (Math and English skills teachers)

In the English skills teacher's activity, she found students successful in the design of a calendar. According to her, they worked enthusiastically and owned the project. This finding also showed the role of the theme in the students' ownership of the problem, because owning the problem caused an increase in students' motivation and success as occurred in this activity. As previously stated, there was a revision in the "observe" stage, and the questions about asking students' problems and requiring making selection among the popular STEM themes were added to guide teachers in their data collection. Therefore, the data from the "observe" stage can provide the needed data about the selection of the project theme, and can assist teachers in creating a bond between the STEM activity and students.

> **English skills teacher:** Children were going to prepare a calendar at "party time". I got them to make a calendar like this.
> **Researcher:** How did it happen? You did not get the result you really wanted in the first term, I think?
> **English skills teacher:** Students did not see the geometry in the first term because they did not know how to use a ruler. I had a hard time making them prepare a weekly plan. Now we have prepared a calendar with them in the second term, so they made 12 sheets; they also prepared a cover. I got them pinched from the top and got the wired outside, and then I put cardboard in between for support. That way, they could put it on their desk and turn every page like that. They made squares, and they were going to write something meaningful or anything in those days into the squares. This time the ruler was more comfortable to use. And I did it with the 5Y and 5X class; yes, I did with two classes, but not with the 5Z class.
> **Researcher:** Did you get the results you wanted?
> **English skills teacher:** As a result, yes, outstanding products came out. (**Researcher:** Did they like it when they were doing it?) They loved the calendars, the Student C and others; also, even some of the calendars were on their desks.
> **Math teacher:** It was on their desk at 5Y until yesterday, and as soon as I entered, they showed me their calendars. "Look, Teacher, look at our calendar." Apparently, you asked for their pictures to create a calendar; they were showing the photos during the class break.
> **Researcher:** They have owned, how nice.

> **English skills teacher:** They asked the teachers for a picture, and they stuck it on the back of that month to remember their birthdays. For example, that month, Emine teacher has a birthday. She was attaching a picture of Emine teacher on the page behind that month.[236] (English skills and math teachers)

Perceived characteristics of the DT approach in the STEM activity design. This interview was investigated about the teachers' perception of the DT approach in the STEM activity design process.

Structuring the STEM activity design as a process through the DT approach. Teachers considered significant the problem-solving characteristic of the DT approach due to customizing the activity design process. The math teacher stated that if STEM education was taught for the first time, the DT approach could assist the teachers in making them understand the whole STEM activity design process.

> **Researcher:** What do you think about the workshop and the method we use there? Or do you have any suggestions for me?
> **Math teacher:** If those steps in the method are going to be done for the first time that first term undoubtedly contributes to the second term, I mean to our understanding.[237] (Math teacher)

Empowering teachers with interdisciplinary collaboration and teamwork in the co-design process through the DT approach for facilitating the STEM activity design process. In this workshop, there was an interdisciplinary collaboration among teachers and the co-design process among teachers and the researcher in the STEM activity design. As previously stated, the co-design process among teachers and the researcher and the interdisciplinary collaboration among teachers enabled teachers to develop creative ideas. Besides, the interdisciplinary collaboration among teachers helped them to get familiar with the students in terms of their level of knowledge, and increase their personal growth from the point of raising their awareness about the connections among the disciplines.

Perceiving students as creative agents through the DT approach in the STEM implementations. As previously discovered that teachers gave importance to getting familiar with the students for the application of the STEM education; consequently, I wanted to get feedback from teachers after the implementation of the STEM activity to understand how they could plan a STEM activity. For instance, the math teacher preferred to get familiar with the students in the first term and to implement the STEM activity in the second term by integrating all subjects into one activity. She also stated to implement the STEM activity in the first term for the 6th class after getting familiar with the students in the 5th class. The English skills teacher preferred to get to know the students and the other teachers in the first term and implement the STEM activity in the second term. According to her, in the 5th class, both teachers and students would be new to each other.

> **English skills teacher:** The first term, maybe, a new teacher or a new student might come. If it is like that, oh my god, then praise the Lord for what we meet with the first term. (**Researcher:** In the sense of getting used to it.) Of course, they can hesitate. Actually, it can be difficult for the teacher and the student to get to know each other, or for the teachers to know each other; it can be harder to group the children. But the second term is reasonable.
> **Math teacher:** For at least five classes. Because the teacher is new, the student is new, but now you know every child, you know them, the child knows you in that aspect. (**English skills teacher:** Of course.) That is the greatest comfort. Oh, maybe, it fits the curriculum, it's done in the 6th class, and then you will do it in the first term because you've already known the child for a year.[238] (English skills and math teacher)

Teachers discovered that one of the most prominent ambiguities in this study was students' situated behaviors, and thus, they focused on getting familiar with the students and also teachers by giving themselves one-term to apply the STEM education. However, it is an extended period, and getting familiar with the students and the teachers can be provided by applying the DT approach. Since it can facilitate teachers' collaboration by using empathy as a tool, shorten the working time and search for answers about students' interests and problems in the "observe" stage. Furthermore, the English skills and math teachers perceived students' situated behaviors as the only cause of some failures during the Main Study I. However; there were other reasons that affected students' reactions that were stated by both teachers and students in the Main Study I. It was also discovered in the Main Study II that school management affected the integration of STEM education because they prioritized maintaining the school order.

In the Main Study II, after discovering the uncertainty about students' feedback, it was decided to observe the students until the implementation of the STEM activity and to disguise the STEM activity from the students. These decisions brought success despite the students' negative feedbacks about STEM education at the beginning of the study. Thus, getting familiar with the students can be provided before the implementation of the STEM activity by applying the DT approach. Using some strategical decisions and defining all the stakeholders to make them involved in the study, and to increase their motivation and ownership are needed to design and implement a productive STEM activity at school. If teachers are new to the class or inexperienced, this way of approach can enable them to get to know the students in a short time.

***Adopting a holistic thinking mindset through the DT approach for changing teachers' and students' result oriented perspectives* in the problem-solving process.** Teachers' and students' result-oriented perspectives in their way of approach to the problem of the STEM activity were discovered in this study. For instance, according to the math teacher, the required solution was clear from the beginning of the STEM activity in the Main Study I.

> In the second term, they made severe design. Students always did the design. In the first term, we focused students on a template that is to say from their words, yes they were conditioned on the first term, and the product was apparent. Now, they really have something to reflect on their imagination (**Social science teacher:** Yes).[239] (Math and social science teachers)

On the contrary, the question was about producing a solution to prevent the melting of the ice cream, and they were not specifically directed to design a particular product. There were also many constraints in that problem similar to this one. Moreover, in this STEM activity, the limitations haven't been understood by all students, and some of them developed stereotype solutions for the problem, as previously mentioned. In both STEM activities, students were required to use their imagination and to consider the constraints when developing solutions, although the math teacher thought reversely.

Consequently, it was discovered that both teachers' and students' way of approach to the problem had a result-oriented perspective instead of a holistic one. This perspective could be a constraint both for the STEM and DT approach. Since in the problem-solving process, it is significant to focus on the problem definition with all its limitations or restrictions before developing solutions. Furthermore, the creative processes similar to STEM and the DT approach do not have one particular solution for the problem. In this perspective, adopting a holistic thinking mindset of the DT approach is considered significant for the integration of disciplines in terms of designing the STEM activity by considering the whole factors. It is also valuable for students in the problem-solving process of the STEM activity to define the problem by considering all factors, reach multiple ideas, and break the stereotypes in their minds.

7.6.3 Part 3. Post-STEM activity interview with the visual arts teacher to evaluate the STEM activity and the overall study

After the implementation of the STEM activity, on May 16, 2018, an individual interview was held with the visual arts teacher to evaluate the STEM activity and overall work, as he could not attend the focus group interview. To achieve my purposes, similar to the focus group interview, I asked my questions under two main groups: the evaluation of the implemented STEM activity and the plans of the teacher about implementing the STEM education after the study (Appendix İ). The interview was conducted in Turkish and voice-recorded; the duration of the conversation was 49 minutes.

The findings of the post-STEM activity interview with the visual arts teacher to evaluate the STEM activity and the overall study. The findings of the individual interview provided us information about the visual arts teacher's evaluation of the Main Study I and II and his perceptions about STEM education. In this respect, this interview was investigated under three categories: the visual arts teacher's reflections about the implemented STEM activity in the Main Study II and his expectations for the future STEM implementation and the leading role of arts discipline in introducing STEM education empowered by DT approach.

The visual arts teacher's reflections about the implemented STEM activity in the Main Study II. The visual arts teacher evaluated the STEM activity that was implemented in the Main Study II and compared it with the previous one. Accordingly, he considered this activity theme, -space-, open to creative solutions; thus, he thought that this activity forced students' creativity. He also stated that the previous Main Study I was productive due to making the abstractness of the interdisciplinary lessons tangible. Besides, he found students more participative, productive, and hardworking compared to the previous STEM activity. He also stated that they were very active and motivated during sketching in the creation of the prototypes, posters, and presentations.

> We saw more active, more productive, more rational children than the first term. As if, they do not look, we are explaining to them, but the child immediately tries to grasp the event, they are trying to produce something with the object that was brought. In the activity of the second term, I never felt their slowness's that it was in the first term. Immediately, drawings, project drawings, sketches, narratives, posters were made. After that, the applications went very well, respectively, and they tried to give it in specific time frames with the materials at hand.[240] (Visual arts teacher)

> **Researcher:** My teacher, what can you tell me if we evaluate the activity of this term and compare it with the previous one?
> **Visual arts teacher:** My teacher, this activity was especially challenging to the creative power of the child, since it included themes such as space and space professions. In the past, that I mean the last term, we have dealt with the STEM most beautifully based on actual data. We tried to present the lessons with three-dimensional shapes, objects, and subjects that our children could bring, which is supposed to be. For a subject to be understood, it must free itself from the abstraction and go to the concrete that is the purpose of education. That is the aim of teaching, the first term of the work was taken very well, and it was supposed to be carried out anyway.[241] (Visual arts teacher)

According to the visual arts teacher, the activity increased students' self-reflection and course understanding, and they could explain the reasons behind their solutions. He also stated that students liked having practice-oriented activity, using tools and equipment in STEM education. In this respect, this kind of hands-on activity provided higher motivation, interest, good collaboration, and communication between the teammates. Besides, he stated that the group working made them discuss and exchange their ideas.

> They really like STEM and STEM activities, as they are mostly practice-oriented. They love using equipment and tools. Whether in the classroom, in the workshop, or in the physical space that we have arranged for them, the groups there can at least discuss, talk, there is movement, nothing like a robotic action. I heard, "Let's put it like this, why did we put it?" there, for example, they were speaking like "Let's cut this like this."[242] (Visual arts teacher)

According to him, success means how students appropriately used and internalized the information and skills. Therefore, he found students successful since they gradually developed themselves about preparing the poster, creating forms, using appropriate materials and equipment for production.

> Success is related to the extent to which they are acquiring a new set of knowledge and skills. Here, from using the material to drawing or poster designing for the child, one way or another, they gradually felt that there would be writings on the poster. The child felt how the material was to be cut, glued to, or how they would form together.[243] (Visual arts teacher)

He also stated that giving a present to the previous winner of the STEM activity in front of the other students, making a hands-on activity, and distributing chocolates during the STEM activity could be motivational factors for the students' success in this activity. Besides, he discovered differences about some of the students after the implementation of the STEM. It was understood that STEM education increased students' motivation, interest, engagement, and responsibility. Consequently, it addressed students' different learning needs.

> Even the most passive person tried to be the most active person. Student K was a calm person; she gave some things, form, shape, sketch, drawing, or something like that in the activity. For example, even Student Y, who resisted bringing a notebook in advance, now comes with something, talking mutually, isn't that enough.[244] (Visual arts teacher)

We also discussed some strategies that I followed to implement the Main Study II. He stated that he would follow the same approach. Since according to him, new things could bring reactions, and students showed responses to the interdisciplinary lessons in the Main Study I owing to making team teaching and expecting to be free in the visual arts lesson. According to him, students got used to STEM education in the Main Study I, and consequently, they did not show objection to the STEM activity and seeing multiple teachers. For this issue, he also stated that teachers' adaptation enabled the students' adjustment. Besides, he favored making regular lessons covering a common theme to show the connection of the subjects in the different disciplines.

> I would do it just like you (He meant the strategies). But I said it first, every new thing brings rebellion, the objection together. Though this is not new, society should adapt to this now. So I think so. If we adopt, the child will adopt. If we are an example in front of him, he also adapts.[245] (Visual arts teacher)

> They reacted because they saw the three teachers together. I taught art, or we were related to mathematics, social science. Then, it was as if the child had not experienced the freedom and comfort of the visual arts lesson. That was the reason for their reactions. But they've gotten used to it over time. At least, we were a few teachers at the STEM activity.[246] (Visual arts teacher)

The visual arts teacher's reflections about his expectations for the future STEM implementation. The visual arts teacher mentioned his expectations regarding the implementation of STEM education at school. For instance, he correlated the STEM with the practice, atelier, and laboratory, and thus, he expected a ready-made workshop environment with tools instead of making it in a prepared environment as we did in the library. He also pointed out the significance of sustaining the interdisciplinary collaboration to continue STEM education at the school.

> **Visual arts teacher:** In this kind of thing, physical spaces should be much better and needs to be equipped with specific tools.
> **Researcher:** Teacher, well, you say that a separate place should be created for the student, so, what does it take for teachers to do this kind of work?
> **Visual arts teacher:** When creating for teachers, we still need to support this with several technical devices. For example, there's a tiny dental appliance that cuts automatically. (**Researcher:** Dental drill) Yes, there should be a dental drill.[247] (Visual arts teacher)

> First of all STEM education is required for children and me, not only for me, but also for other teachers, it is necessary to cooperate with group teachers for a year continuously, and when appropriate, small practices should be done. I do not know maybe getting an opinion of a Social science teacher about a topic in stage design and talking about what we can add.[248] (Visual arts teacher)

The leading role of visual arts discipline in introducing STEM education empowered by the DT approach. From the beginning of the project, the visual arts teacher was one of the motivated teachers among the others because of his previous interdisciplinary collaboration experience. While he was pleased to be in this study and working with a designer, the STEM education and its characteristics made him consider whether going back to a previous educational approach. He was also aware of the necessity of the interdisciplinary lessons in education and discovered the important place of visual arts discipline in STEM education, similar to science and math disciplines. That also caused an expectation on him about an increase in the visual arts course hours, and he would like to apply STEM education in the future.

> Now I am a teacher working with you in this STEM work since the beginning of the year. From what I can see, I have once thought that this is necessary for planning and sharing in education. I concluded that disciplines, interdisciplinary, interdisciplinary integration is essential for education. You should not just look at the event with mathematics, or you should not look at the event with another lesson. As a former teacher, I think that visual arts also has a place in this thing, there is a part for itself in this, and even a considerable part, such as; especially in mathematics, science, and other disciplines, I believe it is definitely and for sure a must. These are already at the core of education. I think this should be updated every time with these studies by taking more time in more scientific terms.[249] (Visual arts teacher)

7.6.4 Discussion of Phase 3

In phase 3, it was intended to implement the STEM activity by collaboratively working with teachers. Phase 3 included three parts: the implementation of the STEM activity, Post-STEM activity focus group with three teachers and Post-STEM activity interview with the visual arts teacher to evaluate the STEM activity and the overall study. The overall findings of Phase 3 provided us information about the perceived role of the researcher in the co-design process and the challenges concerning the stakeholders' expectations and abilities.

Perceived role of the researcher in the co-design process. In this phase, while the researcher-designer has participant observer and guide roles, teachers also performed co-designer and guide roles during the preparation and implementation of the STEM activity. According to this, the facilitator roles of the researcher and using the DT approach as a tool had three impacts on the study:

- Facilitating teachers' perspectives by changing their mindsets and perceptions to integrate STEM education into the institution.
- Facilitating the preparation for the STEM activity.
- Facilitating the implementation of STEM activity.

Challenges concerning the stakeholders' expectations and abilities. During the implementation of the STEM activity, four problems were discovered about the students: not being able to identify the problem, developing stereotype solutions for the problem, their lack of reading, and not being able to transfer their ideas to the prototypes, which was also the problem of the teachers. Besides, teachers' result-oriented perspective about problem definition was discovered. Teachers previously discovered this issue when executing the wallet design exercise in the Main Study I. Thus, implementing an exercise through the DT approach can benefit both students and teachers in finding out their result-oriented perspectives. However, discovering this problem was not enough solution since the critical point was to change yourself to solve this issue. Consequently, adopting a holistic thinking mindset of the DT approach was considered to be needed both for teachers and students in terms of showing the multiple perspectives to assist the problem definition, reach different solutions and break the stereotypes in their minds.

The English skills and math teachers also stated their problems with developing creative ideas, and the English skills teacher pointed out the importance of collaboration to solve this issue. Since both teachers and students had the same problem, if teachers learn how to develop creative ideas, they can teach this ability to the students. Furthermore, according to teachers, creativity, an interdisciplinary collaboration among teachers, and having interdisciplinary knowledge to discover the relationship of the disciplines were needed for the implementation of STEM education. They also pointed out creating extra time for teachers' collaboration. Considering all findings, the teacher training programs imposing the culture of collaboration, and integrating the DT approach because of its impact on teachers' collaboration can be a solution for developing teachers' creativity, interdisciplinary viewpoint, and collaboration skills.

7.7 Phase 4: Focus group with students

After the implementation of the STEM activity, on the 03rd of May 2018, a focus group interview with seven students was conducted to evaluate the STEM activity and the overall study. To achieve my purpose, I prepared my questions under two main groups (Appendix J): students' evaluation of the implemented STEM activity and students' suggestions about STEM education. The interviews were conducted in Turkish and voice and video-recorded. The duration of the conversation was 32 minutes since we had to finish the interview because of being at lunchtime. While there were seven students, the researcher, the visual arts and math teachers during the interview, the participant students were selected by the math teacher and the researcher considering their performances and reactions during the main studies.

7.7.1 The findings of the focus group with students

The findings of the focus group interview provided us information about the students' evaluation of the STEM activity by comparing it with the previous one. According to this, students were pleased with the activity, and they gave constructive feedback. For instance, Student G enjoyed the activity because of having more time for prototyping. Student B and Student C considered this activity easier and enjoyable than the previous one owing to including only one question since the previous one had three different types of questions. Student D and Student B also found this activity better than the previous one because of thinking having no questions in the STEM activity. However, they did not notice solving the scaffolding questions before starting the prototyping part.

Student G: My teacher, it was beautiful like this, but what I said I have a time problem. For example, I was a person who did these things very slowly before, but I can do better when there is a lot of time. I think it was lovely.[250] (Student G)

Student B: My teacher, you gave a few questions in the previous term. It was a bit hard. But this was simpler, I thought it was a little different, but it was lovely.
Student C: Teacher, you asked a lot of questions on paper in the previous one, that's why I think this is more beautiful. We did not do such things; this was more (**Student E:** Fluent) exactly.
Student D: Teacher, I agree with others. You gave us a paper. There were questions. But we did this directly designing in this. That's why (**Student B:** That's why) it was more beautiful. [251] (Student B, Student C, Student D, and Student E)

In this activity, Student D, Student A, and Student C considered themselves freer in the problem-solving process since the problem of the activity was not similar to the previous one. According to them, they could use their imagination more because of the non-existence of the problem currently. But, it was discovered that some of the students could not define the problem and its constraints. For instance, Student F complained about the existence of both space and animals in danger of extinction in the problem. Student A stated that it was challenging to have both space and humans in the problem. In other words, both of them complained about the parts of the problem without being aware of it.

On the contrary, in the previous activity, students were asked to prevent the ice-cream from melting. For this question, some tried to create a cooler as a solution to the problem, referring to real products, although they were not asked to design a cooler directly. Therefore, they considered not using their imagination when solving the problem of the previous activity.

Student F: Having animals has narrowed our space a bit. If there was normal space life [...] You have animals; you're dividing the space into two, people on one side…
Researcher: That was your problem this time. Having animals …
Math teacher: That was the problem you did not notice.
Researcher: Yes, so you had a problem like the last term.[252] (Student F)

Student D: I'm going to talk for myself. We thought a lot of things to keep the ice cream from melting because you gave us a problem. I do not know how to say it; we beat our brains out; it was also difficult for us to do. But now you just gave us space. You gave the space subject. We have worked more freely than we did on the space subject.
Researcher: We had a problem here either. As a result, you go to a new living area, you take animals with you, and there are professions as well.

> **Student D:** Okay, but now there's something like this. Everything depends on our imagination. (**Student A**: Exactly) So we do not know what will happen in the future. For example, maybe the sea will be purple in the future as he says, for example, we can make the sea purple. But to keep the ice from melting.[253] (Student D and Student A)

Student E also claimed not needing to sketch to produce this solution since making a good looking prototype was their priority, but Student A considered reversely.

> **Student E:** Teacher, we were going to do something on the first sheet, and we did not do anything. I just drew a house. We have made a design directly.
> **Researcher:** You think you did something, right?
> **Student E:** Teacher, I think something better happened.
> **Researcher:** You say that?
> **Math teacher:** But the designer, but now we have a designer with us.
> **Student A:** We need to draw a sketch.
> **Researcher:** Yes, exactly. You cannot actually start without sketching, because you do not know what to do. When we talked about why you did this in your solutions, you replied that we added them later. You did not even know why you added it.[254] (Student E and Student A)

Some students liked the previous STEM activity owing to having a real problem contrary to the imaginary one. For instance, Student G preferred to have a real problem due to having limited abstract thinking. Student E also did not like an imaginary problem owing to considering not able to realize the solutions currently. Besides, Student A found the previous STEM activity easier since making a prototype meant making a box for her. Thus, while she tried to make a box to make a cooler as a prototype in the previous activity, the problem of this activity did not enable her to create a prototype like that. Because of students' different choices about the problems, Student G suggested making a selection between the proposed subjects.

> **Student G:** Teacher, I think both of them did not push much, but I think the first term was easier. Because I speak for myself now, I like to work more on real things.
> **Researcher:** You want your feet more on the ground?
> **Student G:** Yes. I mean, how I can tell you...
> **Researcher:** Could not you imagine much?
> **Student G:** Think like this. I can think %70 or %60 real, %40 I can imagine.
> **Math teacher:** You are realistic then. You like to work more real.
> **Student G:** Yes. I like working realistically.[255] (Student G)

> **Student A:** My teacher, we also had a problem, I believe that the problem was challenging because it was in space and there were also people. For example, in the

last time, everyone tried to make it in the form of a box. We could do it more easily. But this time, we could not do it because it is not in the form of a box, and when we say make a model like this, I think home comes to our mind.
Researcher: For example, I did not ask you to do anything in the form of a box; you did it. (**Visual arts teacher:** Yes) You could use your imagination, but you did not. In this way, you have chosen Student F's solutions as a result. Because visually, when you think of freezers, something box-shaped comes to your mind. Why is that? Because there is always a box-shaped refrigerator, freezers (**Student D:** We are used to.).[256] (Student A and Student D)

Student G: Teacher, I think we can bring a system like this if we're going to continue. We can vote between the subjects, for example.
Researcher: I think that's a good suggestion, a helpful idea.
Student A: You can give us three subjects.
Student G: My teacher, for example, raising hands after saying the subjects are these.
Researcher: Okay**.**
Math teacher: Grouping subjects and voting accordingly.[257] (Student G and Student A)

Students also confronted with some problems during the STEM activity. For instance, Student F found the activity difficult due to not being able to transfer his ideas to the prototype. Student G also had conflict with his partner about reaching a joint decision, and he stated that it took a long time for them to decide and apply a decision. However, other students liked their teammates and also the group working in terms of making collaboration. They stated that they could deal with the problem with their partners.

Student F: I know, this period, Student X was not my partner. I know he was not. But still, I had a little difficulty.
Researcher: Is the subject difficult?
Student F: Not the subject. (**Researcher:** What?) (**Math teacher:** Designing?) Designing.
Researcher: It was hard to design for you
Student F: I could not do what I had in mind.[258] (Student F)

Researcher: Friends, how did you find groupings?
Student B: It was good.
Student C: It was good, my teacher; I got rid of Student Y.
Everyone: They all talk at the same time by saying, “It was good, it was perfect”.
Student G: My teacher, I'm a bit of a mixed, in between, but (**Math teacher:** It would have been better if it was someone else.) exactly, if it was someone else.
Student D: My teacher, other than Student Y with Student X, I am not counting them. I think everybody's been good at with their partners.
Researcher: You think so?
Everyone: Yes, my teacher. Me too, my teacher, yes, yes.
Student H: I think my friends were okay. So we can do it together.[259] (All students)

> **Student G:** My teacher, I want to say this. So, now, I know that the groups are right, I know I am on a slightly different topic, but the groups are right. But for me, it can stay a bit between us, or you can say it to Student K, well I'm doing a little slowly with Student K.
> **Researcher:** Hmm, is your decision-making time extends?
> **Student G:** It's not decision-making, for example, to put something here (**Student B:** She talks half an hour) exactly, we talk half an hour, we think how it happens, what happens. We always clash with the ideas.[260] (Student G)

Besides, they mostly complained about construction problems during the creation of their prototypes. They also pointed out that the materials were overused by some students during prototyping, resulting in a lack of some materials. Therefore, Student G offered me bringing less stuff for the sustainability of material used.

> **Student G:** I really do have a recommendation, but you do not have to do it. I do not think you should bring that much. Because when you bring this much, everyone becomes "Aaa (**Student B:** They attacked as if they have never seen before). Teacher, for example, let me tell you what I got from here. I bought two cartons. So I got the thing, cups, three. I got 3-4 straws. Then we got two chopsticks and staples.[261] (Student G)

Furthermore, during the STEM activity, students' choices were incorporated into the activity to vote for the best project. However, about the result of the voting, students criticized themselves and complained about the inequality of the students' selection. Since they claimed that instead of looking for the best prototype, students voted for their friends, and for this issue, Student G criticized his friends: "It is not looked at the logic of the project construction. The ornament is being looked at. […] To the light, and so on. That's what I do not like."[262] (Student G)

We also discussed their objections during the Main Study II for making STEM education. It was discovered that students reacted to STEM education as a result of applying a new educational approach at the school. Student B, Student C, and Student E stated their objection about making the interdisciplinary lessons due to the probability of being back from the lessons and needing to make more effort. But, later, Student B found STEM education enjoyable. Because of these reasons, Student B, Student C, and Student E stated their objection about making the interdisciplinary lessons during this focus group interview. On the contrary, Student G and Student D favored applying STEM education and making interdisciplinary lessons. Besides, Student G wanted the continuity of the STEM education along with Student D, Student H, and Student A. It can be concluded that while half of the students did not want to deal with the STEM education, others considered reversely and wanted the sustainability of it at school.

> **Researcher:** Apparently, you told your teacher not to do STEM all time, did not you? You objected it; you opposed it.
> **Student B:** But, my teacher, I did not know it would be such fun.
> **Researcher:** But did not you do some fun things in the class this term?
> **Student B:** We did it, but we worked very hard.
> **Researcher:** Is dealing with something terrible? But look, in the end, there can be a reward.
> **Student B:** Yes, it can be my teacher, but, well ...
> **Student G:** But nothing happens without a hassle.[263] (Student B and Student G)
>
> **Student G:** My teacher, I think STEM is beautiful. You know why? During the first term, there was a perception. Combining courses. I think it was a good thing (**Student D**: Yes teacher, it was nice to combine lessons).
> **Student G:** Teacher, I said a lot, but I think it was beautiful. I mean STEM. I want it to happen anyway. (**Student A:** I think so too, **Student D:** He gives his approval by raising his hand) Because even if I did not like it at first, I knew I would get used to it. And I knew I was going to love it slowly by slowly. That is why I actually liked it from the beginning.[264] (Student G and Student A)

7.7.2 Discussion of Phase 4

The most crucial finding in this interview was related to the type of problem in the STEM activity. While some of the students favored solving the intangible problem (such as space), some of them preferred more realistic problems (such as preventing the melting of the ice-cream). Students also complained about their inability to transfer their ideas into the prototype, using the excessive materials, having the construction problems during the creation of their prototypes, and the inequality of the students' selection for the best project. Besides, it was discovered that some of them had difficulty in problem definition. Some of them also suggested stereotype solutions for the problem. Based on the students' suggestion and the findings of the focus group interview, some strategies were developed to enable the productivity of STEM education.

- Students should be introduced to the design thinking process *before* the STEM activity itself.
- Integrate the DT approach into STEM activity with a special emphasis on collaboration among students to enhance the students' creative thinking skills.
- In the "observe" stage, make the students select the activity subject (s) from the proposed list.
- In the design of the activity, impose restrictions on using the materials to prevent the unnecessary usage of the materials, and to trigger the creativity of the students in problem-solving.
- In implementing the STEM activity, it would be useful to separate the "answer the questions" part from the hands-on part spatially and cognitively in order to make students concentrate on both parts in a balanced way.
- In the problem-definition stage, encourage students to read and re-interpret STEM activity theme and write down their reflections in the form of a report.
- Emphasize the importance of "ideate" stage during the STEM activity and encourage students to develop new and functional ideas rather than giving priority to building "appealing" prototypes.
- After completing the STEM activity, encourage students to present their outcomes to the class and provide them with a student evaluation table or a comment card for structuring the peer review process for evaluating the performance of student teams. The student evaluation table may include functional qualities, aesthetic qualities, working principles and the innovativeness of the solution.

7.8 Phase 5: Exhibiting the outcomes of the STEM activity at the school’s science fair

In phase 5, it was intended to participate in the Science Fair in the school to exhibit students’ prototypes, “welcome cards” and “pictures about the living environment in the space”. The Science Fair was realized on the 5th of June 2018, between 2.30 pm and 4.30 pm (Figure 7.12). In this phase, both the researcher and teachers were actively involved.

Figure 7.12. A view from the science fair showing the stand on which the prototypes and “welcome cards” were exhibited

In the exhibition day, the visual arts teacher and I collaboratively worked to place the students’ prototypes and “welcome cards” on the stands, and to hang the pictures of the students to the wall (Figure 7.13). The visual arts and math teachers and as a researcher, I dealt with the exhibition since the students and the other teachers had duty on the other stands. The math and visual arts teachers were very enthusiastic and motivated during the exhibition. For instance, the visual arts teacher brought the other teachers to mention the project. While he was talking, he emphasized the place of the visual arts in STEM education along with the other disciplines. The math and visual arts teachers also voluntarily answered the questions of the school foundation manager. Later, the math teacher stated that some of the students from the 3rd-grade found the project about the new settlement in the space not logical since they could not imagine life on another planet. It was apparent that some of the students could not imagine the unrealistic situations, and this finding showed the significance of getting familiar with the students and involving them in the STEM activity design process as a stakeholder. The exhibition was the last phase of the Main Study II, and the study was completed after the Science Fair.

Figure 7.13. An image from the exhibition which showed students' pictures about the living environment in the space

7.9 Discussion of Main Study II

The findings of the Main Study II provided us information about the perceived common characteristics between STEM and DT approach, teachers' and students' holistic view of education through STEM and the DT approach, the roles and contributions of the researcher-designer, teachers, and students in Main Study II and the comparison of the Main Study I and Main Study II.

Adopting risk-taking and embracing ambiguity mindsets through the DT approach for dealing with the ambiguities related to students and other factors. The literature points out that acquiring students' benefits from the interdisciplinary studies is based on the full understanding of the different disciplines that are intended to be interdisciplinary connected (Jacobs, & Borland, 1986). Since STEM education is an interdisciplinary approach, having good students' performances may not be realized at their first attempts, and this may cause ambiguities and uncertainties on teachers if the right mindsets aren't adopted. Therefore, the creative processes similar to the DT and STEM education include risks and require iteration. In that circumstance, adopting risk-taking and embracing ambiguity mindsets are considered significant for teachers for giving creative education, leaving the comfort zone to discover new opportunities and accepting that they will not be successful in the first attempt (Kolk, 2012). They are further crucial for dealing with the ambiguity caused by the students' situated behaviors and other factors. Design thinking is essential for K-12 education due to having a risk-taking mindset, and this mindset is also significant in STEM education (Carroll, 2015). Therefore, adopting a risk-taking mindset of the DT approach is important both for teachers and students.

Increasing motivation and ownership of the students in the design and implementation of STEM education. This study shows that the project theme, owning the problem, the subjects of the STEM activity, causes an increase in students' interest, motivation, and ownership of the problem during the implementation of the STEM activity. The promised presents for the successful students also create a competitive environment in the STEM activity. Teachers also have higher expectations and motivations for STEM activity due to finding the activity theme and subjects enjoyable. Because of that, it is evident that motivational factors have a positive effect both on the students' and teachers' attitudes and expectations towards the implementation of STEM education. According to this, finding ways to increase the students' motivation along with their ownership is considered significant in the design and implementation of the STEM activity.

Both the local and international literatures draw attention to implementing the STEM activities that can motivate or excite the students (Akgündüz et al., 2015; Margot & Kettler, 2019; Ministry of National Education, 2016). Considering the literature, motivational or ownership factors attract students' attention to STEM activity.

According to Pardee (1990), improving motivation in educational settings is important to increase educational productivity, and Enghag (2004) states that ownership of learning is significant for students' competence development and motivation. From these two authors' statements, it is understood that ownership and motivation can be perceived as "fellow travelers". While having sufficient motivation can result in developing ownership because of causing the right behavior, having sufficient ownership can also affect motivation. According to this, to design a STEM activity, it is essential to develop students' ownership along with their motivation to decrease the fuzziness during the design and implementation of the STEM activity. In that circumstance, the "observe" stage in the DT approach can assist teachers in finding an attractive theme or problem for motivating students.

Perceived common characteristics between STEM and DT approach. According to the findings, teachers correlated the STEM education with interdisciplinary, collaboration, hands-on and game-based activity, prototyping, design, creativity, inquiry-based learning. They also associated the DT approach with creativity, complex and holistic thinking, prototype, hands-on activity, inquiry-based learning (problem-solving), interdisciplinary collaboration, and prototyping mindset. Besides, teachers stated similar characteristics about STEM and the DT approach, such as inquiry-based learning, learning by living, group work, hands-on activity, and prototype. Based on the DT approach integrated STEM activity, several characteristics of the STEM and DT approach were also discovered, such as interdisciplinary, collaboration, student-centered learning, hands-on activity, prototype, inquiry-based learning (including problem-solving and brainstorming) and self-reflection. According to this, five common characteristics of STEM and DT approach were found in the Main Study II: inquiry-based learning, interdisciplinary collaboration, hands-on activity, creativity, and prototype.

Except for creativity, these shared characteristics were also defined in the Main Study I since teachers discovered the contribution of the collaboration to creative idea development in the Main Study II after perceiving its benefits on teachers and students. In this respect, the DT approach facilitates teachers’ collaboration in the co-design process to expose teachers’ creativity since, as previously stated, both the co-design process and the DT approach value the creativity of the people in the collaborative design process. Besides, applying the DT approach is significant in the educational context owing to bringing creative confidence (everybody is creative) mindset (Cook & Bush, 2018).

Students also correlated the STEM and DT approach with interdisciplinary, collaboration (group work), hands-on activity, and prototype. Thus, it was not surprising to obtain these common characteristics from teachers, and besides, these showed the alignment of teachers’ and students’ perceptions in STEM education (Table 7.8). The discovery of the common characteristics also supported the visual arts teacher, who stated that teachers should know the DT approach for making collaboration and having interdisciplinary knowledge.

Table 7.8 *The comparison of the characteristics and mindsets among STEM and DT approach inside the STEM activity, STEM education, and the DT approach*

Characteristics of STEM and DT approach in STEM education	Characteristics of STEM education	Characteristics and mindset of DT approach
interdisciplinary	interdisciplinary	interdisciplinary collaboration
collaboration (group working)	collaboration	
hands-on activity	hands-on activity	hands-on activity
prototype	prototype	prototype
inquiry-based learning (problem-solving and brainstorming)	inquiry-based learning	inquiry-based learning (problem-solving)
student-centered (human-centered) learning	creativity	creativity
self-reflection	game-based activity	holistic thinking
learning by living	design	complex thinking
		prototyping mindset (resiliency)

It was understood from the table that teachers mostly cared about engaging students with hands-on activities and prototypes to make them actively involved in the process. The unexpected students' performances also presented the effect of DT approach through STEM activity in the inquiry-based learning and addressing students' different learning needs. Besides, all of this result indicated the transition from teacher-centered education to student-centered education since instead of a teacher, students took the lead about preparing the material. Teachers also highlighted needing teachers' collaboration when creating the STEM activity. According to this, the DT approach made a significant contribution to STEM education in terms of facilitating teachers' collaboration and structuring the STEM activity design as a process. It also facilitated students' collaboration due to being integrated into the STEM activity as a problem-solving method and dividing the STEM activity into stages to facilitate the problem-solving process.

Teachers' and students' holistic view of education through STEM and the DT approach. After conducting the Main Study I, there were concrete changes and improvements in teachers' practices and students' perceptions (Table 7.9). According to this, there was teachers' personal growth about changing their teaching practices and understanding of success. Besides, the DT approach enabled teachers to understand the impact of the teachers' collaboration not only in the STEM activity design process but also in the education system for new teacher's mentoring. It was discovered applying STEM education through the DT approach created more social interaction among actors in the school, and the impact of this study affected the other students and teachers.

Three DT mindsets were adopted by four teachers in this study. Accordingly, the mindset change was expressed by the math and social science teachers in terms of testing the questions before preparing the ones for the STEM activity owing to adopting the prototyping mindset (resiliency). The visual arts teacher changed his teaching practice and his art implementations by adopting a holistic thinking mindset. Besides, the English skills teacher created a mini STEM activity and integrated the DT approach as a problem-solving method, since teachers' collaboration in the co-design workshop increased her creative confidence. Finding these three DT mindsets, among others, is related to teachers' changing roles. According to the literature, teachers get used to being an "implementer" (Kalantzis & Cope, 2010), but, the integration of the STEM curriculum change teachers' role into creator, observer, reflector, guide, and facilitator in a student-centered classroom (Reinking & Martin, 2018).

Mainly, the DT integrated STEM activity provided students' personal growth. Considering Martin-Paez et al. (2019) approach, these benefits could be divided into three categories: cognitive, procedural, and attitudinal benefits. For cognitive benefits, it raised students' awareness about the interdisciplinary relationships, and they started to make suggestion to their teachers by generating new ideas about the STEM activity subjects and their integration into the interdisciplinary lessons. Student performance and comprehension of the course content also improved, since the DT approach facilitated students' collaboration, and increased their engagement in the STEM activity, which in turn, make them apply their disciplinary knowledge into the problem-solving process. Besides, it addressed students' different learning needs. For procedural benefits, it improved their model-making skills due to engaging students' with hands-on activity and prototyping. For attitudinal benefits, it increased students' engagement, and self-reflection. It also developed students' teamwork skills in terms of communication and responsibility. According to teachers, dealing with a hands-on activity, using tools and materials provided higher motivation, interest, good collaboration, and communication between the teammates and facilitated students' learning. Because of incorporated students' choices in the STEM activity, students also owned their learning during the activity.

Table 7.9 *The teachers' and students' personal growth and mindset adoption in Main Study II*

<table>
<tr><th rowspan="2"></th><th colspan="4">Phases of Main Study II</th></tr>
<tr><th>Phase 1</th><th>Phase 2</th><th>Phase 3</th><th>Phase 4</th></tr>
<tr><td>Mindset adoption and personal growth</td><td>Teachers' personal growth: Change in the teacher's perception of success and in their teaching practices.

Teachers' awareness about the benefits of making collaboration with the other teachers, needing an interdisciplinary curriculum and the interdisciplinary relationships.

Mindset adoption: DT approach mindset: The change in visual arts teacher's teaching practice and art implementations by adopting a holistic thinking.

The English skills teacher' creation of the mini STEM activity with integrated DT approach because of the increased creative confidence

Students' personal growth: A better comprehension of the course content, raising awareness about interdisciplinary relationships and improving students' teamwork skills</td><td>Mindset adoption: DT approach mindset: Adopting a prototyping mindset by math and social science teachers to test the questions before asking in the activity.

Students' personal growth: Raising awareness about interdisciplinary relationships and a better comprehension of the course content</td><td>Teachers' personal growth: Teachers' awareness about the interdisciplinary relationships

Students' personal growth: A better comprehension of the course content, raising awareness about interdisciplinary relationships, improving students' model-making skills, self-reflection and teamwork skills</td><td>Students' personal growth: Improving teamwork skills</td></tr>
</table>

In the Main Study I, the implementation of the DT approach integrated STEM activity provided nearly the same benefits to the students that were perceived. Most of the benefits were discovered in the cognitive and attitudinal benefits owing to the effect of the students' collaboration. These findings also verified the literature in terms of the expected benefits from the STEM and DT approach.

The roles and contributions of the researcher-designer, teachers, and students in Main Study II. According to Richardson (2013), the facilitation during the application of the DT approach in non-design practices is situated and dependent on the context and the participants. Thus, it will evolve during the design process, and the design strategies cannot be predicted before starting the design process. According to this, how the researcher facilitated was explored from two aspects: the different facilitator roles and the impact of the roles on the integration of STEM education.

In this respect, the researcher-designer facilitated the preparation of the co-design workshop, the co-design workshop and STEM activity design process, the preparation for the social science lesson, the implementation of the visual arts lessons, the preparation and the implementation of the STEM activity, and creating mindset changes on students and teachers for the integration of the STEM education. In the execution of STEM education, the researcher-designer generated strategies for the integration of STEM education to the school. While I, as a researcher, had the participant-observer role for evaluating the effectiveness of the STEM activity, I also had different facilitator roles. In this respect, the researcher-designer had a co-designer role in the STEM activity co-design workshop, and also a guide role in the implementation of the STEM activity. The co-design process among teachers and the researcher-designer also enabled teachers to discover the scope and benefits of STEM education and DT approach because of the contribution of the researcher-designer's educator and guide roles. As a result, along with having a researcher role, I had an expert facilitator and participant-observer roles in this study.

Teachers facilitated the preparation of the co-design workshop, the STEM activity design process, the preparation and implementation of the social science lesson and the visual arts lessons, the preparation and the implementation of the STEM activity. According to this, teachers were present in the co-design process as expert co-designers to support teachers' collaborative engagement and the researcher with their knowledge. Teachers also acted as a mediator between the students and the researcher for transferring the students' reactions and a collaborator in teachers' collaboration in the STEM activity co-design workshop. They were also an educator in the regular lessons and a guide for students in the implementation of the STEM activity. Teachers considered the co-design workshop efficient, and they preferred using the DT approach as a tool in the STEM activity design process under the facilitation of a designer because of having creative and a holistic viewpoint.

The researcher and teachers worked together in the preparation of the co-design workshop, the design and preparation of the STEM activity and lessons, and the implementation of the STEM activity. Both sides owned the design and implementation of the lessons and the STEM activity commonly. In this study, both teachers and the researcher valued the previous main study and designed the study over their experiences about it. In this respect, the researcher contributed to the study mostly about defining strategies about the implementation of STEM education. During the STEM activity design, the changes in the "ideate" stage made the brainstorming sessions faster and organized. Teachers mainly involved more as co-creators to develop ideas in this stage. Therefore, they were much better about developing ideas compared to the previous study. However, some teachers had difficulty in perceiving the interdisciplinary relationship in the STEM activity design process, and some of them did not see themselves as creative. Thus, the researcher acted as a mediator between the teachers to connect their ideas.

Teachers mostly cared about the subject selection due to trying to find out an attractive theme for the students. They secondly cared about the students' group. Since teachers could observe the changes in students' academic performances, and their feedback about STEM, they mostly intervened in the context of the questions. One of the biggest problems that the researcher and teachers confronted with was to take permission from the school management for the date of the activity and teachers' participation in the implementation of the STEM activity. The second biggest problem was about informing students about the STEM activity; at this point, the math teacher directed the researcher by her suggestions.

In this study, students were accepted as one of the indirect stakeholders whose feedback and reflections led the Main Study II, and they were also participants in the lessons and the STEM activity. As previously stated, this study enabled students' personal growth in many points. Besides, the researcher discovered the effect of the motivation on students and teachers.

Comparison of the Main Study I and Main Study II. Two separate approaches were adopted about the implementation of the lessons in two main studies. In the Main Study I, interdisciplinary lessons with individual and team teaching were conducted to assist teachers and students in getting familiar with the STEM education and making students aware of the interdisciplinary connections of the subjects before the STEM activity. As a result, the interdisciplinary lessons built the participants' perception of interdisciplinary education, and their awareness about the interdisciplinary relationship of the disciplines was raised. However, because of the problems in the planning and implementation of the interdisciplinary lessons, a different perspective was adopted in the Main Study II. In the Main Study II, teachers conducted regular lessons modified as to cover a common theme with the other teachers to serve to the STEM activity by making students dealing with the parts of the STEM activity in the lessons without noticing. According to this, the lessons were implemented successfully and took no students' reactions. Main Study II showed that when applying STEM education as a temporary activity at school, the regular lessons slightly modified to serve the STEM activity could be productive. Besides, these lessons had less team responsibility in comparison to the interdisciplinary lessons with team teaching and because of that they were favored by most of the teachers. But, the interdisciplinary lessons in the Main study I made the interdisciplinary relationships visible for the stakeholders and build the participants' perception of STEM education. The literature points out the limitations originating from the school structure, including inappropriate class, teachers' and students' scheduling (Margot & Kettler, 2019), and lack of materials or equipment to implement STEM education (Carter, 2013). Therefore, the decision about conducting regular lessons modified to cover a shared theme or interdisciplinary lessons with team teaching can be made by considering the structure of the school and its facilities.

In the Main Study I, students' situated behaviors caused problems in the implementation of some interdisciplinary lessons and the STEM activity. Therefore, in the Main Study II, students were observed by teachers until the implementation of the STEM activity to understand the changes in their behaviors. Then, this way of approach resulted in taking the necessary actions for the implementation of STEM activity. In the Main Study I, we also had problems concerning the students' motivation for answering the questions before the prototyping stage. Some of the students also had less intention to deal with the STEM activity. Thus in the Main Study II, we separated the "answering the questions" from the prototyping part in the STEM activity and implemented them successively in separate places under the management of different teachers. As a result, the strategy worked well; the stages of the STEM activity could be completed.

In the Main Study I, students were accepted as only users, but they were involved as indirect stakeholders and users in the Main Study II. When comparing two way of approaches to students' involvement, while students generated ideas about the STEM activity subjects and their integration into the interdisciplinary lessons at the end of the Main Study I, they suggested the way in which they can be included into the selection of STEM activity subjects in the STEM activity design process at the end of the Main Study II. Therefore, involving them directly in the STEM education contributed to the development of the DT approach and showed the significant benefits of defining the stakeholders and engaging them in the STEM activity design process through the DT approach.

In this study, multiple approaches were tried to be applied when designing the lessons and the STEM activities. In the STEM activity design of the Main Study I, the interdisciplinary approach was tried to be used. However, a transdisciplinary approach was adopted in the STEM activity design of the Main Study II. In the interdisciplinary lessons with individual and team teaching, the interdisciplinary approach was applied to show students the connection of the disciplines by using art or English disciplines' contents and teaching practices as a framework. Therefore, disciplines in these lessons were identifiable. On the contrary, in the Main Study II, the lessons were taught separately under common themes by adopting a multidisciplinary approach. Although using all three approaches in the same school could be perceived difficult and complicated; the reason for following this strategy was originated from the context of the school, teachers' teaching scheduling, and the students' approach to STEM. Since instead of adopting one approach for integrating the STEM education to school, strategically movements can be needed considering the setting and participants to discover the most appropriate way of the STEM activity design and implementation.

7.9.1 The revision in the design thinking approach

A revision was executed at some stages of the DT approach for the STEM activity design process (Table 7.11).

Problem definition. No change was executed to the process of the "problem definition" stage. However, its name was changed into "define the subjects" to make its content more understandable and memorable.

The first stage: Understand. The name of this stage was changed into "define the stakeholders" to emphasize the content of this stage. Moreover, I created a table for stakeholder analysis to identify the stakeholders and their involvement easier in the STEM activity design process.

The second stage: Observe. In this stage, I revised the students' interview questions to include the procedure for the Empathy Map. Upon the suggestion of the math teacher, I also decided to conduct students' interview under the management of one of the teachers or the school's counselor teacher instead of all teachers to make collecting and analyzing the students' data easier, and to prevent collecting excessive data from the same students. This way of approach can also provide a reliable feedback from the students as it will be seen as a regular school practice.

The third stage: Point of view. The name of this stage was changed into "develop a point of view" to make its content more memorable. I also changed the name of the Empathy Map into N.I.S. Map (Need/Insight/Strategy map) because of including developing strategies in the process. The reason for making this change stemmed from developing strategies to prevent students from responding to the implementations of STEM activities in the Main Study I and II.

The fourth stage: Ideate. In this stage, I added the *scribble, say, slap* as a brainstorming method and also revised the ideate procedure for generating ideas in details for the STEM activity design process. I also developed a checklist for students' evaluating ideas, since some students thought they were unfair in peer review because of their voting for their closest friends instead of the best solution.

The fifth stage: Prototype. In this stage, I added web-based prototyping tools to make the STEM activity design process and its material development easier and quicker.

Table 7.10 *Final revisions made to the DT approach for STEM activity design*

	Define the subjects	**Define the stakeholders**	**Observe**	**Develop a point of view**	**Ideate**	**Prototype**	**Test**
What is it?	Identify the subjects to be included in the activity/lesson in accordance with the curriculum	Identify the stakeholders, choose the most effective target stakeholder/stakeholders and define a focus group among the target stakeholders, if needed	Make an observation and conduct interview to get to know the stakeholders	Identify the needs and conduct an analysis for the STEM activity design/ lessons according to the information gathered in the former stages, and define the problem statement	Ideate for STEM activity design/ lessons	Write down the STEM activities/lessons designed at the "Ideate" stage in the "STEM activity plan" by applying different prototyping methods	Receive feedback from the students by carrying out the designed STEM activity/lesson in the classroom and to review the activity plan by making corrections, if necessary
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	N.I.S. map (Need/Insight/Strategy map), brainstorming	Brainstorming, mind map, hot potato, scribble, say, slap	Planning, journey map, diagram, model making, web-based prototyping tools	Peer review
Revision in the DT approach	No change	Create a table for the stakeholder analysis	Revise the students' interview questions to include the procedure for the Empathy Map Revise the implementation process of students' interview	Change the name of the Empathy Map into N.I.S. Map and add "Strategy" into the process	Add scribble, say, slap as a brainstorming method Revise the procedure for generating ideas Develop a checklist for students' evaluating ideas	Add web-based prototyping tools	No change

CHAPTER 8

CONCLUSION

This study investigates the impact of DT approach on the development and implementation of STEM activities by secondary school teachers. The goal of the study is to understand the ways in which DT approach can contribute to STEM education and support teachers' collaboration for developing and implementing STEM activities that meet the needs of target students. In this study, the DT approach was utilized for three different purposes:

- The DT approach developed in this study was used to co-develop a STEM activity with the teachers.
- HPI's DT approach was integrated into the in-class STEM activity as a problem-solving process to facilitate students' engagement and collaboration.
- The prototyping mindset facilitated the researcher-designer's evaluating and improving the DT approach developed in this study.

The study seeks answers to the following questions:

Research Question: How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities for 5th graders?

> **Sub-question 1:** How and to what extent does the design thinking approach support collaboration among teachers for developing and implementing STEM activities?

Sub-question 2: How and to what extent does the design thinking approach support teachers' integrating various disciplines into the STEM activity design and implementation?

Sub-question 3: How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities appropriate to the needs of a specific learner level?

In accordance with the research questions, I first conducted a literature review about the STEM and DT approaches to develop a method for teachers' STEM activity design and implementation. Then, I did an exploratory study to get familiar with the current state of STEM education in Turkey (see Chapter 4). Later, I developed a DT approach for STEM activity design and revised it several times through a pilot study conducted with teachers (see Chapter 5) and two main studies with 5th-grade teachers and students (see Chapter 6 and 7); each stage contributed to the following stage and enabled the revision of the DT approach for the STEM activity design and implementation.

In the following sections, I will discuss the conclusions of the study in relation to the research questions with references to both the literature review and the two main studies conducted. The implications for future research are also discussed along with the answers to the research questions. The chapter concludes with the suggestions for integrating design education into teachers' education and K-12 education for the Turkish education system, and the limitations of the study.

8.1 How and to what extent does the design thinking approach support collaboration among teachers for developing and implementing STEM activities?

According to the literature, teachers have inadequate content knowledge about the disciplines other than their own (Margot & Kettler, 2019). Concerning this issue, Moore et al. (2014) recommend that "teachers can also collaborate and share ideas with colleagues from other subjects to support content knowledge and learning in multiple disciplines" (p. 14). Although the literature draws attention to the need for making interdisciplinary collaboration with teachers in STEM education, teachers need to allocate extra time for making collaboration and preparing the materials (Margot & Kettler, 2019).

Teachers in Turkey who graduated from the faculty of education or other faculties specialize in their discipline and do not have the qualifications necessary for integrating various disciplines or interdisciplinary cooperation (Akgündüz et al., 2015). There are studies about integrating STEM courses into pre-service science teachers' education; however, in these studies, the collaboration is among higher education students from the same discipline (Gül, 2019; Türk, 2019). Related to this issue, Akgündüz et al. (2015) suggest interdisciplinary collaboration among faculties and disciplines, among teachers from diverse disciplines, and among higher and K-12 education levels to conduct project-based or inquiry-based activities or to create, revise and/or implement STEM programs in K-12 education. Although interdisciplinary collaboration is essential for STEM education, allocating time to collaboration is a challenge for teachers because of their high workload at school (Okka, 2019).

Even though both the local and international literature highlights the importance of collaboration to design and implement STEM activities, no specific strategies or approaches have been proposed to facilitate teachers' collaboration. As a human-centered and collaborative problem-solving approach, design thinking is considered useful in educational contexts (IDEO, 2012). One of its benefits for teachers is it's supporting a stronger collaboration culture (Tran, 2017). DT also enables the participation of stakeholders and users in the design process (Di Russo, 2016). Although the literature neither indicates a direct connection between the STEM and the DT approach concerning collaboration nor mentions the usage of DT for supporting teachers' collaboration, this study proposes the DT approach to facilitate teachers' collaboration in the integration of STEM education.

In reference to the two main studies conducted, the issue of teachers' collaboration will be discussed in relation to the two phases, STEM activity design and implementation. This section will also discuss the roles of the researcher-designer. The fieldwork shows that using the DT approach as a means for facilitating teachers' collaboration has a significant impact on the STEM activity design and implementation.

STEM activity design as a structured <u>collaborative</u> process. In the literature, the DT approach involves several steps, practices, and methods to customize the design process (IDEO, 2012). This study indicates that this character facilitates teachers' collaboration by structuring the STEM activity design as a collaborative design process with meaningful steps. In the literature, it is stated that teachers' busy scheduling creates a time barrier in front of the teachers' collaboration. Since the DT approach provides a step-by-step process for teachers to follow when designing a STEM activity collaboratively, they use their time more efficiently and effectively. Therefore, DT serves as a time-saving, collaborative process for teachers. DT does not only clarify and structure the STEM activity design process; the process also helps teachers develop a *shared* understanding of the subjects they address and the activity they design, and, therefore, enhances the collaboration among teachers.

The literature also highlights the significance of administrative support (Margot & Kettler, 2019) and constructing parents' understanding of STEM (Carter, 2013) for the implementation of STEM education. In this respect, it is considered that the "understand" stage of the DT approach can organize and facilitate the involvement of the stakeholders, and thus, further research is needed for this proposal.

Teamwork and co-design coupled with expert facilitation. DT approach involves team work and expert facilitation, and emphasizes the participatory and collaborative design with the active involvement of stakeholders in the process (Camacho, 2018; Blomkamp, 2018; Van Mechelen et al., 2019). Teamwork and co-design process coupled with expert facilitation sustain collaboration and knowledge sharing among teachers in the STEM activity design process.

This study indicates that teamwork supports collaboration among teachers by facilitating communication, social interaction, and shared responsibilities. The literature is in line with this finding; teamwork is considered crucial for facilitating collaboration and knowledge sharing among diverse disciplines by enabling mutual communication and influential actions around a shared goal (Hernandez-Monsalve et al., 2017).

The co-design process enhances collaboration among teachers by bringing together teachers from multiple disciplines and the researcher-designer as co-designers. As mentioned in the literature, the co-design process involves the collaborative engagement of users and stakeholders in the design process (Mattelmäki & Visser, 2011). It further facilitates exchanging and translating knowledge among diverse disciplines (Broadley & Smith, 2018). The co-design process and DT approach usually involve a facilitator; this study also utilizes the researcher-designer as an expert facilitator to support and guide the collaborative process.

Developing empathy among teachers. Empathizing is a significant mindset utilized by the DT approach (Carroll et al., 2010). This study shows that empathy functions as an ice-braker and enhances collaboration among teachers in the STEM activity design by assisting them in understanding each other’s content knowledge and way of teaching. There is not a direct relationship between empathy and collaboration in the DT literature, since empathy is typically used to understand the users and their needs in the DT approach. However, both information science and management literature indicate that empathy is accepted as a starting point and critical component in the collaboration process to sustain productive human interactions (Obenauer, 2019; Miller, 2011). Consequently, empathy is used both to support collaboration among team members and to gain insight into the users in the DT approach. This is a significant finding both for the STEM and DT approaches, and further research is needed on empathy and teachers’ collaboration.

Team teaching. Team teaching is one of the co-teaching models referring to "collaboration in planning and teaching" (Thousand, Villa & Nevin, 2006, p.240). Although it is a teaching method utilized in STEM education (Benuzzi et al., 2015), it supports collaboration among teachers and reinforces the collaborative character of the DT approach. This study indicates that collaborating for team teaching before and during the interdisciplinary lessons supports interaction and sharing of experiences and knowledge among teachers in the implementation of interdisciplinary lessons *prior to* STEM activity. Thus, through team teaching, teachers get to know the other teachers in the team vocationally. This collaborative experience raises their awareness about the connections among the disciplines, content knowledge, and opportunities for course material. It also increases teachers' motivation because of high student engagement.

The literature states that team teaching provides benefits to the teachers in terms of peer learning (Shibley, Jr., 2006), such as solving teaching problems and developing teaching practices (Heo, 2013). Considering both the literature and the findings from this study, it can be concluded that team teaching, coupled with a DT approach nurture an influential collaboration culture at school for STEM education. Further research is needed to explore the impact of various co-teaching models on STEM education, the DT approach and collaboration among teachers, and on teacher and student performance.

Furthermore, the design and technology course follows an engineering design process similar to STEM education. This course is given individually by teachers from diverse backgrounds and one of them is visual arts. However, their education does not involve innovation or engineering design based education. This course is open to team teaching because of the nature of the lesson and can be utilized as the first step towards the transition to STEM education. Therefore, the DT approach can be adopted when planning and implementing the course, and the DT integrated STEM activity design guide can be utilized for this purpose. This strategy can help students to adopt the common mindsets of DT approach and STEM education.

Further research is needed to explore the impact of DT approach on design and technology courses.

8.2 How and to what extent does the design thinking approach support teachers' integrating various disciplines into the STEM activity design and implementation?

The literature review indicates that there is a need for the preparation of the STEM activities/curriculum for all disciplines in Turkey (See section 2.5). However, the literature does not propose a guide for integrating disciplines into STEM education (See section 2.1.4).

According to the literature, the DT approach is at the intersection of multiple disciplines (Leifer & Steinert, 2014). DT has also been used in the curriculum and instructional design, and in solving the challenges of education for the last decade (See section 2.2.3). Concerning the integration of disciplines, there is no direct connection between the STEM and the DT approach in the literature.

This study employs the DT approach to facilitate the integration of disciplines into STEM education for developing and implementing STEM activities. The fieldwork shows that using the DT approach as a means for facilitating the integration of disciplines has a significant impact on the STEM activity design and implementation. The following sections discuss this issue from activity design and implementation perspectives.

STEM activity design as a structured <u>creative</u> process. Creative confidence is a significant mindset utilized by the DT approach (The Field Guide to Human-Centered Design, 2015). This study indicates that the DT approach facilitates the integration of disciplines by engaging the teachers in a structured and customized *creative* process that supports idea development for synthesizing the disciplines. Since the DT approach renders the STEM activity design process visible, every stage shows teachers how to approach the activity design problem as a designer and assists them to reveal their creativity. The DT approach is useful in this particular context because it helps teachers to get into a creative mindset, and this study shows that the customized DT approach succeeds in making teachers adopt this mindset. This is a significant result considering the limited resources available for teachers in Turkey and the need for teachers' engaging in the creative process for designing new STEM activities (Uştu, 2019). In this respect, the procedure in the "ideate" stage make faster and ordered the brainstorming session and thus has a significant impact on synthesizing the disciplines in the STEM activity design. The "ideate" stage also recommends to actively involving the students in generating ideas for the STEM activity development when needed. According to this, further research is needed to investigate the involvement of students in the integration of disciplines.

Collaboration and co-design coupled with expert facilitation. Collaboration is a significant characteristic of the DT approach (Howard, 2015). Similar to the DT approach, the co-design process values collaboration among stakeholders for enhancing creativity (Van Mechelen et al., 2019). Collaboration and co-design process coupled with expert facilitation reveal teachers' creativity for integrating various disciplines in the STEM activity design process.

This study indicates that the collaboration among teachers from diverse disciplines can raise teachers' content knowledge about the other disciplines and support the idea development for synthesizing the disciplines.

The co-design workshops conducted for the STEM activity design show that the involvement of the teachers and the researcher-designer as co-designers in the STEM activity design process reveals teachers' creativity and contributes to generating ideas for integrating the disciplines. In the co-design process, the researcher-designer also supports teachers' efforts for integrating various disciplines in the STEM activity design as a facilitator in terms of raising their awareness about the content knowledge of the disciplines, triggering the idea generation and mediating teachers' exchange of ideas.

8.3 How and to what extent does the design thinking approach support teachers' developing and implementing STEM activities appropriate to the needs of a specific learner level?

In the international literature, one of the essential challenges of STEM education is about STEM programs having an inappropriate learner level (Carter, 2013). In this respect, it was discovered from the literature that teachers modify the existing STEM units or designed new ones about specific subjects for high school students' level of knowledge and skills (Bruce-Davis et al., 2014). Consequently, there is a need for designing and implementing STEM activities considering students' levels.

In the exploratory research, it was discovered that teachers adapted the STEM activities considering the students' needs and abilities for the primary school level in Turkey. Moreover, according to Uştu (2019), a ready-made activity that is prepared for a particular class level cannot be appropriate for specific regions, school facilities, students, or teachers' implementation understanding.

Although both the local and international literature highlights the importance of designing and implementing the STEM activities considering students' level, no specific strategies or approaches are proposed about this issue for the secondary school level. DT approach is based on human-centricity (Efeoglu et al., 2013) and defined as a "discipline that uses the designer's sensibility and methods to match people's needs" (Brown, 2008, p.85). Concerning creating STEM activities for the specific learner level, there is no direct connection between the STEM and the DT approach.

This study employs the DT approach to facilitate teachers' developing and implementing STEM activities considering the students' level. The fieldwork shows that the DT approach has a significant impact as a means for developing and implementing STEM activities, considering the students' level. The following sections discuss this issue from activity design and implementation perspectives.

STEM activity design with a human-centered approach. As a human-centered approach, the DT assists teachers to empathize with, observe and understand the students, and develop STEM activities considering the students' level. Our conclusion is supported by the relevant literature, which recommends incorporating the DT approach into all areas of instruction to get familiar with the students' strengths and interests (McGlynn & Kelly, 2019).

Defining the stakeholders and their degree of involvement in the "understand" stage, gathering information about the students/stakeholders in the "observe" stage and synthesizing the students'/stakeholders' data for identifying students' needs in the "POV" stage have a significant impact on aligning the STEM activity design with the target students' needs. Additionally, the way of approaching to the STEM activity design problem with the human-centered perspective accelerates the process of getting familiar with the students. This finding is further valuable for teachers who are new to the class or have new students. By working with the educational planners, further research can be conducted to involve students' developmental stages and competencies in the DT approach to design STEM activities for students' level.

Using the co-design process as a method. Co-creation activities are considered useful for figuring out users' needs and preferences (Hernandez-Monsalve et al., 2017). Representation of customers during the co-creation process is crucial for developing insights about them (Di Russo, 2016).

The co-design workshops conducted for the STEM activity design indicate that teachers act as stakeholders and expert co-designers, and "represent" students in the STEM activity design process which contribute teachers' developing STEM activities appropriate to the students' level.

Collaboration among teachers through empathy. This study indicates that collaboration among teachers from diverse disciplines through empathy is helpful for getting to know the students from different perspectives, and developing STEM activities appropriate to their level. In this collaboration, teachers discover the students’ situated behaviors and their varied academic performances in each lesson and their changeable social relationship with each other. The literature also supports this conclusion and indicates that the DT approach enhances teachers’ collaboration and assists them in creating more personalized learning experiences for students (Power, 2019).

In this respect, using empathy as a tool has two following roles about getting familiar with the students in teachers’ collaboration. First, empathy functions as an ice-braker and supports communication and collaboration among teachers, and as a result, eases sharing of their opinions about the students. Second, empathy supports the process of collecting and analyzing data about the students for the STEM activity design.

In the literature other than DT, the collaboration and empathy are accepted as “fellow travelers”, since one view states that collaboration enables creativity and empathy, in the other perspective, empathy is said to allow for collaboration and which in turn, creative ideas. Both have one thing in common, which is to focus on other more than yourself (Rosen, 2009). As previously stated, the co-design process supports teachers’ collaboration to expose teachers’ creativity. Both of them also assist in getting to know the students and teachers. According to this, empathy isn’t only fellow travelers with the collaboration, but also with the co-design process. In this respect, empathy is an essential tool for making collaboration, approaching problems with the human-centered viewpoint in the STEM activity design process, and it functions well in the co-design process since the co-design process and collaboration can complete each other to perform their duties.

DT approach as a structured, collaborative and hands-on problem-solving process. The DT approach facilitates the students’ problem-solving process by structuring the STEM activity. Structuring the STEM activity as a problem-solving process with stages reduces the ambiguity of the process and supports students’ hands-on practices, collaboration, and interaction during the STEM activity.

In an educational context, what DT approach offers differently from the other existing inquiry-based approaches is its human-centered nature which deals with designing for others. While engineering design process also has design components, the DT approach intentionally uses empathy as a tool for developing insights about others' needs, interests, and desire by "incorporating artistic elements of personal expression and position-taking that other engineering process approaches do not necessarily privilege" (Cook & Bush, 2018, p. 94). The engineering design process focuses on the innovative problem-solving process, whereas the DT approach is a human-centered and creative problem-solving process that prioritizes defining and redefining the problem. In the engineering design process, the problem is generally well-defined. The DT approach, on the other hand, is user-centered, and the problem is defined by developing insights from the users. Therefore, in the DT approach, the process starts with ill-defined problems and limited knowledge.

There has been an inclination towards implementing the DT approach in the project-based STEM activities in the K-12 schools to teach multidisciplinary collaboration, creativity, empathy, prototyping mindset, and innovation (Lor, 2017). In this respect, the DT approach is an alternative to the engineering design process and can be a facilitator and a binder in STEM education as a problem-solving method to facilitate students' problem-solving process, enhance their STEM learning, abilities, and skills. Further research is needed to fully explore the similarities and the differences between adopting the DT approach and the engineering design process in STEM activity design and implementation.

Adopting a <u>prototyping mindset</u> in teachers' implementing the STEM activities. Prototyping is a significant mindset utilized by the DT approach (Kolk, 2012). It supports teachers' preparing, testing and finalizing the STEM activity questions considering the students' level. Carroll (2015) indicates that DT is essential for K-12 education because of including the prototyping mindset (resiliency), which means learning from failure and trying again (Kolk, 2012). This mindset is also essential in STEM education (Carroll, 2015) and called "trying and failing"

(Fredette, 2013). Therefore, adopting a prototyping mindset is significant both for teachers and students in the STEM and DT approach. There is not research about teachers adopting a prototyping mindset (resiliency) and its effect on the design and implementation of STEM education; consequently, further research is needed.

8.4 Strategy developed for the design and implementation of the interdisciplinary lessons and STEM activity

In this study, two groups of strategies were developed for the design and implementation of the interdisciplinary lessons and STEM activity considering teachers' and students' feedback and suggestions. Table 8.1 describes the strategies developed for STEM activity, and Table 8.2 the strategies developed for interdisciplinary lessons.

Table 8.1 *Strategies developed for STEM activity*

STEM activity	
Strategies for STEM activity design	In the "observe" stage, make the students select the activity subject (s) from the proposed list.
	Identify an activity theme that attracts students' attention to STEM activity.
	Integrate the DT approach into STEM activity with a special emphasis on prototyping and collaboration among students.
	Include team working for students in the STEM activity.
	Impose restrictions on using the materials to prevent the unnecessary usage of the materials, and to trigger the creativity of the students in problem-solving.
	If appropriate, include a job introduction into the STEM activity design.
	Do not place any more questions after the prototyping part.
Strategies for teachers	Introduce the design thinking process and STEM education to students before conducting the interdisciplinary lessons and the STEM activity.
	Test similar questions in class before implementing STEM activity.
	Review the relevant subjects in class before implementing STEM activity.
	Inform the students of the activity subjects before the STEM activity date.
	Separate the "answer the questions" part from the hands-on part spatially and cognitively in order to make students concentrate on both parts in a balanced way.
	Observe the students until the implementation of the STEM activity to understand the changes in students' situations, and to develop and take the necessary actions.
	In the problem-definition stage, encourage students to read and re-interpret the STEM activity theme and write down their reflections in the form of a report.
	Emphasize the importance of the "ideate" stage during the STEM activity and encourage students to develop new and functional ideas rather than giving priority to building "appealing" prototypes.
	After completing the STEM activity, encourage students to present their outcomes to the class and provide them with a student evaluation table or a comment card for structuring the peer review process for evaluating the performance of student teams. The student evaluation table may include functional qualities, aesthetic qualities, working principles and the innovativeness of the solution.
	Grade the STEM activity in order to make students take the activity seriously.
	In grading, give more points to the "answering the questions" part than the prototyping part.
Strategy for the researcher	Determine the date of the STEM activity in accordance with the collaborating teachers' schedule and students' exam schedule.
	Inform collaborating teachers about the necessary points of the activity to enable successful guidance in the STEM activity.

Table 8.2 *Strategies developed for interdisciplinary lessons*

Interdisciplinary lessons	
Strategies for interdisciplinary lesson design	In planning the interdisciplinary lessons, the teaching order and timing of particular subjects and their interdisciplinary compatibility with each other should be taken into account.
	Integrating the visual arts and English disciplines along with the STEM disciplines into the interdisciplinary lessons would be advantageous due to their interdisciplinary curricula and activity based natures.
Strategies for implementing interdisciplinary lesson	When conducting a series of interdisciplinary lessons through individual teaching, making them consecutively would be more efficient for students' interdisciplinary learning.
	The interdisciplinary lessons can be concluded with short or introductory STEM activities for increasing students' familiarity with STEM activities.
Strategies for teachers	Conducting interdisciplinary lessons through individual teaching may be preferred when team teaching requirements concerning collaborating and scheduling cannot be met.
	In interdisciplinary lessons through team teaching, the workload of collaborating teachers should be equally distributed.

8.5 Discussion about the research questions

Within the scope of this study, the DT approach has been developed for the STEM activity design and implementation (Appendix U and V), and the research questions have been answered in reference to this guide. In these questions, while several ways have been discussed for realizing the design and implementation of the STEM activities and the lessons, some strategies have further been proposed to deal with the situated context and students' behaviors, teachers' and students' changeable schedules. These strategies also expand the effect and extent of the DT approach and support the implementation of the STEM activities and the lessons.

Regarding the answers, there are common points for all three research questions. Structuring the STEM activity design as a process through the DT approach in the co-design process is related to the three main challenges in STEM education addressed in the research questions: collaboration among teachers, integration of disciplines, and STEM activities matching the students' level. Moreover, collaboration among teachers in the STEM activity design process through co-design further supports the integration of disciplines and developing STEM activities matching the students' level. Empathy also supports teachers' getting familiar with each other and with the students. Therefore, empathy enhances collaboration among teachers and the development of STEM activities matching the students' level. Both structuring the STEM activity design as a process through the DT approach and collaboration among teachers support the creative integration of disciplines.

Information science literature indicates that “empathic communication” is essential to elicit insightful information from people, and developing empathy may be necessary for “stimulating creativity, innovation and generating solutions to problems” (Miller, & Wallis, 2011, p. 129). In a similar way, during the STEM activity design, developing empathy may support the *creative* integration of disciplines in a way that matches the students’ level (Figure 8.1).

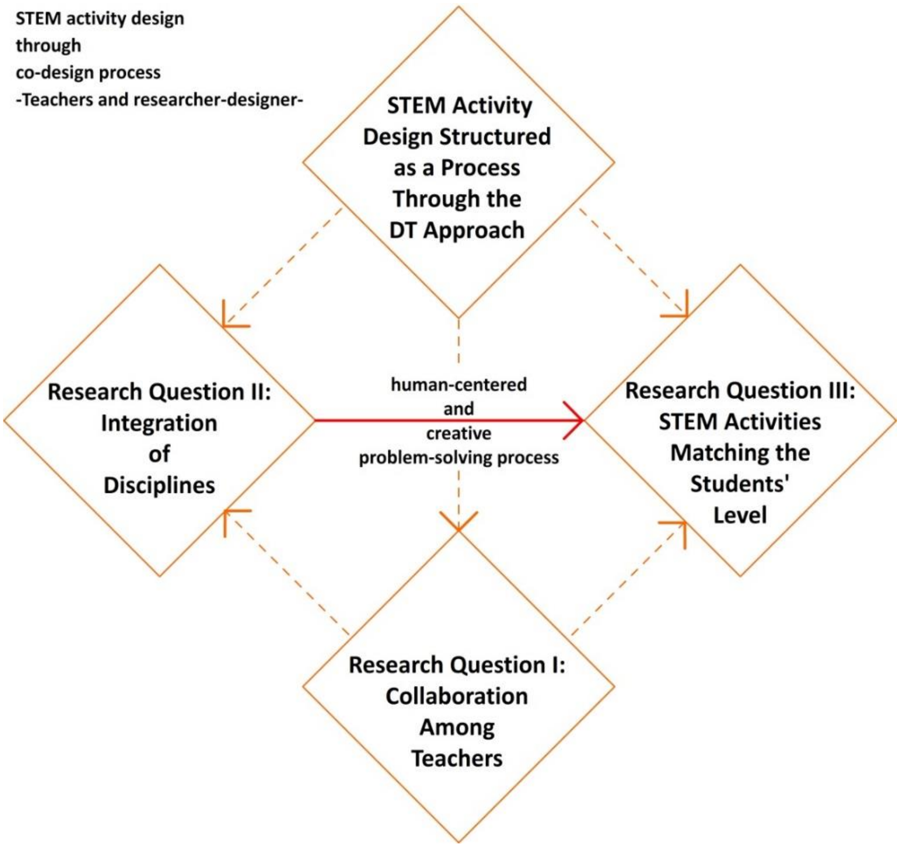


Figure 8.1. The relationship of the research questions among themselves and with the structured STEM activity design process through the DT approach

In this study, the significance of six DT mindsets was discovered in STEM education. While the contribution of the *prototyping* and *creative* mindsets, and *developing empathy* were observed in the implementation of STEM education, others could not be adopted by teachers for STEM, since mindset adoption needs time. Adopting a *holistic thinking* mindset through the DT approach has been considered significant for teachers in terms of integration of disciplines in the STEM activity design process because it helps to take into consideration all factors when developing ideas. Adopting *risk-taking* and *embracing ambiguity* mindsets has also been thought important to conduct creative education as involved in STEM and DT approach; they help to benefit from failure and accept not succeeding in the first attempts, and to deal with the ambiguity related to the students' situated behavior.

The literature supports these findings that in the study of Henriksen and Richardson (2017), the DT approach is used as a framework for the in-service teacher education course and in-service teachers adopted the prototyping and risk-taking mindsets for finding multiple solutions to the problems. In this course, three key points are identified to enable problem-solving in the educational contexts: embracing ambiguity, developing empathy, and perceiving the work of teaching as designing (Henriksen & Richardson, 2017).

As previously stated, there is no similar research in the literature to make a comparison with; the findings should be considered preliminary. The answers to the research questions and the potential findings can be used to make this study open to generalization in the educational context.

8.6 A DT integrated STEM activity design guide for teachers

Within the scope of this study, a guide has been developed to design and implement STEM activities by adopting the DT approach for the activity design process (Appendix U). This guide is recommended to be utilized by the assistance provided by an industrial designer who is knowledgeable about STEM education. The interview and observation forms, sample interview questions for students, all tables and figures, proposed methods, the directions for its stages, and the STEM activity plan in the guide have been designed accordingly. It has also been suggested using the DT approach as a problem-solving method instead of the engineering design process, and the ideation procedure has been designed based on the DT approach.

During the development process of the guide (Table 8.3) there has been no revision concerning the “problem definition” stage. Minor revisions have been made for the “prototype” and “test” stages. Having difficulty with the students when implementing the STEM activity in the Main Study I caused a major change in the “understand” stage; stakeholders have been involved instead of the target group. This change has also brought other revisions in the “observe,” “point of view” and “ideate” stages. Interview questions for students were added for the “observe” stage; it also caused the development of the ideate procedure. In the “point of view” stage, the main difficulty was to simplify the empathy map process for facilitating the process of identifying the needs and conducting an analysis. Teachers also had difficulties in brainstorming; therefore, multiple brainstorming methods were added into the guide.

As a further study, a teacher-oriented version of this guide can be developed by working together with educational planners to include more teaching techniques for facilitating teachers’ adaptation to the process.

Table 8.3 *The development process of the DT integrated STEM activity design guide within the study*

Pilot study							
	Problem Definition	**Understand**	**Observe**	**Point of View**	**Ideate**	**Prototype**	**Test**
What is it?	Identify the subjects which will be included in the STEM activity design	Make research about the identified subjects and define the target group	Conduct interviews with and make observations about the target students	Compile and group all data from the previous stages to identify the needs, conduct an analysis, and define the problem statement	Generate ideas for the STEM activity design	Create a prototype of the STEM activity plan through multiple prototyping methods	Implement the STEM activity in the class and revise the STEM activity plan
Methods	Brainstorming	Brainstorming, 5W1H Questions	Interview, observation, brainstorming	Empathy map, bundle ideas, brainstorming	Brainstorming, mind map, itemised response and PMI	Planning, journey map, diagram, model making	Peer review
Revision in the DT approach	No change	Remove 5W1H questions	Create an observation template Revise the interview template	Remove POV template Revise the Empathy Map process by involving bundle ideas	Remove "How Might We" questions Remove the brainstorming template Simplify the evaluation part	Revise the STEM Activity Plan template	Revise the peer evaluation questions
Main Study I							
What is it?	No change	No change	No change	No change	No change	No change	No change
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	Empathy map, brainstorming	Brainstorming, mind map, itemised response and PMI	Planning, journey map, diagram, model making	Peer review
Revision in the DT approach	No change	Remove "Define the Target Group" Add "Define the Stakeholders"	Add an interview guide for teachers' conducting interviews with students	Develop a structured procedure for creating an Empathy Map	Add Hot Potato as a brainstorming method Develop a structured procedure for generating ideas Revise the evaluation part by removing the itemised response and PMI method	No change	No change
Main Study II							
What is it?	No change	Identify the stakeholders,	Conduct interviews with	No change	No change	No change	No change

		choose the most effective target stakeholder(s) and define a focus group among the target stakeholder(s), if needed	and make observations about the target stakeholders				
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	Empathy map, brainstorming	Brainstorming, mind map, hot potato	Planning, journey map, diagram, model making	Peer review
Revision in the DT approach	No change	Create a table for the stakeholder analysis	Revise the students' interview questions to include the procedure for the Empathy Map Revise the implementation process of students' interview	Change the name of the Empathy Map into N.I.S. Map and add "Strategy" into the process	Add scribble, say, slap as a brainstorming method Revise the procedure for generating ideas Develop a checklist for students' evaluating ideas	Add web-based prototyping tools	No change
	Define the subjects	**Define the stakeholders**	**Observe**	**Develop a point of view**	**Ideate**	**Prototype**	**Test**
What is it?	Identify the subjects to be included in the activity/lesson in accordance with the curriculum	Identify the stakeholders, choose the most effective target stakeholder/stakeholders and define a focus group among the target stakeholders, if needed	Make an observation and conduct interviews to get to know the stakeholders	Identify the needs and conduct an analysis for the STEM activity design/ lessons according to the information gathered in the former stages, and define the problem statement	Ideate for STEM activity design/ lessons	Write down the STEM activities/lessons designed at the "Ideate" stage in the "STEM activity plan" by applying different prototyping methods	Receive feedback from the students by carrying out the designed STEM activity/lesson in the classroom and review the activity plan by making corrections, if necessary
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	N.I.S. map (Need/Insight/Strategy map), brainstorming	Brainstorming, mind map, hot potato, scribble, say, slap	Planning, journey map, diagram, model making, web-based prototyping tools	Peer review

This guide is designed to be used by *secondary school* teachers and for training future teachers in higher education for developing STEM activities. Applying this guide for the STEM activity design requires an exploration of the context and stakeholders at schools. Therefore, researchers can benefit from this guide for developing STEM activities with *primary* or *high school* teachers. Researcher-designers may also use this guide to explore STEM or STEAM education in K-12 schools.

According to the literature, the AICAD Group (Association of Independent Colleges of Art and Design, 2002) suggests collaboration between the education and design programs in higher education, besides collaboration between design faculty and K-12 education (as cited in Davis, 2004). According to this, industrial design departments may utilize this guide for collaborating with education departments, STEM departments (departments of math, science, chemistry and biology), or with in-service teachers.

There are some strategies listed in the guide, and K-12 teachers may benefit from these strategies provided in this guide in their STEM activity design and implementation. Educators, researchers, specialists, or institutions may utilize this guide to provide DT training to teachers, or to their institutions. Turkish Ministry of Education or STEM research centers may utilize this guide for training secondary school teachers to diffuse STEM education in Turkey.

8.7 Empowering teachers' education and STEM education through DT approach and designer's facilitation

DT approach can develop teachers' holistic thinking and prototyping mindsets for the implementation of STEM education. Besides, the adoption of risk-taking and embracing ambiguity mindsets by teachers is considered crucial for STEM education. In the literature, the DT approach encourages risk-taking and prototyping mindsets which are important both in K-12 education (Kolk, 2012) and

STEM education (Carroll, 2015). Therefore, it is considered that STEM education facilitated by designers can help teachers' adopting these mindsets easily and effectively. By thinking like a designer, teachers can analyze the issues and develop ways effectively by exploring and examining students' experience about curriculum, assignments, classroom activities, and school environment (Henriksen & Richardson, 2017).

The DT approach can support teachers to gain creative confidence, to develop empathy for students and other teachers, and to develop holistic and creative problem-solving skills. This is an essential benefit for teachers who are expected to be the designer of their learning area (Kalantzis & Cope, 2010). However, in Turkey, there are challenges such as having a test-oriented educational system, compartmentalized and strict curriculum, and time constraints, which prevent teachers from placing design at the center of their teaching practices. Therefore, it is considered that integrating the DT approach into the education of teachers, or training teachers in DT approach can help them to be the designers of their learning area.

8.8 Suggestions for integrating design education in teachers' education and K-12 education to support Turkey's education vision

The expectation about teachers' skills and requirements were changed because of the shift from teacher-centered education to student-centered education (ISTE, 2008). They are expected to be collaborators, contributors and instructional designers instead of an implementer (Kalantzis & Cope, 2010). In STEM education, teachers are also required to be the facilitators and mentors for students. According to Turkey's Education Vision 2023, equipping teachers with new roles is one of the primary goals of the Turkish education system. In the literature, design thinking is stated to help teachers for creating a productive and expressive learning environment (IDEO, 2012). McFadden (2015) also proposes that teachers can collaborate with designers to create a design content in education, as we employed in this research. Therefore, DT approach through designers' facilitation can make a contribution to STEM and regular education for supporting teachers to fulfill their new roles.

Generation P ('P' for participatory) students would like to be creators, collaborators, innovators, problem solvers or risk-takers and active learners (Kalantzis & Cope, 2010). Therefore, it is getting more important to design personalized learning experiences for students. Prioritizing personalized education is also one of the goals of the Turkish education system (Turkey's Education Vision 2023 report, n.d.). Personalized learning is based on presenting teaching experiences considering individual differences and interests. It is against providing one type of learning model for each person (Özarslan, 2010). One of the most crucial contributions of the DT approach in the STEM activity design process is to enable faster familiarity with students and the development of STEM activities considering the students' levels due to being a human-centered approach. Therefore, DT approach can support teachers for their developing personalized learning experiences.

This study shows that both English and the visual arts can play a leading role in facilitating the integration of disciplines. Turkish Ministry of Education encourages the integration of different disciplines into the English language course (Turkey's Education Vision 2023, n.d.). This can create an opportunity for the English language course to have a leading role in STEM education. Besides English language course, the visual arts course can also have a leading role in STEM education by aligning its curricula with other disciplines.

According to Turkey's Education Vision 2023, including all disciplines in education, developing solutions for social problems, and getting stakeholders involved in education are some of the primary goals of the Turkish education system. DT approach can help realize these goals with its human-centered, collaborative, creative and interdisciplinary nature.

One of the critical deficiencies of STEM education in Turkey is teachers' lacking 21st-century skills (Akgündüz et al., 2015); the ministry intends to open minor degree programs to equip teachers with these skills (Turkey's Education Vision 2023, n.d.). Since the DT approach includes the 21st-century skills (Cooper-Hewitt, 2014), integrating the DT approach into teachers' training and employing it in STEM activity design can develop teachers' and students' 21st-century skills. The literature also supports this suggestion and it is stated that integrating design education into pre-service teacher education can offer extra advantages to develop teaching and learning (Davis, 1998).

The chairman of the board of trustees at TED University criticized the faculties of education for not giving priority to production in their education. Similarly, according to the Minister of Education, in the faculty of education, the practical courses' level is 5% currently; however, it was %50 in the teachers' school in the past. Because of that, Ministry of Education has been working with the Council of Higher education to re-design the education of teachers (Ministry of National Education, 2019b). It is considered that making collaboration with industrial design academics or professional industrial designers can be beneficial for the Turkish educational system.

Ministry of Education has planned supporting teachers' professional development through training them about STEM education and DT (Ministry of National Education, 2019a). In this respect, industrial designers can contribute to teachers' professional development programs by guiding them in the implementation of STEM education and the DT approach.

8.9 Contribution of the study

According to the literature, developing a learner level appropriate STEM activity (Carter, 2013) and the collaboration among teachers (Margot & Kettler, 2019) are the main challenges of STEM education. Moreover, STEM research in Turkey has less focus on in-service teachers; they mostly focus on the students from K-12 or higher education. Most of the graduate theses on STEM education at secondary school level are based on the implementation and evaluation of STEM activities either developed by the researchers or previously integrated into the institutions (See section 2.1.5). Developing STEM activities or curriculum together with in-service teachers is a relatively unexplored area.

This study is important on four grounds. Firstly, this study provides the proposed DT approach as a guide for designing and implementing STEM activities for secondary school teachers. Secondly, the implementation of the DT approach developed in this study presents solutions to the challenges of STEM education, including collaboration among teachers, teachers' integrating disciplines, and developing a learner level appropriate STEM activity. Thirdly, the DT integrated STEM activity design guide proposes the DT approach as a problem-solving process for the STEM activity instead of the engineering design process. And fourthly, this study provides the full documentation of the STEM activities developed through the proposed DT approach for the 5th-graders.

8.10 Limitations of the study

This study utilized the single case study approach in the same setting with the same participants in the main studies. In this respect, one of the limitations was the conduct of the main studies in the same school with the same participants. However, this helped to build trust among the researcher and the participants, and resulted in more accurate and credible data; it also increased the reliability of the research instruments and methods. Another limitation of the study was the conduct of the main studies in a *private* school. Therefore, a preliminary investigation needs to be made against the possibility of encountering different challenges or conditions in *public* schools. However, the DT integrated STEM activity design guide is considered appropriate to be utilized in public schools because it involves prior research about the setting. The guide was developed by a researcher-designer;

an educational developer or planner could have supported the development of the guide to make it more teacher-oriented. This is another limitation and requires further study with experts from the education field.

Another limitation of the research was the sample size of the main studies; six teachers and 16 students were involved in the main studies. However, according to McMillan (2004), in a case study, the small number of participants allows the researchers to make a better description of the research topic. Although it would have been better to be able to compare the cases in this study with similar cases in the literature, no previous DT approach developed for the STEM activity design was identified in the literature. Since the developed DT approach cannot be compared with the relevant literature, the findings should be considered preliminary.

The limitations were also described for each data collection method in Chapter 3, and the importance of the triangulation of data was highlighted. This study can be accepted as reliable and valid because of the research design, triangulating the data, the data collection methods, and its sources, the iterative approach to gathering and analyzing the data, and developing a guide for the STEM activity design. According to the literature, there may not be generalization from a single setting to other cases because of its being contextual (Bhattacherjee, 2012). However, transferability and generalizability can be realized by using this study as discussed in section 3.6.

REFERENCES

Aflatoony, L., Wakkary, R., & Neustaedter, C. (2018). Becoming a design thinker: assessing the learning process of students in a secondary level design thinking course. *The International Journal of Art & Design Education*, 438-453.

Aguirre, M., Agudelo, N., & Romm, J. (2017). Design facilitation as emerging practice: Analyzing how designers support multi-stakeholder co-creation. *She ji: The Journal of Design, Economics, and Innovation, 3*(3), 198-209.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Cavaş, B., Çorlu, M. S., Öner, T., &. Özdemir, S. (2015). *STEM eğitimi Türkiye raporu: günün modası mı yoksa gereksinim mi?* İstanbul, Turkey: Aydın Üniversitesi. http://www.aydin.edu.tr/belgeler/IAU-STEM-Egitimi-Turkiye-Raporu-2015.pdf

Alıcı, M. (2018). *Probleme dayalı öğrenme ortamında STEM eğitiminin tutum, kariyer algı ve meslek ilgisine etkisi ve öğrenci görüşleri* (Publication No. 507585) [Master dissertation, Kırıkkale University, Turkey]. CoHE Thesis Center.

Allen, M., Webb, A.W., & Matthews, C. (2016). Adaptive teaching in STEM: characteristics for effectiveness. *Theory into Practice, 55*(3), 217-224.

Altaş, S. (2018). *STEM eğitimi yaklaşımının sınıf öğretmeni adaylarının mühendislik tasarım süreçlerine, mühendislik ve teknoloji algılarına etkisinin incelenmesi* (Publication No. 506175) [Master dissertation, Muş Alparslan University, Turkey]. CoHE Thesis Center.

An Introduction to Design Thinking "Wallet" Edition: Facilitators' guide, (2012). Retrieved June 26, 2020, from https://dschool-old.stanford.edu/sandbox/groups/designresources/wiki/4dbb2/attachments/d5c91/Wallet%20Facilitators%20Guide2012.pdf?sessionID=284984d22365aed841322860a725264d47aa06ec

Ayar, M. C., & Yalvaç, B. (2016). Lesson learned: authenticity, interdisciplinarity, and mentoring for STEM learning environments. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 30-43.

Aydemir, A. (2019). *Sosyal bilgilerde tasarım odaklı düşünme yaklaşımı* (Publication No. 538473) [Doctoral dissertation, Gazi University, Turkey]. CoHE Thesis Center.

Aziz, N. (2015). *Research and Study of Developing an Integrated Entrepreneurial and Innovative Co-design Thinking Model and Toolkit* (Publication No. 392421) [Master dissertation, Fatih University, Turkey]. CoHE Thesis Center.

Baran, E., Canbazoğlu-Bilici, S., Mesutoğlu, C., & Ocak, C. (2016). Moving STEM beyond schools: students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 9-19.

Barron, B., Schwartz, D., Vye, N., Moore, A., Petrosino, A., Zech, L., & Bransford, J. (1998). Doing with understanding: lessons from research on problem- and project-based learning. *The Journal of the Learning Sciences*, *7*(3/4), 271-311.

Baştuğ, E. (2015). *Learning Design Thinking Through Pattern Generation: A computational Framework Toolkit* (Publication No. 419036) [Master dissertation, Istanbul Technical University, Turkey]. CoHE Thesis Center.

BAUSTEM STEM course plan (n.d.). Retrieved November 15, 2017, from http://inteach.org/duyurular/

BAUSTEM teacher self-evaluation form (n.d.). Retrieved November 15, 2017, from http://inteach.org/duyurular/

Belek, F. (2018). *FETEMM etkinliklerinin, fen bilgisi öğretmen adaylarının öz-yeterlik inançlarına, FETEMM eğitim yaklaşımına ve fen öğretimine yönelik düşüncelerine etkisinin incelenmesi* (Publication No. 528343)

[Master dissertation, Çanakkale Onsekiz Mart University, Turkey]. CoHE Thesis Center.

Benuzzi, S., Golez, F., Grace, L., Hamm, D., & Straits, W. (2015). *Continuum for Integrating STEM in Teacher Preparation and Induction*. S. Benuzzi & G. Lori (Eds.). Retrieved April 24, 2017, from http://teachingcommons.cdl.edu/ngss/documents /ContinuumforIntegrating STEMinTeacherPreparationandInductionfinal2.pdf

Bequett J., & Bequett, B.B. (2012). A place for art and design education in the STEM conversation. *Art Education*. *65*(2), 40-47.

Bevins, S. (2012, December/January). Moving the liberal arts education into the 21st century. *Technology and Engineering Teacher*, 10-13.

Bhattacherjee, A. (2012). Social science research: principles, methods, and practices. *Textbooks Collection*. Book 3. Retrieved April 03, 2020, from http://scholarcommons. usf.edu/oa_textbooks/3

Blomkamp, E. (2018). The Promise of Co-Design for Public Policy. *Australian Journal of Public Administration*, 1-15. Retrieved May 15, 2018, from https://onlinelibrary.wiley.com/doi/epdf /10.1111/1467-8500.12310.

Body, J., Terrey, N., & Tergas, L. (2010). Design facilitation as an emerging design skill: A practical approach. In *Proceedings of the 8th Design Thinking Research Symposium (DTRS8)* (pp. 61-70). Sydney, Australia.

Bouchard, J. (2013). *Design thinking: exploring creativity in higher education* [Master dissertation, Michigan State University, USA]. Retrieved from https://d.lib.msu.edu/etd/1621/datastream/OBJ/View/

Brainstorming rules. (n.d.). Retrieved August 01, 2017, from https://www. designkit.org/methods/28

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, (3), 77-102.

Brenner, W., Uebernickel, F., & Abrell, T. (2016). Design thinking as mindset, process, and toolbox. In W. Brenner & F. Uebernickel (Eds.), *Design thinking for innovation: research and practice* (pp. 3-21). Switzerland: Springer International Publishing.

Broadley, C., & Smith, P. (2018). Co-design at a distance: context, participation, and ownership in geographically distributed design processes. *The Design Journal*, *21*(3), 395-415.

Brooks, J., & King, N. (2014). Doing template analysis: evaluating an end-of-Life care service. In *SAGE Research Methods Cases* SAGE Publications Ltd. https://doi.org/10.4135 /978144627305013512755

Brown, T. (2008). Design thin king. *Harvard Business Review*, *86*(6), 84-92.

Brown, M., & Edelson, D. C. (2001, April). Teaching by design: curriculum design as a lens on instructional practice. *American Educational Research Association Annual Meeting (AERA)*. Seatle, USA.

Brown, M., & Edelson, D. C. (2003, June). *Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice?* (LeTUS Report Series-03) Center for Learning Technologies in Urban Schools. http://www.inquirium.net/people/matt/teaching_as_design-Final.pdf

Bruce-Davis, M. N., Gubbins, E. J., Gilson, C. M., Villanueva, M., Foreman, J. L., & Rubenstein, L. D. (2014). STEM high school administrators', teachers', and students' perceptions of curricular and instructional strategies and practices. *Journal of Advanced Academics*, *25*(3), 272-306. https://doi.org/10.1177/1932202X14527952

Buckley, C. M., Naras, K. R., Fraser, S., & Garbely, T. C. (2018). *Developing STEM activities for the museum of London*. [Licentiate thesis, Worcester

Polytechnic Institute, UK]. Retrieved from https://digitalcommons.wpi.edu/iqp-all/5201

Bundle ideas. (n.d.). Retrieved August 01, 2017, from http://www.designkit.org/methods/30

Burkett, I. (2012). *An Introduction to Co-Design*. Knode. Retrieved from https://www.yacwa.org.au/wp-content/uploads/2016/09/An-Introduction-to-Co-Design-by-Ingrid-Burkett.pdf

Bybee, R. W. (2010). Advancing STEM education: a 2020 vision. *Technology and Engineering Teacher*, *70*(1), 30-35.

Camacho, M. (2018). An integrative model of design thinking. In *Proceedings of 21st DMI: Academic Design Management Conference; Next Wave* (pp. 627-641). London, UK.

Carlgren, L. (2013). *Design thinking as an enabler of innovation: exploring the concept and its relation to building innovation capabilities* [Doctoral dissertation, Chalmers University of Technology, Sweden]. Retrieved from http://publications.lib.chalmers.se/records/fulltext/185362/185362.pdf

Carroll, M.P. (2014). Shoot for the moon! The mentors and the middle schoolers explore the intersection of design thinking and STEM. *Journal of Pre-College Engineering Education Research (J-PEER)*, *4*(1), 13-30.

Carroll, M. (2015). Stretch, dream, and do - A 21st century design thinking & STEM journey. *Journal of Research in STEM Education*, *1*(1), 59-70.

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein M. (2010). Destination, imagination & the fires within: design thinking in a middle school classroom. *International Journal of Art & Design Education*, *29*(1), 37-53.

Carter, V. R. (2013). *Defining Characteristics of an Integrated STEM Curriculum in K-12 Education* [Doctoral dissertation, University of Arkansas, USA]. Retrieved from https://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1818&context=etd

Casey, J. E., Mireles, S. E., & Viloria, M. L., Garza E. (2018). Literacy & arts integration in science: engaging English language learners in a lesson on mixtures and solutions. *Texas Journal of Literacy Education*, *6*(1), 51-68.

Catterall, J. (2013). Getting real about the E in STEAM. *The STEAM Journal*, *1*(1). doi: 10.5642/steam.201301.06. Retrieved September 18, 2016, from http://scholarship.claremont.edu/steam/vol1/iss1/6

Ceylan, S. (2014). *Ortaokul fen bilimleri dersindeki asitler ve bazlar konusunda fen, teknoloji, mühendislik ve matematik (fetemm) yaklaşımı ile öğretim tasarımı hazırlanmasına yönelik bir çalışma* (Publication No. 372224) [Master dissertation, Uludag University, Turkey]. CoHE Thesis Center.

Chen, Z., & Xiaoting, L. (2016). Developing STEAM education to improve students' innovative ability - an interview with Prof. Georgette Yakman, a famous American STEAM educator. *Open Education Research*, *22*(5). Retrieved October 20, 2016 from http://steamedu.academia.edu/GeorgetteYakman & in Chinese; http://www.duxuan.cn /doc/26649688.html

Chesson, D. (2017). *Design thinker profile: Creating and validating a scale for measuring design thinking capabilities* [Master dissertation, Antioch University, USA]. AURA: Antioch University Repository and Archive. https://aura.antioch.edu/cgi/viewcontent.cgi?article=1398&context=etds

Chon, H., & Sim, J. (2019). From design thinking to design knowing: an educational perspective. *Art, Design & Communication in Higher Education*, *18*(2), 187-200.

Cisneros, K. (2013, September 24). *Design in the classroom supports the common core standards*. Retrieved September 08, 2016, from http://www.cooperhewitt.org/2013/09/24/design-in-the-classroom-supports-the-common-core-standards/

Cohen, L., & Manion, L., & Morrison. K. (2007) *Research methods in education* (6th Ed.). Routledge

Connor, A.M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: strategies for enhancing engineering & technology education. *International Journal of Engineering Pedagogies*, *5*(2), 37-47. http://dx.doi.org/10.3991/ijep.v5i2.4458

Cook, K. L., & Bush, S. B. (2018). Design thinking in integrated STEAM learning: surveying the landscape and exploring exemplars in elementary grades. *School Science and Mathematics.* 118, 93-103.

Cooper-Hewitt. (2014). *Cooper-Hewitt What is design? Teacher resource packet*. Smithsonian Design Museum. https://www.cooperhewitt.org/wp-content/uploads/2014/09/Teacher-Resource-Packet-What-is-Design.pdf

Coursera MOOCs course. (n.d.). Retrieved August 06, 2017 from https://www.coursera.org/learn/uva-darden-design-thinking-innovation

Coşkun, A. (2010). *Post-Use Design Thinking for Product Design Process and Sustainability: A Study on an Educational Project in Glass Packaging* (Publication No. 268999) [Master dissertation, Middle East Technical University, Turkey]. CoHE Thesis Center.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2012). *Educational research: planning, conducting, and evaluating quantitative and qualitative research* (4th Ed.). USA: Pearson.

Çalışıcı, S. (2018). *FETEMM uygulamalarının 8.sınıf öğrencilerinin çevresel tutumlarına, bilimsel yaratıcılıklarına, problem çözme becerilerine ve fen* *başarılarına etkisi* (Publication No. 530773) [Master dissertation, Gazi University, Turkey]. CoHE Thesis Center.

Çınar, G. Ç. (2018). *Design Thinking in Business Education: A Case Study Perspective* (Publication No. 517258) [Master dissertation, Izmir University of Economics, Turkey]. CoHE Thesis Center.

Çınar, S. & Çiftçi, M. (2016). Disiplinler arası STEM yaklaşımına yönelik yapılan çalışmaların içerik analizi. In *Proceedings of the 10 International Computer & Instructional Technologies Symposium* (pp. 1031-1039). Rize, Turkey.

Çorlu, S., & Çallı, E. (2017). *STEM kuram ve Uygulamaları*. İstanbul: Pusula Yayıncılık

Dagar, A. (2013). Motivational theories and their implications. *International Research Journal of Management Science & Technology*, *4*(2), 1058-1061.

Daugherty, M. K. (2013). The Prospect of an A in STEM education. *Journal of STEM Education*, *14*(2). 10-15.

Davis, M. (1998). Making a case for design-based learning. *Arts Education Policy Review*, *100*(2), Retrieved September 21, 2016, from https://www.ncsu.edu/www/ncsu/design/sod5/phd/resources /Davis_Making _a_Case. pdf

Davis, M. C. (2004). Education by design. *Arts Education Policy Review*, *105*(5), 15-22.

DeBoer, G., Carman, E., & Lazzaro, C. (2019). *The role of language arts in a successful STEM education program*. Retrieved November 13, 2019, from https://files.eric.ed.gov/fulltext/ED563458.pdf

De Campos, R. (2014). *Design thinking in education: a case study following one school district's approach to innovation for the 21st century* [Doctoral dissertation, The University of San Francisco, USA]. Retrieved from https://repository.usfca.edu/cgi/viewcontent.cgi?article=1116&context=diss

Dedetürk, A. (2018). *6. sınıf ses konusunda FETEMM yaklaşımı ile öğretim etkinliklerinin geliştirilmesi, uygulanması ve başarıya etkisinin araştırılması* (Publication No. 506867) [Master dissertation, Erciyes University, Turkey]. CoHE Thesis Center.

Define your audience. (n.d.) Retrieved August 01, 2017, from https://www. designkit.org/methods/11

Delaney, M. (2014, Spring). Schools shift from STEM to STEAM. *EdTech*. Retrieved October 30, 2016 from http://www.edtechmagazine.com/k12 /article/2014/04/schools-shift-stem-steam

Design Council. (2005). *Learning Environments Campaign Prospectus: From the Inside Looking Out*. Retrieved April 17, 2017, from archive.teachfind.com/ttv/static.teachers.tv/shared/files/2424.pdf

Di Russo, S. (2016). *Understanding the behaviour of design thinking in complex environments* [Doctoral dissertation, Swinburne University of Technology, Australia]. Swinburne Theses Collection. https://researchbank.swinburne.edu.au/file/a312fc81-17d3-44b5-9cc7-7ceb48c7f277/1/Stefanie%20Di%20Russo%20Thesis.pdf

d.loft STEM. (n.d.). Retrieved September 06, 2016, from https://dloft.stanford.edu/

Dong, H., & Yuan, S. (2013). *Learning from co-designing*. *2nd International Conference for Design Education Researchers*. Norway.

Download your learnings. (n.d.). Retrieved August 01, 2017, from http://www.designkit.org/methods/12

Drake, S. M. (1991). How our team dissolved the boundaries. *Educational Leadership*, *49*(2), 20-22.

Drake, S., & Burns, R. (2004). *Meeting standards through integrated curriculum*. USA: Association for Supervision and Curriculum Development.

Duygu, E. (2018). *Simülasyon tabanlı sorgulayıcı öğrenme ortamında FeTeMM eğitiminin bilimsel süreç becerileri ve FeTeMM farkındalıklarına etkisi* (Publication No. 507586) [Master dissertation, Kırıkkale University, Turkey]. CoHE Thesis Center.

d.school at Stanford University (n.d.). Retrieved August 18, 2017, from https://dschool.stanford.edu/resources/the-bootcamp-bootleg

Dyson, J. (2010, March). *Ingenious Britain: making the UK the leading high tech exporter in Europe*. Retrieved October 15, 2016, from https://www.catapult.org.uk/wp-content/uploads/2016/04/Ingenious-Britain-James-Dyson-Report-2010.pdf.pdf

Efeoglu, A., Møller, C., Sérié, M., & Boer, H. (2013). Design thinking: characteristics and promises. In *Business Development and Co-creation: Proceedings of the 14th International CINet Conference* (pp. 241-256). Nijmegen, Netherlands.

Enghag, M. (2004). *Miniprojects and context rich problems: case studies with qualitative analysis of motivation, learner ownership and competence in small group work in physics* [Licentiate thesis, Linköping University, Sweden]. Retrieved from https://www.diva-portal.org/smash/get/diva2:21379/FULLTEXT01.pdf

European Commission. (2015). *Science education for responsible citizenship*. Retrieved September 19, 2016 from http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf

Fantauzzacoffin, J., Rogers, J. D., & Bolter, J. D. (2012, March). *From STEAM research to education: an integrated art and engineering course at Georgia Tech*. *IEEE Integrated STEM Education Conference*. NJ, USA.

Fogg, B. (2009, April). A behavior model for persuasive design. *4th International Conference on Persuasive Technology- Persuasive ’09*. California, USA.

Fogtmann, M. H., & Kinch, S. (2011, October). The design researcher in quandary- The conflicting roles of being both a designer and a design researcher. *Proceedings of DESIRE'11*. Eindhoven, Netherlands.

Fortus, D., Dershimer, R. C., Krajcik, J., Marx, R. W., & Mamlok-Naaman, R. (2004). Design-based science and student learning. *Journal of Research in Science Teaching*, *41*(10), 1081-1110.

Foshay, A. W. (Summer, 1991). The curriculum matrix: Transcendence and mathematics. *Journal of Curriculum and Supervision*, *6*(4), 277-293.

Fredette, M. (2013). For these schools, adding arts to STEM boosts curriculum. *T.H.E. Journal,* Retrieved October 10, 2016, from https://thejournal.com/articles/2013/10/17 /for-these-schools-adding-arts-to-stem-boosts-curriculum.aspx

Gardner, K., Glassmeyer, D., & Worthy, R. (2019). Impacts of STEM professional development on teachers’ knowledge, self-efficacy, and practice. *Front. Educ*. *4*(26)

Gettings, M. (2016). Putting it all together: STEAM, PBL, scientific method, and the studio habits of mind. *Art Education*, *6*9(4), 10-11.

Gassmann, O., & Schweitzer, F. (2014). Managing the unmanageable: the fuzzy front end of innovation. In O. Gassmann & F. Schweitzer (Eds.), *Management of the fuzzy front end of innovation* (pp. 3-14). Switzerland: Springer International Publishing.

Ghanbari, S. (2015). Learning across disciplines: a collective case study of two university programs that integrate the arts with STEM. *International Journal of Education & the Arts*, *16*(7).

Gibson, W. J., & Brown, A. (2009). *Working with qualitative data*. SAGE Publications.

Grácio, A. H. L., & Rijo, C. (2017). Design thinking in the scope of strategic and collaborative design. *Strategic Design Research Journal*, *10*(1), 30-35.

Gül, K. (2019). *Fen bilgisi öğretmen adaylarına yönelik bir STEM eğitimi dersinin tasarlanması, uygulanması ve değerlendirilmesi* (Publication No. 552171) [Doctoral dissertation, Gazi University, Turkey]. CoHE Thesis Center.

Hartley, J. (2004). Case Study Research. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organizational research* (pp. 323-333). Sage Publications.

Hassi, L., & Laakso, M. (2011). Design thinking in the management discourse; defining the elements of the concept. *18th International Product Development Management Conference*. Delft, Netherlands.

Henriksen, D., & Richardson, C. (2017). Teachers are designers: addressing problems of practice in education. *Phi Delta Kappan*, 60-64.

Heo, J. (2013). *A case study of team teaching and team teachers in Korean primary schools* [Doctoral dissertation, University of Warwick, UK]. Modern Records Centre Theses. http://wrap.warwick.ac.uk/58689/1/WRAP_THESIS_Heo_2013.pdf

Hernandez-Monsalve, M. C., Velasquez-Montoya, M., Mejia-Gutierrez, R., Hohn, H., & Tassoul, M. (2017). First view designlab: a fuzzy front end platform for innovation and education. In *Proceedings of the 21st International Conference on Engineering Design (ICED17), Vol. 9: Design Education* (pp. 189-198). Vancouver, Canada.

Howard, Z. (2015). *Understanding design thinking in practice: A qualitative study of design led professionals working with large organisations* [Doctoral dissertation, Swinburne University of Technology, Australia]. Swinburne

Theses Collection. https://researchbank.swinburne.edu.au/file/bbcf5fac-46f2-4de3-9d83-32f331761a1f/1/Zaana%20Howard%20Thesis.pdf

Howes, A., Kaneva, D., Swanson, D., & Williams, J. (2013, August). *Re-envisioning STEM education: curriculum, assessment and integrated, interdisciplinary studies.* Retrieved October 13, 2016, from https://royalsociety.org/~/media/education/policy/vision/reports/ev-2-vision-research-report-20140624.pdf

HPI (Hasso Plattner Institut) (n.d.). Retrieved May 18, 2020, from https://hpi-academy.de/en/design-thinking/what-is-design-thinking.html

IDEO (Design Thinking for Educators). (2012). Retrieved September 06, 2016, from http://www.designthinkingforeducators.com/toolkit/

International Society for Technology in Education (ISTE). (2008). *National educational technology standards*. Retrieved December 26, 2014, from http://cnets.iste.org/

ideaport. (2016, February 11). *Tasarım Odaklı Düşünme Nedir?* [Video]. You Tube. Retrieved August 13, 2017, from https://www.youtube.com/watch?v=QdF-avTxXOI

İstanbul Aydın University STEM School. (n.d.). Retrieved April 08, 2017 from http://www. stemokulu.com/

Johansson-Sköldberg, U., Woodilla, J., & Cetinkaya, M. (2013). Design thinking: past, present and possible futures. *Creativity and Innovation Management, 22*(2), 121-146.

Johnny Ryan. (2013, December 13). *Design Thinking workshop with Justin Ferrell from Stanford d. school at The Irish Times* [Video]. YouTube. Retrieved https://www.youtube.com /watch?v=Z4gAugRGpeY

K12 lab network. (n.d.) Retrieved September 06, 2016, from http://www.k12lab.org/

Kalantzis, M., & Cope, B. (2010). The teacher as designer: pedagogy in the new media age. *E–Learning and Digital Media*, *7*(3), 200-222.

Kannengiesser, U. & Gero, J.S. (2005). Understanding situated design agents. In A. Bhatt (Ed.). *CAADRIA'05, TVB* (Vol 2, pp. 277-287). New Delhi.

Keane, L., & Keane, M. (2016). STEAM by design. *Design and Technology Education: An International Journal*, *21*(1), 61-82.

Keane, L., & Keane, M. (2014). Design is our nature disseminating design practices in K12 education. In *Proceedings of the International Teacher Education Conference 2014 (ITEC 2014)* (pp. 253-262). Dubai, UAE

Kimbell L. (2011). Rethinking design thinking: Part I. *Design and Culture, 3*(3), 285-306.

King, N. (2004). Using templates in the thematic analysis of text. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organizational research* (pp. 256-270). Sage Publications.

Koçkan, P. (2012). *Tasarım Araştırmaları Bağlamında Tasarımcı Düşünme ve Tasarım Süreci* (Publication No. 314919) [Master dissertation, Hacettepe University, Turkey]. CoHE Thesis Center.

Kolk, M. (2012). *Build 21st century skills with design thinking*. Retrieved September 07, 2016, from https://creativeeducator.tech4learning.com/2012/articles /Interview-Dr_Maureen_Carroll

Kolodner, J. L. (2002). Facilitating the learning of design practices: lessons learned from an inquiry into science education, *Journal of Industrial Teacher Education*, *3*9(3), 9-40.

Kolodner, J. L., Crismond, D., Gray, J., Holbrook, J., & Puntambekar, S. (1998). Learning by design from theory to practice. In A. S. Bruckman, M. Guzdial, J. L. Kolodner & A. Ram (Eds.). In *Proceedings of the International Conference of the Learning Sciences* (pp. 16-22). Atlanta, GA: AACE. Retrieved November 01, 2016, from http://www.cc.gatech.edu/projects/lbd/htmlpubs/lbdtheorytoprac.html

Korea Ministry of education, & KOFAC (Korea Foundation for the Advancement of Science & Creativity) (2016). *Enjoy Science with STEAM*. Korea Foundation for the Advancement of Science & Creativity. Retrieved January 22, 2017, from https://steam.kofac.re.kr/?page_id=6898&m=V&n=8578&search_key=&search_word=&current_page=1

Kwack, J. (2014). *Connecting the dots: mapping STEAM in K-12 education* [Master dissertation, Rhode Island School of Design, USA]. Retrieved from https://www.academia.edu/7690880/Connecting_the_Dots_Mapping_STEAM_in_K_12_Education_A_Masters_Thesis_in_Art_and_Design_Education_in_Teaching_and_Learning_in_Art_and_Design_RISD_2014

Laursen, L. N., & Haase, L. M. (2019). The Shortcomings of design thinking when compared to designerly thinking. *The Design Journal*, *22*(6), 813-832.

Leifer L.J., & Steinert M. (2014). Dancing with ambiguity: causality behavior, design thinking, and triple-loop-learning. In O. Gassmann & F. Schweitzer (Eds.), *Management of the fuzzy front end of innovation* (pp. 141-158). Switzerland: Springer International Publishing.

Li, C. (2016). Maker-based STEAM education with scratch tools. *World Transactions on Engineering and Technology Education*, *14*(1), 151-156.

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., Duschl, R. A. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research*, *2*(2), 93-104.

Lor, R. R. (2017). Design thinking in education: a critical review of literature. In *Proceedings of the ACEP-Asian Conference on Education and Psychology* (pp. 36-68). Bangkok, Thailand.

Margot, K. C., & Kettler T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education*, *6*(2).

Martín-Páez, T., Aguilera, D., Perales-Palacios, F. J., & Vílchez-González, J. M. (2019). What are we talking about when we talk about STEM education? A review of literature. *Science Education*, 103, 799-822.

Mason, J. (2002). *Qualitative researching* (2nd Ed.).UK: SAGE Publications.

Mattelmäki, T., & Visser, F. S. (2011). Lost in Co-X: interpretations of co-design and cocreation. In *Diversity and Unity, Proceedings of IASDR2011*, *the 4th World Conference on Design Research* (Vol. 31). Delft, Netherlands: Delft University of Technology.

McDonald, C. V. (2016). STEM Education: a review of the contribution of the disciplines of science, technology, engineering and mathematics. *Science Education International*, *27*(4), 530-569.

McGlynn, K. & Kelley, J. (2019). Making it work: incorporating design thinking into all areas of instruction to fit the needs of unique learners. *Science Scope*, 20-25.

MEB Science education curriculum (2018). Retrieved May 06, 2018, from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325

MEB Technology and design course curriculum (2018). Retrieved May 06, 2018, from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=380

McFadden, J. R. (2015). *Teachers as designers: the iterative process of curriculum design focused on STEM integration* [Doctoral dissertation, University of

Minnesota, USA]. University of Minnesota Digital Conservancy. https://conservancy.umn.edu/handle/11299/175257

McMillan, J. H. (2004). *Educational research: Fundamentals for the consumer* (4th Ed.). Boston: Pearson.

McNiff, J. & Whitehead, J. (2002). *Action research: principles and practice* (2nd Ed.). London and New York: RoutledgeFalmer

MIT MOOCs course (n.d.). Retrieved August 06, 2017, from https://www.edx.org/course/design-thinking-leading-learning-mitx-microsoft-education-11-155x

Ministry of National Education. (2016). *STEM Education Report*. Retrieved April 08, 2017, from http://yegitek.meb.gov.tr/STEM_Education_ Report.pdf

Ministry of National Education (2016a, October). *Kayseri de 30 okulumuzda STEM projemizi uyguluyoruz*. Retrieved November 10, 2016 from, https://kayseri.meb.gov.tr/www /kayseride-30-okulumuzda-stem-projemizi-uyguluyoruz/icerik/1062

Ministry of National Education (2019, September). *Buluşları artıracak projede ilk eğitimler tamamlandı*. Retrieved January 02, 2020, http://www.meb.gov.tr/buluslari-artiracak-projede-ilk-egitimler-tamamlandi/haber/19414/tr

Ministry of National Education (2019a, September). *Öğretmenlere "eğitim, sanat, spor" ağırlıklı mesleki gelişim programı*. Retrieved January 02, 2020, http://www.meb.gov.tr/ogretmenlere-egitim-sanat-spor-agirlikli-mesleki-gelisim-programi/haber/19225/tr

Ministry of National Education (2019b, November). *Uluslararası öğretmen eğitimi ve akreditasyon kongresi*. Retrieved January 02, 2020, from http://www.meb.gov.tr/uluslararasi-ogretmen-egitimi-ve-akreditasyon-kongresi/haber/19824/tr

Moore, T. S., Lapan, S. D., & Quartaroli, M. T. (2012). Qualitative research: An introduction to methods and designs. In S. D. Lapan, M. T. Quartaroli & F. J. Riemer (Eds.), *Case study research* (pp. 243-270). USA: John Wiley & Sons, Inc.

Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K-12 STEM education. In Ş. Purzer, J. Strobel, & M. Cardella (Eds.), *Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices* (pp. 35-60). USA: Purdue University Press.

Nağaç, M. (2018). *6. sınıf fen bilimleri dersi madde ve ısı ünitesinin öğretiminde fen, teknoloji, mühendislik ve matematik (FeTeMM) eğitiminin öğrencilerin akademik başarısı ve problem çözme becerilerine etkisinin incelenmesi* (Publication No. 522774) [Master dissertation, Hatay Mustafa Kemal University, Turkey]. CoHE Thesis Center.

Nathan, M., & Pearson, G. (2014, June). *Integration in K–12 STEM education: status, prospects, and an agenda for research. 121st ASEE Annual Conference & Exposition*. IN, USA.

National Academy of Engineering [NAE], & National Research Council [NRC]. (2014). *STEM integration in K-12 education: status, prospects, and an agenda for research*. Washington, DC: National Academy Press. https://www.nap.edu/catalog/18612/stem-integration-in-k-12-education-status-prospects-and-an

National STEM school education strategy. (2015, December). *A comprehensive plan for science, technology, engineering and mathematics education in Australia*. Australian Department of Education, Skills, and Employment. Retrieved November 12, 2016, from http://www.educationcouncil.edu.au/site/DefaultSite/filesystem/documents/National%20STEM%20School%20Education%20Strategy.pdf

National Research Council. (2009). *Transforming agricultural education for a changing world*. Washington, DC: The National Academies Press. Retrieved October 30, 2016, from https://www.nap.edu/catalog/12602/transforming-agricultural-education-for-a-changing-world

New, S., & Kimbell, L. (2013). Chimps, Designers, Consultants and Empathy: A "Theory of Mind" for Service Design. *2nd Cambridge Academic Design Management Conference*. London, UK.

Obenauer, S. (2019). *Collaboration begins with empathy*. Retrieved November 13, 2019, from https://www.invisionapp.com/inside-design/collaboration-begins-with-empathy/

Okka, A. (2019). *Bilim uygulamaları dersinde STEM alanları temelinde bir öğretim tasarımı deneyimi* (Publication No. 542643) [Master dissertation, Bahçeşehir University, Turkey]. CoHE Thesis Center.

Okulu, H. Z. (2019). *STEM eğitimi kapsamında astronomi etkinliklerinin geliştirilmesi ve değerlendirilmesi* (Publication No. 538296) [Doctoral dissertation, Muğla Sıtkı Koçman University, Turkey]. CoHE Thesis Center.

O'leary, Z. (2004). *The essential guide to doing research.* SAGE Publications.

Owen, C. (2007). Design thinking: notes on its nature and use. *Design Research Quarterly*, *2*(1), 16-27.

Özacar, B.H. (2018). *Interdisciplinary STEM education: exploring technology and engineering integration in mathematics and science classes* (Publication No. 515178) [Master dissertation, Yıldız Technical University, Turkey]. CoHE Thesis Center.

Özarslan, Y. (2010). Kişiselleştirilmiş Öğrenme Ortamı Olarak IPTV. *Uluslararası Eğitim Teknolojileri Sempozyumu 2010 (International Educational Technology)*. İstanbul.

Özbaki, Ç. (2016). *Model Yapma Yoluyla Tasarım Düşünme Süreci: Analog ve Dijital Model Karşılaştırması* (Publication No. 445130) [Doctoral dissertation, Istanbul Technical University, Turkey]. CoHE Thesis Center.

Özekin, M. (2006). *İlköğretim 2., 3., 4., 5. ve 6. sınıf öğrencilerinin eğitiminde tasarımcı düşünce eğitim modelinin değerlendirilmesi* (Publication No. 195885) [Master dissertation, Hacettepe University, Turkey]. CoHE Thesis Center.

Pardee, R. L. (1990). *A literature review of selected theories dealing with job satisfaction and motivation*. US Department of Education. https://files.eric.ed.gov/fulltext/ED316767.pdf

P21. (2010). *21st century knowledge and skills in educator preparation*. Retrieved September 13, 2016, from http://www.p21.org/storage/documents /aacte_p21_whitepaper2010.pdf

Plaza, O. (2004). Technology education versus liberal arts education? *The Journal of Technology Studies*, *30*(1), 16-19.

Potvin, A. S. (2018). *Designing for Teacher-Student Relationships: an Investigation into the Emotional and Relational Dimensions of Co-Design* [Doctoral dissertation, University of Colorado, Boulder, USA]. Dissertation Abstracts International. https://pqdtopen.proquest.com/doc/2048235388 .html?FMT=AI

Power, M. (2019, Summer). TEAMWORK by Design. *Educational leadership*, 73-78.

Razzouk, R., & Shute V. (2012). What is design thinking and why is it important? *Review of Educational Research, 82*(3), 330-348.

REDlab (n.d.). Retrieved October 11, 2017, from http://www.stanford.edu/group/redlab/cgi-bin/

Reinking, A. K., & Martin, B. (2018). Strategies, research, and examples for elementary teachers to integrate STEM. *K-12 STEM Education*, *4*(4), 413-419.

Richardson, A. R. (2013). *Design Thinking for Non-Design Communities of Practice* [Master dissertation, The Savannah College of Art and Design, USA]. Retrieved from https://www.academia.edu/33200981/Design_Thinking_for_Non-Design_Communities_of_Practice

Roberts, A. S. (2013). *Preferred instructional design strategies for preparation of pre-service teachers of integrated STEM education* (Publication No. 1464791223) [Doctoral dissertation, Old Dominion University, USA]. ProQuest Dissertations & Theses Global.

Root-Bernstein, R. (2015). Arts and crafts as adjuncts to STEM education to foster creativity in gifted and talented students. *Asia Pacific Education Review*, *16*(1).

Rosen, E. (2009). *The culture of collaboration*. Retrieved November 13, 2019, from https://collaborationblog.typepad.com/collaboration/2009/07/empathy-and-collaboration-whats-the-link.html

Sanders, E. B. -N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, *4*(1), 5-18.

Sarvi, J., Munger, F., & Pillay, H. (2015). *Transitions to K-12 education systems: experiences from five case countries*. The Asian Development Bank. Retrieved October 28, 2016, from https://www.adb.org/sites/default/files/publication/177761/transitions-k12-education.pdf

Schensul, J. J. (2012). Methodology, methods, and tools in qualitative research. In S. D. Lapan, M. T. Quartaroli & F. J. Riemer (Eds.), *Case study research* (pp. 69-103). USA: John Wiley & Sons, Inc.

Schweitzer, J., Groeger, L., & Sobel, L. (2016). The design thinking mindset: an assesment of what we know and what we see in practice. *Journal of Design, Business & Society, 2*(1), 71-94.

School Retool. (n.d.). Retrieved September 06, 2016, from http://schoolretool.org/

Serbes, A. S. (2015). *Bir Tasarımcı Girişiminde 'Design Thinking'in İçkin Olarak Kullanımı* (Publication No. 421063) [Master dissertation, Istanbul Technical University, Turkey]. CoHE Thesis Center.

Shadow a student. (n.d.). Retrieved September 06, 2016, from http://shadowastudent.org/

Shelly, K. (2011). *Sharing design with students in the Midwest*. Cooper Hewitt. Retrieved September 08, 2016, from http://www.cooperhewitt.org/2011/04/14/sharing-design-with-students-in-the-midwest/

Shibley, Jr. I. A. (2006). Interdisciplinary team teaching negotiating pedagogical differences. *College Teaching*, *54*(3), 271-274.

Sibo-Ingrid, H., Celis-David A., G., & Liou, S. (2018). Systems Thinking: a paradigm for advancing technology to enhance humanity. *2018 International Conference on Orange Technologies*. Bali, Indonesia.

Sinop Üniversitesi. (2016, December 23). *FeTeMM-STEM Disiplinler Arası Fen Sinop Üniversitesi* [Video]. You Tube. https://www.youtube.com /watch?v=Y2Ou_Fut9-E

Sobel, L., & Groeger, L. (2012). *Design thinking: exploring opportunities for the design industry and business in Australia* [Research Paper Series 952-2012]. Macquarie Graduate School of Management (MGSM). Retrieved July 26, 2016, from http://ssrn.com/abstract=2194672

Sousa, D., & Pilecki, T. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the arts*. USA: Corwin

STEM Education Policy Statement 2017–2026 (2017). Ireland Department of Education and Skills. Retrieved November 13, 2019, from https://www.education.ie/en/The-Education-System/STEM-Education-Policy/stem-education-policy-statement-2017-2026-.pdf

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, *2*(1), 28-34.

Strobel, J., Wang, J., Weber, N. R., & Dyehouse, M. (2013). The role of authenticity in design-based learning environments: the case of engineering education. *Computers & Education*, 64, 143-152.

Şentürk, F. K. (2017). *FeTeMM etkinliklerinin fen bilimleri dersindeki kavramsal anlama ve bilimsel yaratıcılık üzerindeki etkileri ve öğrenci görüşleri* (Publication No. 483087) [Master dissertation, Muğla Sıtkı Koçman University, Turkey]. CoHE Thesis Center.

Tabar, V. (2018). *Ülkemizde fetemm alanında yapılmış olan çalışmaların içerik analizi* (Publication No. 511714) [Master dissertation, Yüzüncü Yıl University, Turkey]. CoHE Thesis Center.

Taking Design Thinking to Schools. (n.d.). Retrieved September 06, 2016, from https://stanford.edu/dept/SUSE/taking-design/presentations/Taking-design-to-school.pdf

Taşar, M. F. (2001). *A case study of one novice college student's alternative framework and learning of force and motion*. [Doctoral dissertation, The Pennsylvania State University, USA]. Retrieved from https://etda.libraries.psu.edu/catalog/5858

The Co-create handbook (2019). Retrieved January 19, 2020, from http://www.cocreate.training/wp-content/uploads/2019/03/co-design_ handbook_FINAL.pdf

The Field Guide to Human-Centered Design. (2015). Retrieved November 01, 2019, from https://www.designkit. org/resources/1/

Tim, W. K., & Yin, L. C. (2015, December). Embedd “Art” and “Inclusion” into the STEM education. In *Proceedings of the 2015 IEEE International Conference on Teaching, Assessment, and Learning for Engineering* (pp. 242-245). Zhuhai, China: United International College

Topsakal, İ. (2018). *Probleme dayalı STEM eğitiminin öğrencilerin öğrenme iklimlerine, eleştirel düşünme eğilimlerine ve problem çözme becerilerine yönelik algılarına etkisinin araştırılması* (Publication No. 529304) [Master dissertation, Erzincan Binali Yıldırım University, Turkey]. CoHE Thesis Center.

Thousand, J. S., Villa, R. A., & Nevin, A. I. (2006). The many faces of collaborative planning and teaching. *Theory into practice*, *45*(3), 239-248.

The Teachers Guild. (n.d.) Retrieved September 06, 2016, from http://teachersguild.org/about

Thomasian, J. (2011, December). *Building a science, technology, engineering, and math: an update of state actions*. National Governors Association. http://files.eric.ed.gov/fulltext/ED532528.pdf

Thoring, K., & Mueller, R.M. (2011a, October-November). Creating knowledge in design thinking: the relationship of process steps and knowledge types. *IASDR2011, the 4th World Conference on Design Research*. Delft, NL.

Thoring, K., & Müller, R.M. (2011b, September). Understanding design thinking: a process model based on method engineering. *International Conference on Engineering and Product Design Education*. London, UK.

Tran, N. (2017). *Design thinking playbook for change management in K12 schools*. Retrieved November 25, 2019 from https://dschool-old.stanford.edu/sandbox/groups/k12/wiki/ad2ce/attachments/3946e/DESIGN%20THINKING%20PLAYBOOK%20%281%29.pdf?sessionID=8cbdfc6129ceb041dbad2247ffc9d0112fd0ebce

Tschimmel, K. (2012). Design Thinking as an effective toolkit for innovation. *XXIII ISPIM Conference: Action for Innovation: Innovating from Experience*. Barcelona, Spain.

Turkey's Education Vision 2023. (n.d.). Retrieved February 2, 2020, from http://2023vizyonu.meb.gov.tr/doc/2023_VIZYON_ENG.pdf

Türk, N. (2019). *Eğitim fakültelerinin lisans programlarına yönelik fen, teknoloji, mühendislik ve matematik (STEM) öğretim programının tasarlanması, uygulanması ve değerlendirilmesi* (Publication No. 567281) [Doctoral dissertation, Gazi University, Turkey]. CoHE Thesis Center.

Uştu, H. (2019). *İlkokul düzeyinde bütünleşik STEM/STEAM etkinliklerinin uygulanması: sınıf öğretmenleriyle bir eylem araştırması*. (Publication No. 589311) [Doctoral dissertation, Necmettin Erbakan University, Turkey]. CoHE Thesis Center.

Van Boeijen, A., & Daalhuizen, J. (Eds.) (2010). *Delft design guide*. Retrieved July 20, 2017, from https://arl.human.cornell.edu/PAGES_Delft/Delft_Design_Guide.pdf

Van Mechelen, M., Leanen, A., Zaman, B., Willems, B., & Abeele, V.V. (2019). Collaborative design thinking (CoDeT): a co-design approach for high child-to-adult ratios. *International Journal of Human-Computer Studies*, 130, 179–195.

Vande Zande, R. (2007). Design education as community outreach and interdisciplinary study, *Journal for Learning through the Arts*, *3*(1).

Vasquez, J., Sneider, C., & Comer, M. (2013). *STEM lesson essentials, grades 3–8: integrating science, technology, engineering, and mathematics*. Portsmouth, NH: Heinemann.

Vidal, R.V. V. (2006). *Creative and participative problem solving - the art and the science*. Retrieved January 12, 2020, from http://www2.imm.dtu.dk/pubdb/edoc/imm4901.pdf

Vint, T. W. (1996). *Martin Heidegger's Structure of Existence as a Framework for Site Design Thinking* (Publication No. 56748) [Doctoral dissertation, Middle East Technical University, Turkey]. CoHE Thesis Center.

Yakman, G. (2008). STEAM education: an overview of creating a model of integrative education. *Pupils' Attitudes towards Technology (PATT-19) Conference: Research on Technology, Innovation, Design & Engineering Teaching*. Salt Lake City, Utah.

Yamak, H., Bulut, N., & Dündar, S. (2014). 5. Sınıf öğrencilerinin bilimsel süreç becerileri ile fene karşı tutumlarına FETEMM etkinliklerinin etkisi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*. *34*(2), 249-265.

Yıldırım, B. (2016). *7. Sınıf fen bilimleri dersine entegre edilmiş fen, teknoloji, mühendislik, matematik (STEM) uygulamaları ve tam öğrenmenin etkilerinin incelenmesi* (Publication No. 429441) [Doctoral dissertation, Gazi University, Turkey]. CoHE Thesis Center.

Yıldırım, A. & Şimsek, H. (2016). *Sosyal bilimlerde nitel araştırma yöntemleri* (10th Ed.). Ankara: Seçkin Yayınevi.

Yılmaz, A., Gülgün, C., Çetinkaya, M., & Doğanay, K. (2018). Initiatives and new trends towards STEM education in Turkey. *Journal of Education and Training Studies*, *6*(11a).

Waddington, D. (2004). Participant Observation. In C. Cassell & G. Symon (Eds.), *Essential guide to qualitative methods in organizational research* (pp. 154-164). Sage Publications.

Walker III, W. S., Moore, T. J., Guzey, S. S., & Sorge, B. H. (2018). Frameworks to develop integrated STEM curricula. *K-12 STEM Education*, *4*(2), 331-339.

Wallet design exercise worksheet. (n.d.). Retrieved August 01, 2017, from https://dschool-old.stanford.edu/sandbox/groups/designresources/wiki/4dbb2/attachments/d5c91/Wallet%20Facilitators%20Guide2012.pdf?sessionID=573efa71aea50503341224491c862e32f5edc0a9

Wang, H. (2012). *A New era of science education: science teachers' perceptions and classroom practices ofscience, technology, engineering and mathematics (STEM) integration* [Doctoral dissertation, University of Minnesota, USA]. University of Minnesota Digital Conservancy. http://hdl.handle.net/11299/120980

Watson, A. D. (2015). Design thinking for life. *Art Education*, *68*(3), 12-18.

Wrigley, C., & Straker, K. (2015). Design thinking pedagogy: the educational design ladder. *Innovations in Education and Teaching International*. doi:10.1080/14703297.2015. 1108214

Wynn, T., & Harris, J. (2012). Toward a STEM + Arts curriculum: creating the teacher team. *Art Education*, *65*(5), 42-47.

APPENDICES

A. Interview Questions in the Exploratory Research (Turkish and English Translation)

- Sizin için STEM (STEAM / STEM-A) nedir? (Soru okulun STEM anlayışına göre yapılandırıldı.)
- Sizin STEM (STEAM/STEM-A) yaklaşımı ile tanışmanız nasıl oldu? (Soru okulun STEM anlayışına göre yapılandırıldı.)
- Diğer yaklaşımlar (STEAM, STEM ve STEM-A) hakkında ne düşünüyorsunuz? Sizin verdiğiniz eğitim ile aralarında benzerlik veya fark var mı? (Soru okulun STEM anlayışına göre değiştirildi.)
- Okulunuzda nasıl bir STEM (STEAM / STEM-A) eğitimi verilmekte?
  - ➢ STEM eğitimi hangi branşlarda uygulanmakta?
  - ➢ Verilen STEM (STEAM / STEM-A) eğitimi ile MEB müfredatı uyumlu mu?
  - ➢ STEM müfredatı/aktiviteleri nasıl oluşturuluyor? Ne gibi prensipleriniz var?
- Öğretmenler STEM (STEAM / STEM-A) eğitimi vermek için kendileri nasıl bir eğitim aldılar?
  - ➢ Kurum içi STEM (STEAM / STEM-A) eğitimi veriyor musunuz? Evet ise, bu eğitimleri kim veriyor ve içeriği ne oluyor?
  - ➢ Verilen eğitimlerde odak noktanız nedir?
  - ➢ STEM merkezlerinden hiç eğitim aldınız mı?
- STEM (STEAM / STEM-A) eğitimi uygulamalarında hem öğretmenler hem de öğrenciler ne gibi bir zorluklar ile karşılaşıyor?
- Türkiye'de STEM eğitimi uygulamasıyla ilgili sizce ne gibi zorluklarla karşı karşıyayız?
- Tasarımı hiç STEM yaklaşımı çerçevesinde kullandınız mı? Nasıl?

English Translation

- What does STEM (STEAM / STEM-A) mean for you? (This question has been structured according to the STEM approach of the school.)
- How have you first become acquainted with the STEM (STEAM/STEM-A) approach? (This question has been structured according to the STEM approach of the school.)
- What do you think about other approaches (STEAM, STEM, and STEM-A)? Are there any similarities or differences between them and the education you give? (This question has been changed according to the STEM approach of the school.)

- What kind of STEM (STEAM / STEM-A) education is provided in your school?
  - In which courses is STEM education applied?
  - Is the ongoing STEM (STEAM / STEM-A) education compatible with the curriculum of the Ministry of National Education?
  - How is the STEM curriculum/activity created? What kind of principles do you have?
- What kind of training have the teachers received to give STEM (STEAM / STEM-A) education?
  - Are you giving in-house STEM (STEAM / STEM-A) education? If yes, who is providing this education, and what is the content of it?
  - What is your focus point during the education given?
  - Have you ever taken education from the STEM centers?
- What kind of difficulties do both the teachers and the students encounter during the implementation of STEM (STEAM / STEM-A) education?
- According to you, what kind of difficulties do we face within Turkey about the implementation of STEM education?
- Have you ever made use of design within the scope of the STEM approach? If yes, how?

B. Focus Group Questions for Teachers after the Pilot Workshop (Turkish and English Translation)

- Çalıştay öncesi ve sonrasına dair düşüncelerinizden (olumlu veya olumsuz) bahsedebilir misiniz?
- Workshop sizin için nasıl geçti?
- Sizin için zor /kolay kısım neydi?
- En şaşırtıcı kısım neydi?
- Bu çalıştayda uygulanan "tasarım odaklı düşünme" metoduna dair düşüncelerinizi benimle paylaşır mısınız?
- "Tasarım odaklı düşünme" metodunun sizce STEM yaklaşımını öğretmeye yönelik bir katkısı var mı? Evet ise, nelerdir?
- Sürecin bir tasarımcı tarafından yönetilmesi hakkında ne düşünüyorsunuz?
- STEM aktivitesini "tasarım odaklı düşünme" metodu olmadan ve/veya süreç bir tasarımcı tarafından yönetilmeden tasarlayabilir miydiniz?
- İleriki aşamalarda kendiniz takım halinde STEM aktivitesi tasarlamak isterseniz süreci yönetmesi adına bir yürütücü/uzmana ihtiyacınız duyar mısınız? Cevabınız evet ise, bu kişi ya da kişilerin hangi meslek grubundan olmasını tercih ederdiniz? (Tasarımcı, eğitmen, mühendis, vb.) Neden?
- Bu çalıştaya ve/veya orada kullanılan metoda dair önerileriniz var mı? Evet, ise benimle paylaşır mısınız?

English Translation

- Can you please tell your opinions about the period before and after the workshop (as positively or negatively)?
- How was the workshop for you?
- What was the easiest/most difficult part for you?
- What was the most remarkable part?
- Can you please share your opinions with me about the "Design Thinking" method, which was applied in this workshop?
- Does the "Design Thinking" method contribute to the teaching of the STEM approach? If yes, what are these contributions?
- What do you think about a designer's leading the process?
- Would you be able to design the STEM activity without the "Design Thinking" method and/or without a designer's leading the process?
- If you want to design a STEM activity as a team in the future stages, will you need a coordinator/an expert to conduct the process? If yes, which occupational group would you prefer this person or these people to belong to? (A designer, an educator, an engineer, etc.) Why?

C. Templates in the Pilot Study

Interview Template

Design Thinking for Leading and Learning 1

Gorusme Formu Hazirlama & Uygulama

Kullanici (Genel ayrıntılar, ör. "18 yaşındaki kadın"): ______________________

Tasarım projesinin konusu (örn: sabah nasil hazırlanıyor): ______________________

1. **10-15 röportaj sorusu hazirlamak icin beyin fırtınası yapın:**

2. **Yukarıdaki sorulardan en uygun 4-5 açık uçlu soruyu secin.**

3. **Gorusmenize ait notları aşağıya kaydedin.**

Gorusme Sorusu	Cevap	Gözlemler (Yüz ifadeleri, ses tonu, beden dili, vb.)
1. Sabahın en güzel yanı ne? Yanıtla ilgili devam sorusu: Bugün ne giymeniz gerektiğini nasil seçtiniz?	Sabahın en güzel yanı, ne giyeceğime karar vermek. Devam sorusu cevabi: Bu sabah biraz zordu çünkü gerçekten bu yeni kazağı giymek istedim.	Giysilerini nasil sectigini anlatma konusunda cok heyecanli. Kazagin kirli olduğunu fark ettiğinde duyguları dramatik bir şekilde değişmesi.
2.		
3.		
4.		
5.		

TEACHING SYSTEMS LAB

Brainstorming Template

Kullanici: ____

Kullanici: Problemi: ____

1. **Beyin fırtınasindan sonra, çözüm fikirlerinden birkaçını ve fikir hakkinda neyi sevdiğinizi belirtin.**

Çözüm fikri	Bu fikri niçin sevdiğiniz üzerine düşünceler
1- Iş yerinde kahvalti hazirlamak icin kahvalti istasyonu kurmak. 2- Kahvaltı, tablet formundadır ve ısıtılması gerekmez.	1- Belki doğrudan bağlı değil, ancak çözüm icin yararlı olabilir. 2- Fütüristik fikir yararlı olabilir.

2. **Beyin fırtınası fikirlerinizi farklı kategorilere ayırın.**

Dijital: • Çantasında mini mikrodalga fırın.
Yeni deneyim: • Kahvaltı istasyonu- iş yerine gelince yemegini hazırlar.

POV Template

Bakış açınızı belirleyin.

Problem Cümlesi:

Bulguları Yakalayın.

Amaçlar ve İhtiyaçlar:

Analizler: Kullanıcızın hisleri ve motivasyonları hakkında yeni öğrenmeler. Kullanıcızın belki göremediği ama senin onun deneyimlerine dair gördüğün şeyler nedir?
(Duyduklarından kendi çıkarımlarını yap)

Bakış Açınızı Oluşturun.

____

... ihtiyacı var ____________________
kullanıcının ihtiyacı

Çünkü (veya "Fakat..." veya "Şaşırtıcı olarak...")
(birini daire içine alın)

____

____
Analiz

D. Interview Questions for Teachers before the Main Workshop I (Turkish and English Translation)

"Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma" adlı araştırma kapsamında, çalıştay öncesi öğretmenler ile yapılacak görüşmeye ait sorular aşağıdaki gibidir.

- Bana kendinizden bahseder misiniz?
    - Yaşınızı sorabilir miyim?
    - Hangi üniversiteden mezun oldunuz?
- Ne kadar süredir öğretmenlik yapıyorsunuz?
    - Ne kadar süredir bu okulda öğretmenlik yapıyorsunuz?
- Derslerinizi genellikle nasıl işlersiniz?
    - Derslerinizi işlerken akıllı defter, test bankası veya okuma kitaplarından faydalanıyor musunuz? Nasıl?
- Daha önce hiç disiplinlerarası bir ders işlediniz mi?
    - Bu derse nasıl hazırlandınız?
    - Bu dersi nerede gerçekleştirdiniz?
    - Dersi nasıl işlediğinizi bana anlatır mısınız? Süreç nasıl geçti?
    - Öğrencilerin bu derse yaklaşımı ne oldu?
- STEM yaklaşımı hakkında ne düşünüyorsunuz?
- Daha önce STEM yaklaşımını derslerinizde uyguladınız mı?
    - Bu derse nasıl hazırlandınız?
    - Bu dersi nerede gerçekleştirdiniz?
    - Dersi nasıl işlediğinizi bana anlatır mısınız? Süreç nasıl geçti?
    - Öğrencilerin bu derse yaklaşımı ne oldu?
- Siz hangi disiplinler ile birlikte ortak bir STEM aktivitesi tasarlamak isterdiniz?
    - Özellikle size yakın olan veya beraber çalışmak istediğiniz bir alan var mı?
    - Birlikte çalışamam veya konularımı bağdaştıramam dediğiniz bir disiplin var mı? Evet, ise nedir?
- Dersine girdiğiniz 5. sınıf öğrencileri hakkında ne düşünüyorsunuz? (Akademik ve Sosyal anlamda)
    - Bu öğrencilerin dersinize olan ilgisi nasıl?
    - Sınıfa yeni katılan öğrenciler var mı? Bu öğrencilerin sınıfla olan uyumu nasıl?
- Bu çalıştaydan ne gibi bir beklentiniz var?
- Çalıştay için fen ve matematik disiplini ile uyumlu olabilecek, kendi alanınıza ait ve bu dönemki müfredatınızda bulunan hangi konuları bana önerebilirsiniz? (fen ve matematik disiplini dışındaki alan öğretmenler için)
    - Bu konuyu hangi dersler ile ve nasıl ilişkilendirebilirsiniz?

- Çalıştay için sizin alanınız dışındaki diğer disiplinler ile uyumlu olabilecek ve bu dönemki müfredatınızda bulunan hangi konuları bana önerebilirsiniz? (fen ve matematik alanındaki öğretmenler için)
    - ➢ Bu konuyu hangi dersler ile ve nasıl ilişkilendirebilirsiniz?
- Yeni bir aktiviteyi ders planınız içine entegre etmek isterseniz, kaç hafta önceden bunun planlamasını ve hazırlığını yapmanız gerekmekte?

English Translation

Below are the questions belonging to the interview, which will be made with the teachers before the workshop to be held within the scope of the research titled “Designing STEM activities by applying Design Thinking Approach”.

- Can you please tell me about yourself?
    - ➢ Can I ask how old you are?
    - ➢ Which university did you graduate from?
- How long have you been working as a teacher?
    - ➢ How long have you been working as a teacher in this school?
- How do you usually teach your lessons?
    - ➢ Do you benefit from interactive notebooks, question banks, or reading books while you are teaching your lessons? How?
- Have you ever conducted an interdisciplinary lesson before?
    - ➢ How did you get prepared for that lesson?
    - ➢ Where did you carry out that lesson?
    - ➢ Can you please tell me how you taught that lesson? How was the process?
    - ➢ How did the students approach to that lesson?
- What do you think about the STEM approach?
- Have you ever applied the STEM approach to your lessons before?
    - ➢ How did you get prepared for that lesson?
    - ➢ Where did you carry out that lesson?
    - ➢ Can you please tell me how you taught that lesson? How was the process?
    - ➢ How did the students approach to that lesson?
- With which disciplines would you prefer to design a cooperative STEM activity?
    - ➢ Are there any fields that you especially feel close to or you want to study together?
    - ➢ Are there any disciplines which you think as you cannot study together or you can not relate your subjects to? If yes, what is it?
- What do you think about the 5-grade students whom you teach? (As academically and socially)
    - ➢ How are the interests of these students for your lesson?
    - ➢ Are there any newcomers to the class? What about their adaptation to the class?

- What do you expect from this workshop?
- As belonging to your field, existing in this term’s curriculum, and being compatible with science and math disciplines, which subjects can you recommend me for this workshop? (for the teachers out of the fields of science and math disciplines)
    - To which lessons can you relate this subject, and how?
- As being compatible with the other disciplines out of your field and existing in this term’s curriculum, which subjects can you recommend me for this workshop? (for science and math teachers)
    - To which lessons can you relate this subject, and how?
- If you want to integrate a new activity into your lesson plan, how many weeks ago should you make a plan and preparation for this?

E. Focus Group Questions for Teachers after the Main Workshop I (Turkish and English Translation)

“Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma” adlı araştırma kapsamında düzenlenen çalıştaylar sonrası, öğretmenler ile yapılacak odak grup görüşmesine ait sorular aşağıdaki gibidir.

- Çalıştay öncesine dair düşüncelerinizi benimle paylaşır mısınız?
- Çalıştay sırasında nasıl bir süreç yaşadığınızı bana anlatabilir misiniz?
- Bu çalışmanın en zor tarafının size göre ne olduğunu bana anlatır mısınız?
- Bu çalışmanın en kolay tarafının size göre ne olduğunu benimle paylaşır mısınız?
- Bu çalıştayda uygulanan “tasarım odaklı düşünme” metoduna dair düşüncelerinizi benimle paylaşır mısınız?
  - Sunulan yöntemin organizasyonu/sıralaması nasıldı?
  - Bu yöntemi öğreten kişi eğer siz olsaydınız, bu metotla ilgili nasıl bir yol izlerdiniz?
- “Tasarım odaklı düşünme” metodunun sizce STEM yaklaşımını öğretmeye yönelik bir katkısı var mı? Evet ise, nelerdir?
- Sürecin bir tasarımcı tarafından yönetilmesi hakkında ne düşünüyorsunuz?
- İleride STEM aktivitesi tasarlamak isterseniz, süreci yönetmesi adına bir yürütücü veya uzmana ihtiyaç duyar mısınız? Evet, ise bu kişi ya da kişilerin hangi meslek grubundan olmasını tercih edersiniz? (Tasarımcı, eğitmen, mühendis, vb.) Açıklayabilir misiniz?
- Bu çalıştaya ve/veya orada kullanılan metoda dair önerileriniz var mı? Evet, ise benimle paylaşır mısınız?
- Eklemek istediğiniz başka bir şey var mı?

English Translation

Below are the questions belonging to the focus group interview, which will be made with the teachers after the workshops to be held within the scope of the research titled “Designing STEM activities by applying Design Thinking Approach”.

- Can you please share your opinions about the period before the workshop?
- Can you please tell me what kind of process did you experience during the workshop?
- Can you please tell me the most difficult aspect of this study, according to you?
- Can you please tell me the easiest aspect of this study, according to you?

- Can you please share your opinions with me about the “Design Thinking” method, which was applied in this workshop?
    - How was the organization/arrangement of the method being presented?
    - If you were the person to teach this method, which way would you follow for this method?
- Do you think that the “Design Thinking” method contributes to the teaching of the STEM approach or not? If yes, what are these contributions?
- What do you think about a designer’s leading the process?
- If you want to design a STEM activity later, do you need a coordinator/an expert to conduct the process? If yes, which occupational group would you prefer this person or these people to belong to? (A designer, an educator, an engineer, etc.) Can you explain it?
- Do you have any further suggestions for this workshop and/or the method used there? If yes, can you please share them with me?
- Do you want to add something different?

F. Interview Questions for Teachers after the Activity (Turkish and English Translation)

"Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma" adlı araştırma kapsamında, tasarlanan STEM aktivitelerinin uygulanması sonrasında, öğretmenler ile yapılacak görüşmeye ait sorular aşağıdaki gibidir.

- Bu aktivitede neyi sevdiğinizi benimle paylaşır mısınız?
- Bu aktivitede neyi sevmediğinizi bana açıklar mısınız?
- En çok ne zaman eğlendiniz?
- Bu çalışmanın en zor tarafının size göre ne olduğunu bana anlatır mısınız?
- Bu çalışmanın en kolay tarafının size göre ne olduğunu benimle paylaşır mısınız?
- Bu aktivitede değişiklik yapmak ister miydiniz? Evet ise, açıklayabilir misiniz?
- Aktiviteye dair olan açıklamalar ve süreç öğrenciler açısından sizce anlaşılır mıydı?
- Aktiviteye dair aklınızda sorular var mı? Açıklayabilir misiniz?
- Ne hakkında daha fazla bilgi edinmek isterdiniz?

English Translation

Below are the questions belonging to the interview, which will be made with the teachers after implementing the STEM activities designed within the scope of the research titled "Designing STEM activities by applying Design Thinking Approach".

- Can you please tell me what you have liked most about this activity?
- Can you explain what you have disliked in this activity?
- When did you enjoy most?
- Can you tell me what the most difficult section of this study was, according to you?
- Can you share what the easiest section of this study was, according to you?
- Would you like to make a change in this activity? If yes, can you explain it?
- Were the explanations and the process of the activity clear enough for the students?
- Do you have any further questions about the activity? Can you explain them?
- What would you like to learn about more?

G. Interview Questions for Students after the Activity (Turkish and English Translation)

“Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma” adlı araştırma kapsamında, tasarlanan STEM aktivitelerinin uygulanması sonrasında, öğrenciler ile yapılacak olan odak grup görüşmesine ait sorular aşağıdaki gibidir.

- Bu aktivitede neyi sevdiğinizi benimle paylaşır mısınız?
- Bu aktivitede neyi sevmediğinizi bana açıklar mısınız?
- Bu projedeki en eğlenceli kısım sizin için neydi? Açıklar mısınız?
- Bu çalışmanın en zor tarafının size göre ne olduğunu bana anlatır mısınız?
- Bu çalışmanın en kolay tarafının size göre ne olduğunu benimle paylaşır mısınız?
- Bu projeden ne öğrendiğinizi benimle paylaşır mısınız?
- Aktiviteye dair aklınızda sorular var mı? Açıklayabilir misiniz?
- Bu aktivitede değişiklik yapmak ister miydiniz? Evet ise, açıklayabilir misiniz?
- Ne hakkında daha fazla bilgi edinmek isterdiniz?

English Translation

Below are the questions belonging to the interview, which will be made with the students after implementing the STEM activities designed within the scope of the research titled “Designing STEM activities by applying Design Thinking Approach”.

- Can you please tell me what you have liked about this activity?
- Can you please explain what you have disliked in this activity?
- What was the most entertaining section for you in this section? Can you please explain?
- Can you tell me what the most difficult section of this study was, according to you?
- Can you explain what the easiest section of this study was, according to you?
- Can you share with me what you have learned from this project?
- Do you have any further questions about the activity? Can you explain them?
- Would you like to make a change in this activity? If yes, can you explain it?
- What would you like to learn about more?

H. Focus Group Questions for Teachers after the Main Workshop II (Turkish and English Translation)

"Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma" adlı araştırma kapsamında, aynı okulda yapılacak olan 2. çalıştay sonrası, öğretmenlere sorulacak odak grup görüşmesine ait sorular aşağıdaki gibidir.

- Bu çalıştay ile ilgili izlenimleriniz nelerdir? Ne gibi bir beklentiniz vardı? Çalıştay beklediğiniz gibi geçti mi?
  - ➢ Geçen dönem "tasarım odaklı düşünme" metodu ve STEM ile ilk kez tanışmıştınız. Bir karşılaştırma yaparsanız, bugünkü çalıştay geçen döneme kıyasla nasıl geçti?
  - ➢ Yeni 1 etkinlik tasarlarken kendinizi nasıl hissettiniz? Bunu 2. kez yapıyor olmak sizde neyi değiştirdi?
  - ➢ Aktiviteyi tasarlarken neleri dikkate aldınız? Geçmişte sahip olduğunuz deneyimler size yardımcı oldu mu? Evet ise, nasıl?
  - ➢ Sınıfınızı 1 dönemdir tanıyor olmanız ve geçen dönem yapılan çalışmalar, ikinci çalıştay da size ne gibi bir katkı sağladı?
  - ➢ Sizce, şimdiye kadar tasarladığınız aktiviteleri değiştirmeden, aynı düzeyde farklı bir sınıfta uygulamanız mümkün mü? Neden?
  - ➢ Size göre yeni tasarlanan bir STEM aktivitesi ilk dönem mi yoksa 2. dönem mi uygulanmalı? Neden?
- Sürecin tekrardan bir tasarımcı tarafından yönetilmesi hakkında ne düşünüyorsunuz? Bu çalıştay'ın yönetimi ile ilk çalıştay'ın yönetimini karşılaştırsanız bana neler söyleyebilirsiniz?
  - ➢ Siz de kendi başınıza bu süreci yönetebilir miydiniz? Evet ise, nasıl bir yol izlerdiniz?
- "Tasarım odaklı düşünme" metodunun 2. çalıştay da sizce STEM aktivitesi tasarlatmaya yönelik bir katkısı oldu mu? Nasıl?
  - ➢ Hiç böyle bir metot kullanılmasa, aktivite tasarlamakta zorlanır mıydınız? Evet/hayır ise, neden?
  - ➢ Bu çalıştay da ki "tasarım odaklı düşünme" metodunun uygulama basamakları hakkında ne düşünüyorsunuz?
  - ➢ Sunulan yöntemin organizasyonu/sıralaması nasıldı?
  - ➢ Bu yöntemi öğreten kişi siz olsaydınız, 2. çalıştay da bu metotla ilgili nasıl bir yol izlerdiniz?
  - ➢ Sizce "tasarım odaklı düşünme" metodu aktivite tasarımında neyi / hangi aşamaları kolaylaştırdı?
  - ➢ Sadece 2 disiplin olarak bir aktivite tasarlasaydınız, "tasarım odaklı düşünme" metodunu kullanma ihtiyacı duyar mıydınız?
  - ➢ Ben hepinizi bir araya getirtip, bütün gününüzün bir arada geçmesini sağlasaydım ve böyle bir aktivite tasarlamanızı

isteseydim, ne yapardınız? Nasıl bir yol izlerdiniz ve neyi farklı yapardınız?

- Bu çalıştay öncesinde diğer branş öğretmenleriyle fikir alışverişi yapıyor muydunuz? Evet ise, hangi durumlar için bir araya geliyordunuz? Hayır ise, neden yapmıyor dunuz?
  - ➢ Farklı disiplinlerden öğretmenler ve bir tasarımcı ile tekrar beraber çalışmak sizin için nasıl bir deneyimdi? Bunu 2. kez yapıyor olmanın geçen dönemden bir farkı oldu mu?
  - ➢ Bu sizin öğrenme sürecinize ne anlamda katkı sağladı?
  - ➢ Disiplinlerarası çalışırken hangi noktalarda birleşebildiniz veya hangi noktalarda fikir ayrılığı yaşadınız? Bu sizin aktivite tasarlama ve karar verme sürecinize olumlu veya olumsuz anlamda ne kattı?
- Tasarım siz –eğitimcilerin- kullandığı bir kavram mıdır? Sizde bu kavramın bir karşılığı var mıdır? Evet ise, siz tasarım kavramını ne anlamda kullanıyorsunuz?
  - ➢ Sizin aklınızda ki tasarım kavramı ile benim size gösterdiğim tasarım kavramı (tasarım odaklı düşünme metodu) birbiriyle örtüştü mü? Arasında ne gibi benzerlik ya da farklılıklar var?
  - ➢ Bu çalıştaylar sonrasında tasarım kavramına bakış açınız ve bunun kullanımı değişti mi?
  - ➢ Sizin profesyonel hayatınıza tasarım veya tasarımcı bir katkı sağladı mı? Nasıl?
  - ➢ Kendi (mesleki veya kişisel) değer yargılarınız ile diğer disiplinlerden olan öğretmenlerin ve tasarımcının değer yargılarını karşılaştırmanızı istesem, bana neler söyleyebilirsiniz?
  - ➢ Benim bu çalıştaydaki rolümü nasıl tanımlarsınız?
  - ➢ Kendinizi bu iki çalıştay da bir eğitimci gibi mi, bir tasarımcı gibi mi, yoksa her ikisinin rolüne sahip biri gibi mi hissetiniz? Neden?
  - ➢ Kendinizi yaratıcı buluyor musunuz? Aldığınız eğitimin yaratıcılığınıza bir katkısı oldu mu? Nasıl?
- Tasarladığımız etkinliklerde, sizin önemsediğiniz veya üzerinde durduğunuz noktalar vardı. Sizin beklentileriniz ile öğrencilerinizin beklentileri birbiriyle örtüştü mü? Evet/hayır ise, neden?
  - ➢ Sizce öğrencileriniz STEM aktivitelerinde neyin olmasına önem vermekteler? Bu durum, sizin isteklerinizle uyumlu mu, yoksa çatışıyor mu?
- Bu çalıştay sonrasında bir takım şeyleri daha farklı yapacağınızı düşünüyor musunuz?
- Ben bir daha ki dönem sizinle çalışmayacağım. İleride bu çalışmadan öğrendiğiniz herhangi bir şeyi kullanmayı hiç düşünüyor musunuz? Evet ise, nedir?
  - ➢ Geleceğe dair aklınızda yapmak istediğiniz bir aktivite var mı? Bunu nasıl ve kim ile yapmayı düşünüyorsunuz?

English Translation

Below are the questions belonging to the focus group interview, which will be made with the teachers after the second workshop to be conducted in the same school within the scope of the research titled “Designing STEM activities by applying Design Thinking Approach”.

- What is your impression of this workshop? What were you expecting? Did the workshop go on as you expected?
  - In the previous term, you first met the “Design Thinking” method and STEM. If you make a comparison, how did this workshop run in comparison with the previous term’s?
  - How did you feel yourself while designing a new activity? What has changed for you because you did this for the second time?
  - What did you pay regard to while designing the activity? Did your previous experiences help you with doing it? If yes, how?
  - How did your knowing your class for one-term-long and the studies conducted in the previous term contribute to you during this second workshop?
  - According to you, is it possible to implement the activities you have designed till now in a different class within the same grade without any change? Why?
  - According to you, should a newly designed STEM activity be implemented in the first term or the second term? Why?
- What do you think about the process’ being conducted again by a designer? If you make a comparison between the conduction of this workshop and the first workshop, what can you tell me about it?
  - Do you think that you would be able to conduct this process on your own? If yes, what kind of way would you follow?
- Do you think that the “Design Thinking” method contributed to the designation of STEM activity in the second workshop? How?
  - If this kind of method were not used, would you have difficulty in designing an activity? If yes/no, why?
  - What do you think about the stages of the “Design Thinking” method in this workshop?
  - How was the organization/arrangement of the method being presented?
  - If you were the person to teach this method, what kind of way would you follow for this method in the second workshop?
  - According to you, which stages/what did the “Design Thinking” method make easier in activity design?
  - If you designed an activity only with two disciplines, would you need to use the “Design Thinking” method?
  - If I made all of you gather and spend your whole day all together and asked you to design such an activity, what would you do? What kind of way would you follow, and what would you do differently?

- Were you exchanging ideas with the other branch teachers before this workshop? If yes, for which situations were you gathering? If no, why were not you doing that?
    - What kind of experience was working together with the teachers from different disciplines and a designer again? Did your doing this for the second time differ from the one you did in the previous term's workshop?
    - In what way did this contribute to your learning process?
    - While you are working in an interdisciplinary way, at which points did you agree or disagree? What did this contribute to your activity design and decision-making process positively or negatively?
- Is "Design" a concept which you -educators- use? Do you have an equivalent term for this concept? If yes, in what sense do you use the design concept?
    - Did the design concept in your mind match up with the one (design thinking method) which I introduced you? What kind of differences or similarities are there between them?
    - Has your point of view for the design concept and its use changed after this workshop?
    - Has a design or a designer ever contributed to your professional life? If yes, how?
    - What can you tell me if I ask you to compare your value judgments (professional or personal ones) with the value judgments of the designer and the teachers from other disciplines?
    - How can you describe my role in this workshop?
    - Did you feel yourself like an educator or a designer in these two workshops or feel like someone having the role of both of them? Why?
    - Do you find yourself creative? Has the training you received contributed to your creativity? How?
- In the activities we designed, there were some points that you attached importance to or underlined. Did your expectations match up with the students' expectations? If yes/no, why?
    - According to you, what do your students give importance to in STEM activities? Is this situation compatible with your demands, or does it conflict with them?
- Do you think that you will do many things more differently after this workshop?
- I will not be working with you next term. Have you ever been thinking of using anything you have learned from this workshop in the future? If yes, what is it?
    - Do you have any activity that you want to do in the future in your mind? In what way and with whom do you imagine to do this?

İ. Focus Group Questions for Teachers after the Activity (Turkish and English Translation)

“Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma” adlı araştırma kapsamında tasarlanan STEM aktivitelerinin uygulanması sonrasında, öğretmenler ile yapılacak bireysel görüşmeye / odak grup görüşmesine ait sorular aşağıdaki gibidir.

- Neden bu aktiviteyi tasarladınız?
  - Sizin bu aktiviteye nasıl bir katkınız oldu? Aktivite öncesinde bir araya gelip aktivite hakkında konuştunuz mu?
  - Aktiviteyi tasarlarken neleri dikkate aldınız?
  - Bu aktivitenin uygulanmasında kolay / zor geçen taraflar nedir?
  - Sizce bu aktivite yaratıcı mıydı? Evet ise, ne açıdan?
  - Bu aktivitede daha az disiplin olmasını ister miydiniz? Evet/hayır ise, neden?
- Aktivite bitiminde neler hissettiniz?
  - Aktiviteniz planladığınız şekilde ilerledi mi? Bu aktivite de doğru / yanlış giden şeyler nedir?
  - Aktiviteye dair olan açıklamalar ve süreç öğrenciler açısından sizce anlaşılır mıydı?
  - Uygulanan aktivite sonucunda, çocukların başarısında veya algısında bir farklılık / değişiklik oldu mu?
- Tasarladığınız STEM aktivitesine baktığınızda, size ve öğrencilere göre aktivitenin olumlu veya olumsuz tarafları nelerdir?
  - Sizce öğrencilerin ilgisini çekti mi? Öğrencileriniz bu aktivite hakkında sizce ne düşünüyor? (Aktiviteyi sevdiler mi /sevmediler mi?)
  - Aktiviteye dair aklınıza takılan sorular var mı? Nelerdir? (İçerik, işleyiş açısından)
  - Bu aktivite de değişiklik yapmak ister miydiniz? Nasıl?
- Öğrencilerinize öğretmek istediğiniz bilgileri öğretebildiniz mi? Bunu neye dayanarak söylüyorsunuz?
  - Öğrencileriniz planlamadığınız başka bilgi ya da becerileri kazanmış olabilirler mi?
- Sizin bu çalıştay da belirlediğiniz hedef kitle kimdi?
  - Bu aktivite hedeflenen öğrenci kitlesi için uygun muydu? Aktivite sonunda belirlediğiniz hedef kitleye ulaşabildiniz mi?
  - Sizin için başarı ne demek?
  - Aktivite sırasında belirlediğiniz başarı kriterlerine ulaşamayan öğrenci
    oldu mu? Neden?

- Tasarladığımız etkinliklerde sizin önemsediğiniz veya üzerinde durduğunuz noktalar vardı. Sizin beklentileriniz ile öğrencilerinizin beklentileri birbiriyle örtüştü mü? Neden?
    - ➢ Sizce öğrencileriniz STEM aktivitelerinde neyin olmasına önem vermekteler? Bu durum sizin isteklerinizle uyumlu mu yoksa çatışıyor mu?
- Farklı disiplinler ile beraber ders işleme (Eğer varsa) hakkında ne düşünüyorsunuz? Sizin için nasıl bir deneyimdi?
    - ➢ Disiplinlerarası ders anlatırken hangi noktalarda birleşebildiniz veya hangi noktalarda fikir ayrılığı yaşadınız?
- Daha önce hiç konularımı bağdaştıramam veya birlikte çalışamam dediğiniz farklı bir ders var mıydı? Evet ise, hangi derslerdi?
    - ➢ Bu konu hakkında şu anki düşünceleriniz nedir?
    - ➢ Sizin için Matematik ve Fen bilgisi dersi ne ifade ediyor?
    - ➢ Sizin için Matematik ve Fen bilgisi dışındaki dersler (Sosyal bilgiler, İngilizce, Görsel sanatlar, Türkçe, vs.) ne ifade ediyor?
    - ➢ Sizce dersler arasında bir hiyerarşi var mı? Neden?
- Aktiviteleri uyguladıktan sonra, bu çalıştaya ve/veya orada kullanılan metoda (tasarım odaklı düşünme) dair şu anda neler düşünüyorsunuz?
    - ➢ Çalıştay ve uygulanan metot için önerileriniz var mı?
    - ➢ "Tasarım odaklı düşünme" metodunun ve bir tasarımcının sizce STEM yaklaşımını öğretmeye yönelik bir katkısı oldu mu? Evet ise, nelerdir?
    - ➢ Sizin aklınızda ki tasarım kavramı ile benim size gösterdiğim tasarım kavramı (tasarım odaklı düşünme metodu) birbiriyle örtüştü mü? Arasında ne gibi benzerlik ya da farklılıklar var?
    - ➢ Bu çalıştay sonrasında tasarım kavramına bakış açınız ve bunun kullanımı değişti mi?
    - ➢ Sizin profesyonel hayatınıza tasarım veya tasarımcı bir katkı sağladı mı? Evet ise, nasıl?
    - ➢ Kendinizi yaratıcı buluyor musunuz? Aldığınız eğitimin yaratıcılığınıza bir katkısı oldu mu? Nasıl?
- Bu çalışma sonrasında bir takım şeyleri daha farklı yapacağınızı düşünüyor musunuz?
    - ➢ Aktivitenin, işlenen disiplinlerarası derslerin (Eğer varsa) ve çalıştay da beraber çalışmanızın size mesleki veya kişisel anlamda nasıl bir etkisi oldu?
- İleride bu çalışmadan öğrendiğiniz herhangi bir şeyi kullanmayı hiç düşünüyor musunuz? Evet ise, nedir?
    - ➢ Geleceğe dair aklınızda yapmak istediğiniz bir aktivite var mı? Bunu nasıl ve kim ile yapmayı düşünüyorsunuz?
    - ➢ Eğer bir aktivite tasarlamayı düşünmüyorsanız, bunun sebebi nedir?
    - ➢ Size göre yeni tasarlanan bir STEM aktivitesi ilk dönem mi yoksa 2. dönem mi uygulanmalı? Neden?

English Translation

Below are the questions belonging to the individual / the focus group interview, which will be made with the teachers after implementing the STEM activities designed within the scope of the research titled “Designing STEM activities by applying Design Thinking Approach”.

- Why did you design this activity?
  - How did you contribute to this activity? Did you talk about the activity by getting together before the activity?
  - What did you pay attention to while you were designing the activity?
  - What were the easy/difficult parts of implementing this activity?
  - Do you think that this activity was creative? If yes, from what aspect?
  - Would you like that there would be less discipline in this activity? If yes/no, why?
- What did you feel when the activity finished?
  - Did the activity go on as you planned? What are the correct/wrong things in this activity?
  - Do you think that the explanations and the process of the activity were clear enough for the students?
  - Was there a difference/change in the success or perception of the students as a result of the activity implemented?
- When you look at the STEM activity that you designed, what are the positive or negative aspects of the activity, according to you and the students?
  - Did this activity arouse the students’ interests, in your opinion? What do your students think about this activity, according to you? (Did they like the activity or not?)
  - Are there any questions that stick in your mind? What are they? (In terms of content and process)
  - Would you like to make any changes to this activity? If yes, how?
- Were you able to teach your students the information you wish for? How can you claim this?
  - Is it possible that the students might have gained other information or skills which you did not plan before?
- What was the target group that you defined in this workshop?
  - Was this activity suitable for the target student group? Were you able to reach the defined target group at the end of the activity?
  - What does “Success” mean to you?
  - Were there any students who failed in obtaining the criteria of success that you defined during the activity? Why?
- In the activities you designed, there were some points that you attached importance to or underlined. Did your expectations match up with the students’ expectations? Why?

    - What do you think your students care about what STEM activities include? Is this situation compatible with your demands, or does it conflict with them?
- What do you think about teaching a lesson together with different disciplines (if possible)? How an experience was it for you?
    - While you are teaching your lesson in an interdisciplinary way, at which points did you agree or disagree?
- Has there ever been a different lesson before which you thought as you could not relate your subjects to or you could not study together? If yes, which lessons were they?
    - What are your opinions about this topic now?
    - What do math and science lessons mean for you?
    - What do the lessons out of math and science mean for you? (Social studies, English, Visual arts, Turkish, etc.)
    - Do you think that there is a hierarchy among lessons? If yes, why?
- After implementing the activities, currently, what do you think about this workshop and/or the method (design thinking) which was used there?
    - Do you have any suggestions for the workshop and the method applied?
    - Do you think that the "Design Thinking" and a designer have contributed to teaching the STEM approach? If yes, what are these contributions?
    - Did the design concept in your mind match up with the one (design thinking method) which I introduced you? What kind of differences or similarities are there between them?
    - Has your point of view for the design concept and its use changed after this workshop?
    - Has a design or a designer ever contributed to your professional life? If yes, how?
    - Do you find yourself creative? Has the training you received contributed to your creativity? How?
- Do you think that you will do many things more differently after this study?
    - How did the activity, the interdisciplinary lessons conducted (if any), and your collaboration in the workshop affect you in a professional and individual sense?
- Have you ever been thinking of using anything you have learned from this workshop in the future? If yes, what is it?
    - Do you have any activity that you want to do in the future in your mind? In what way and with whom do you imagine to do this?
    - If you are not planning to design activity, what is the reason for this?
    - According to you, should a newly designed STEM activity be implemented in the first term or the second term? Why?

J. Interview Questions for Students after the Activity (Turkish and English Translation)

"Tasarım Yaklaşımını Kullanarak STEM Aktiviteleri Oluşturma" adlı araştırma kapsamında tasarlanan STEM aktivitelerinin uygulanması sonrasında öğrenciler ile yapılacak olan odak grup görüşmesine ait sorular aşağıdaki gibidir.

- Bugünkü aktiviteyi nasıl buldunuz?
    - Daha önce de sizinle aktivite yaptık. Bir karşılaştırma yaparsanız bu aktivite, daha önceki yaptıklarınıza göre nasıl geçti? (Eğer ilk defa yapılmıyorsa)

      -Zor/kolay tarafları açısından.-
    - Aktivitedeki tema hakkında ne düşünüyorsunuz? Daha önceden yaptığınız aktivitedeki tema ile (Eğer ilk defa yapılmıyorsa) şimdikini karşılaştırabilir misiniz?
    - Bu aktivite de sıkıldığınız ya da eğlendiğiniz bir zaman oldu mu? Evet ise, neden?
    - Bu aktivitenin en sevdiğiniz tarafı neydi?
    - Grup çalışmasını (Eğer varsa) nasıl buldunuz?
    - Bu aktiviteden ne öğrendiğinizi benimle paylaşır mısınız?
    - Aktiviteye dair aklınıza takılan sorular var mı? Nelerdir?
- Bu aktivite de değişiklik yapmak ister miydiniz? Nasıl?
    - Siz bu aktiviteyi nasıl tasarlardınız? İçeriğinde neler olmasını isterdiniz?
- Derslerin nasıl işlenmesini isterdiniz?
    - Sizin için Matematik ve Fen bilgisi dersi ne ifade ediyor?
    - Sizin için Matematik ve Fen bilgisi dışındaki dersler (Sosyal bilgiler, İngilizce, Görsel sanatlar, Türkçe, vs.) ne ifade ediyor?
    - Bazı dersler (Görsel sanatlar veya İngilizce) bazen başka öğretmenler tarafından alınıyor. Böyle durumlarda ne hissediyorsunuz?
    - Sizin için "başarılı olmak" ne demek?

English Translation

Below are the questions belonging to the focus group interview, which will be made with the students after implementing the STEM activities designed within the scope of the research titled "Designing STEM activities by applying Design Thinking Approach".

- What do you think about today's activity?
    - ➢ We previously practiced an activity together with you. If you make a comparison, how did this activity go on in comparison with the ones you practiced before? (If the activity has not been practiced for the first time)

      -From the point of difficult/easy aspects-

    - What do you think about the theme of the activity? Can you compare the theme in the activity that you practiced before with the one at the moment (If it has not been practiced for the first time)?
    - Was there a moment you got bored or enjoyed in this activity? If yes, why?
    - What was the most favorite aspect of this activity?
    - What do you think about group working (If any)?
    - Can you please share what you have learned from this activity?
    - Are there any questions that stick in your mind? If yes, what are they?
- Would you like to make a change in this activity? How?
  - How would you design this activity? What do you wish it would involve in its content?
- In what way would you like the lessons to be taught?
    - What do math and science lessons mean for you?
    - What do the lessons out of math and science (Social studies, English, Visual arts, Turkish, etc.) mean for you?
    - Other teachers sometimes take some lessons (Visual arts or English). What do you feel in such situations?
    - What does “to be successful” mean for you?

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T.C.
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İl Millî Eğitim Müdürlüğü

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DAĞITIM YERLERİNE

İlgi : a) Millî Eğitim Bakanlığı Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü'nün 07/03/2012 tarihli ve 3616 sayılı, 2012/13 nolu Genelgesi,
b) Ankara Ortadoğu Teknik Üniversitesinin 01/11/2017 tarihli ve 54850036-300. 5281 sayılı yazısı.

Ankara Ortadoğu Teknik Üniversitesi Fen Bilimleri Enstitüsü Endüstri Ürünleri Tasarımı EABD Doktora Öğrencisi Ahsen ÖZTÜRK' ün, Atakum İlçe Milli Eğitim Müdürlüğüne Bağlı 5. Sınıf Öğretmenleri ve Öğrencilerine yönelik olarak "Tasarım Yaklaşımı Kullanarak STEM Aktiviteleri Oluşturma" konulu araştırmak yapmak istediğine ilişkin ilgi (b) yazı, ilgi (a) genelgeye göre incelenmiş ve komisyon tarafından uygun görülmüştür.

Söz konusu çalışmanın komisyon kararı doğrultusunda tez çalışma sonuçlarının rapor halinde Müdürlüğümüz Ar-Ge Birimine gönderilmesine dikkat edilerek, Türkiye Cumhuriyeti Anayasası, Millî Eğitim Temel Kanunu ile Türk Milli Eğitiminin genel amaçlarına uygun olarak, ilgili yasal düzenlemelerde belirtilen ilke, esas ve amaçlara aykırılık teşkil etmeyecek şekilde, duyurusu ve denetimi ilçe millî eğitim müdürlüğünüz tarafından gerçekleştirilmek üzere okul müdürlüğü sorumluluğunda, eğitim-öğretimi aksatmadan çalışmanın yapılmasının sağlanması hususunda;

Bilgilerinizi ve gereğini rica ederim.

Coşkun ESEN
Vali a.
İl Milli Eğitim Müdürü

Ekler :
1- İlgi (b) Yazı ve ekleri (13 sayfa)
2- 10//11/2017 tarihli komisyon kararı (1 sayfa)

DAĞITIM:

Gereği:
Atakum Kaymakamlığı (İlçe MEM)

Bilgi:
Ankara Ortadoğu Teknik Üniversitesi
Fen Bilimleri Enstitüsü

Recep KORKMAZ
Şef

Güvenli Elektronik İmzalı
Aslı ile Aynıdır.
21-11-2017

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Elektronik Ağ: http://samsun.meb.gov.tr
Yükseköğretim ve Yurt Dışı Eğitim Şubesi
e-posta: yuksekogretimyurtdisi55@meb.gov.tr

Ayrıntılı bilgi için: R.KORKMAZ (Şef)
Tel: (0 362) 435 80 63 (340)
435 80 64
Faks: (0 362) 43248 54

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L. The permission from the Applied Ethics Research Center

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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10 EKİM 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Yrd. Doç .Dr. Pınar KAYGAN ;

Danışmanlığını yaptığınız doktora öğrencisi Ahsen ÖZTÜRK'ün **"Tasarım Yaklaşımını Kullanarak STEM aktiviteleri Oluşturma"** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-FEN-057** protokol numarası ile **10.10.2017 – 30.06.2018** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

BULUNAMADI
Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Yrd. Doç. Dr. Pınar KAYGAN
Üye

Yrd. Doç. Dr. Emre SELÇUK
Üye

M. Consent Forms Prepared for Taking Permission from the Parents (Turkish)

VELİ ONAY MEKTUBU

Sayın Veliler, Sevgili Anne-Babalar,

Bu çalışma, Orta Doğu Teknik Üniversitesi Endüstri Ürünleri Tasarımında doktora öğrencisi olan Ahsen Öztürk tarafından tarafından Yrd. Doç. Dr. Pınar Kaygan danışmanlığındaki doktora tezi kapsamında yürütülmektedir.

Bu çalışmanın amacı nedir?: Araştırmanın amacı, Koleji 5. Sınıf öğretmenleri ile tasarlanacak olan STEM aktivitelerinin, sınıfta uygulanması sonrasında, öğrencilerin bu aktivitelere dair görüşlerini almaktır.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?: Çalışmanın amacını gerçekleştirebilmek için, çocuklarınızdan okullarında katıldıkları STEM aktivitesini içeren derse ilişkin görüşlerini almak istiyoruz. Katılmasına izin verdiğiniz takdirde, aktivitenin uygulanması sırasında sınıfta görüntü kaydı alınacak, ayrıca çocuğunuz ile görüşme, sınıfta ders saatinde, odak grup görüşmesi şeklinde yapılacaktır. Dolayısıyla görüşmeler, birebir değil sınıfça toplu olarak ve öğretmenlerinde refaketinde uygulanan STEM aktivitesini değerlendirme amacıyla gerçekleştirilecektir. Bu amaç doğrultusunda, çocuğunuzdan sorulan sorulara cevap vermesi rica edilecek ve cevapları görüntü kaydı alınması suretiyle toplanacaktır. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacaktır.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?: Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacı tarafından değerlendirilecektir. Elde edilecek bilgiler, sadece bilimsel araştırma amacıyla kullanılacak, çocuğunuzun ya da sizin ismi ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?: Çocuğunuzun sınıf içinde cevaplayacağı soruların ona olumsuz etkisi olmayacağından emin olabilirsiniz. Yine de, bu formu imzaladıktan sonar, hem siz hem de çocuğunuz katılımcılıktan ayrılma hakkına sahipsiniz. Katılım sırasında, sorulan sorulardan, ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü, çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya sorular tamamlanmadan ve derhal son verilecektir. Şayet öğretmeni, çocuğunuzun rahatsız olduğunu hissederse, böyle bir durumda çalışmadan sorumlu kişiye, çocuğunuzun çalışmadan ayrılmasını istediğini kendisinin söylemesi yeterli olacaktır.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz: Araştırma hakkında daha detaylı bilgiye ihtiyaç duyarsanız Endüstri Ürünleri Tasarımı öğretim üyelerinden Yrd. Doç. Dr. Pınar Kaygan (Tel: 0 312 2102239, E-posta: pkaygan@metu.edu.tr) ya da doktora öğrencisi Ahsen Öztürk (E-posta: ahsenozturk@gmail.com) ile iletişim kurabilirsiniz.

Saygılarımızla,
Ahsen ÖZTÜRK
0542 8414298
ahsenozturk@gmail.com

Lütfen bu araştırmaya katılmak konusundaki tercihinizi aşağıdaki seçeneklerden size en uygun gelenin altına imzanızı atarak belirtiniz ve bu formu çocuğunuzla okula geri gönderiniz.

A) Bu araştırmaya tamamen gönüllü olarak katılıyorum ve çocuğum ....’nın da katılımcı olmasına izin veriyorum. Çalışmayı istediğim zaman yarıda kesip bırakabileceğimi biliyorum ve verdiğim bilgilerin bilimsel amaçlı olarak kullanılmasını kabul ediyorum.

Velinin Adı-Soyadı...............................

İmza ....

B) Bu çalışmaya katılmayı kabul etmiyorum ve çocuğumun ....’nın da katılımcı olmasına izin vermiyorum.

Velinin Adı-Soyadı..............................

İmza ....

N. Consent Forms Prepared for Taking Permission from the Parents (English Translation)

PARENT PERMISSION LETTER

Dear Parents, Dear Mothers, and Fathers,

This study has been being conducted by Ahsen ÖZTÜRK, who is a Ph.D. student at Middle East Technical University in the Department of Industrial Design within the scope of her Ph.D. dissertation consulted by Asst. Prof. Dr. Pınar KAYGAN.

What is the aim of this study?: The objective of this study is to obtain the students' views about the activities after implementing the STEM activities, which will be designed with ______ School's teachers of fifth-grade classes.

What do we expect from your child as a participant?: To realize the study's aim, we want to obtain your children's views about the lesson involving the STEM activity in which they participated in their school. In case you give permission to him/her, a video will be recorded during the practice of the activity in the classroom. Moreover, the interview with your child will be done during the period in the classroom in the form of a focus group interview. Consequently, the interviews will not be one-on-one; they will be made with the whole class as a group, and they will also be carried out for evaluating the STEM activity practiced in the company with the teachers. In accordance with this aim, your child will be requested to answer the questions, and his/her answers will be recorded with a video recorder. As we ask your permission for your child's participation, also your child's oral approval will be absolutely received before giving a start to the study.

For what purpose and how will the information obtained from your child be used?: The answers to your child will be entirely kept private, and the researcher will only evaluate them. The information collected will only be used for the aim of scientific research; furthermore, the name and identity card information of you and your child will never be shared with someone else.

What should you do if your child wants or you want to quit this study?: You can be sure that the questions that your child will answer in the classroom will not affect him/her negatively. However, both you and your child have the right to quit being a participant even after signing this form. If your child states that he/she is disturbed because of the questions asked during his/her participation or due to another reason about any practice, or if the researcher feels the child's disturbance even he/she does not state it, the study will be immediately ended without finishing to ask all the questions. If his/her teacher feels that your child is disturbed, the teacher's statement that he/she wants your child's quitting the study to the person in charge of this study will be enough.

If you want to get further information about this study: If you need more detailed information about this study, you can make contact Asst. Prof. Dr. Pınar KAYGAN, an academic member of the Department of Industrial Design (Phone: +90 312 210 22 39, e-mail address: pkaygan@metu.edu.tr) or with Ahsen ÖZTÜRK, Ph.D. student (e-mail address: ahsenozturk@gmail.com)

Best regards,
Ahsen ÖZTÜRK
0542 8414298
ahsenozturk@gmail.com

Please state your preference for participating in this study by signing the most appropriate option for you and return this form with your child to the school.

A) I am voluntarily participating in this study, and I have permitted my son/daughter ……………………. for being a participant. I know that I can quit this study whenever I want, and I approve the information I have given to be used for scientific purposes.

The Name-Surname of the Parent : …………………………
Signature : …………………………

B) I do not accept participating in this study, and I do not permit my son/daughter …………………….'s being a participant.

The Name-Surname of the Parent : …………………………
Signature : …………………………

O. Consent Forms Prepared for Taking Permission from the Teachers (Turkish)

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma, Orta Doğu Teknik Üniversitesi Endüstri Ürünleri Tasarımında doktora öğrencisi olan Ahsen Öztürk tarafından Yrd. Doç. Dr. Pınar Kaygan danışmanlığındaki doktora tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir? STEM eğitimi; fen, teknoloji, mühendislik ve matematik gibi dört disiplinin ayrı ayrı kullanılması yerine, disiplinlerarası işbirliği yaparak derslerin birbirine entegre edilmesini amaçlamaktadır. STEM yaklaşımı sadece 4 disiplini (Fen, Matematik, Teknoloji, Mühendislik) kapsamakta ve sosyal ve beşeri bilimler bunun dışında bırakılmaktadır. **Yalnız tüm disiplinleri kapsamayan bir STEM eğitiminin eksik kalacağı düşünülmektedir.**

"Tasarım odaklı düşünme" yaklaşımı disiplinlerarası ve insan odaklı problem çözme metodu olarak tanımlamakta ve eğitimde, müfredat tasarımı ve problem çözme metodu olarak kullanılmaktadır. Bu sebeple, bu çalışmada amacımız, tüm disiplinleri STEM yaklaşımı içine dâhil etmek amacıyla, öğretmenlerimiz ile birlikte tasarım odaklı düşünme metodunu kullanarak bir STEM aktivitesi tasarlamaktır.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz? Araştırmaya katılmayı kabul ederseniz, sizden yaklaşık 9 kişiden oluşan (Koleji 5. sınıf öğretmenleri) iki çalıştaya katılmanız beklenmektedir. Yaklaşık olarak ilkinin 2 gün ve ikincisinin 1 gün sürmesi beklenen bu çalıştaylarda sizlerden, kendi müfredatlarınız doğrultusunda gruplar halinde STEM aktivitesi tasarlamanız istenecektir. Bu araştırma 2 aşamada gerçekleşecektir.

- İlk aşamada, 2017-2018 eğitim ve öğretim yılı 1. dönemi, Ekim ayı içinde, siz 5. sınıf öğretmenleri ile okulunda uygun gördüğü tarihlerde, toplamda iki güne denk gelecek şekilde bir çalıştay yapılacaktır. Çalıştay öncesi, öğretmenler ile yapılacak çalışmaya dair bir görüşme yapılacaktır. Sonrasında, öğretmenler bu çalıştay da gruplara ayrılarak, kendi müfredatları doğrultusunda STEM aktivitesi tasarlayacaklardır. Çalıştay sırasında gözlem yapılacak ve sonrasında öğretmenler ile odak grup görüşmesi yapılacaktır. Arkasından öğretmenler bu aktiviteleri sınıflarında uygulayacaklardır. Tasarlanan aktivitelerin uygulanabilir olup olmadığını görmek amacıyla, STEM aktivitelerinin uygulandığı derslere gözlemci olarak katılıncak ve sonrasında aktiviteye dair öğretmen görüşleri alınacaktır.
- İkinci aşama, 2017-2018 eğitim ve öğretim yılı 2. döneminde, Şubat ayında gerçekleşecektir. Bu sefer tahminen 1 günlük süreye denk gelecek bir çalıştay yine 5. sınıf öğretmenleri ile okulunda uygun

gördüğü tarihlerde yapılacaktır. Çalıştay sırasında gözlem yapılacak ve sonrasında öğretmenler ile odak grup görüşmesi yapılacaktır. Arkasından öğretmenler bu aktiviteleri sınıflarında uygulayacaklardır. Tasarlanan aktivitelerin uygulanabilir olup olmadığını görmek amacıyla, yine STEM aktivitelerinin uygulandığı derslere gözlemci olarak katılıncak ve sonrasında aktiviteye dair öğretmen görüşleri alınacaktır.

- Hem derslerde, hem de çalıştaylar da veri toplamak için kamera kaydı alınacaktır.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız? Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Çalışmada, sizden kimlik/kurum veya birim belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır. Sağladığınız veriler gönüllü katılım formlarında toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Katılımınızla ilgili bilmeniz gerekenler: Çalışma, genel olarak kişisel rahatsızlık verecek sorular içermemektedir. Katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz, cevaplama işini yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda, çalışmayı uygulayan kişiye, çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır. Çalışma sonunda, bu araştırmayla ilgili sorularınız cevaplanacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz: Çalıştaylar sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Endüstri Ürünleri Tasarımı öğretim üyelerinden Yrd. Doç. Dr. Pınar Kaygan (Tel: 0 312 2102239, E-posta: pkaygan@metu.edu.tr) ya da doktora öğrencisi Ahsen Öztürk (E-posta: ahsenozturk@gmail.com) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad	Tarih	İmza
	----/----/-----	

P. Consent Forms Prepared for Taking Permission from the Teachers (English Translation)

THE VOLUNTARY PARTICIPATION FORM FOR THE STUDY

What is the aim of this study? STEM education aims to integrate the lessons one another by collaborating in an interdisciplinary way instead of teaching four disciplines such as science, technology, engineering, and math separately from each other. STEM approach only consists of four disciplines (Science, Technology, Engineering, Math), but social sciences and humanities are left apart from these. **However, it is thought that a STEM education that does not consist of all disciplines will fall short.**

"Design Thinking" approach is defined as an interdisciplinary and a human-centered problem-solving method and used as a problem-solving method and curriculum design in education. For this reason, our aim in this study is to design a STEM activity with our teachers by applying the design thinking method for the purpose of getting all disciplines involved in the STEM approach.

In what way will we ask you for help?: If you agree to participate in the study, you are expected to attend two workshops consisting of nine persons (School's teachers of 5th-grade). You will be asked to design STEM activities in groups in accordance with your curricula in these workshops, first of which will nearly last for two days and the second of which will almost last for one day. This study is going to realize in two stages.

- At the first stage, a two-day workshop will be held in October, during the first term of the 2017-2018 academic year, with 5th-grade teachers on the dates the school approved. Before the workshop, an interview about the study will be done with teachers. Then, by being divided into groups in this workshop, the teachers will design a STEM activity in line with their curricula. An observation will be made during the workshop, and a focus group interview will be done with the teachers. After that, the teachers will implement these activities in their classrooms. The researcher will attend the classes in which STEM activities are implemented as a participant-observer to understand whether the activities designed are practicable or not; then, the teachers' views about the activity will be collected.
- The second stage will be realized in February, in the second term of the 2017-2018 academic year. A nearly one-day workshop will be conducted on the dates the school approved again with the teachers of the 5th-grade. An observation will be made during the workshop, and then a focus group interview will be done with the teachers. After that, the teachers will implement these activities in their classrooms. The researcher will again attend the classes in which

STEM activities are implemented as a participant-observer to understand whether the activities designed are practicable or not; then, the teachers' views about the activity will be collected.

- A video will be recorded to collect data both in the lessons and in the workshops.

How will we use the information which we get from you?: Your participation in the study should be based on voluntariness. In this study, no information determining your identity, institution, or department is demanded from you. Your answers will be kept private; they will be evaluated only by the researchers. The information obtained from the participants will be assessed and be used in scientific publications. The data that you provide will not be matched with the identity information collected from the voluntary participation forms.

What you should know about your participation: This study does not generally include any individually disturbing questions. If you feel disturbed because of the questions or any other reason during your participation, you are free to quit answering the questions. In such a situation, it will be enough to tell the person who runs the study that you want to leave the study. At the end of the study, your questions about this study will be answered.

In case you want to get further information about this study: At the end of the workshops, your questions about this study will be answered. Thank you in advance for your participation in this study. To get more information about this study, you can make contact with Asst. Prof. Dr. Pınar KAYGAN, an academic member of the Department of Industrial Design (Phone: +90 312 210 22 39, e-mail address: pkaygan@metu.edu.tr) or with Ahsen ÖZTÜRK, Ph.D. student (e-mail address: ahsenozturk@gmail.com).

I have read the information above, and I am voluntarily participating in this study.

(Please return this form to the practitioner of this study after filling and signing it.)

Name-Surname	Date	Signature
	----/----/-----	

Q. Developed STEM Activity in Main Study I (English)

Date: 9th January 2018, Tuesday
Theme (5 minutes): The students are waiting in the cafeteria queue. At this moment, two students are talking about the flood disaster which happened in Canik, Samsun, yesterday because one of their friends has been negatively affected. At this time, they are the first in the queue, and they attempt to take their food. But they notice that the ice cream served on that day's menu has melted because of the freezer's getting out of order. These two friends who like ice cream very much think that a system should be built to prevent ice cream from melting. Then they take their lunches, take a seat, and start eating. Nevertheless, they cannot finish eating all their food on time as they have lost so much time in the queue, and they do not want to waste their food. As a result, they realize that they need a storage box, and then they quickly return to their classrooms in order not to be late for the afternoon class.
The menu: Soup, Meatballs and Potato, Pasta, Yoghurt, Ice cream, Bread

Question 1 (15 minutes)
Name - Surname:

The flood disaster in Canik, Samsun: 8 dead, 4 of which were kids … Mert River overflew its banks because of heavy rain in Canik district of Samsun, the ground floors in Kuzey Yıldızı housing estates were flooded.
Heavy rain, which started in the morning and intensified on the advancing hours at night in Samsun, brought flooding. Eight people, four of which were kids in Kuzey Yıldızı housing estates, died because of Mert River's flood. Moreover, on the Samsun-Ordu Highway, four people who were stuck in a vehicle driven by the floodwater were rescued with the help of heavy equipment and taken to the hospital at the last moment. Besides, a landslide crashed down onto the road in Derbent because of rain. A large number of houses and working places have been under floodwater, so it has been announced that the heavy equipment working is continuing in the region. On the other hand, it has been stated that heavy equipment has been sent to the area for rescuing the people stuck on the roofs and in the cars, but the helicopters are not able to take off because of heavy rain and cannot fly at night as they do not have night vision device. It has also stated that the rescuing operation is continuously running for the people who have been stuck.

Having returned to their classrooms, two students have been thinking of their friend who suffered from the flood disaster in Canik. As a result, they call their friend as soon as possible and ask him the questions below:
1-What is the reason for this flood disaster in Canik?
2- What can be done to prevent such a disaster from happening again?
3- Their friend with whom the students talked on the phone has told them that he was nearly stuck in the room, and the water level was almost at his height. This student is 1,5 meters tall, and the ceiling height of the room is 2,5 meters. In your opinion, if how many percent had been the level of the water close to the ceiling height, the students' friend could not have got out of the room?
4- Please, write the words below in English across them.
Sel:
Çığ:
Deprem:
Yangın:

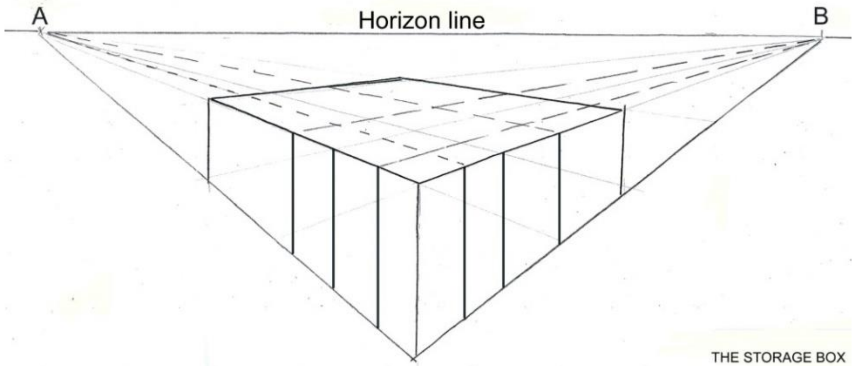
EVALUATION of QUESTION 1
Mathematics (5 points):
Social science and Science
(10 points):
English speaking (5 points):
Total (20 points)
Time management: (Rewarding with Stickers)

Question 2 (20 minutes)
Name-Surname:

After talking to their friends on the phone, the students realize that they are hungry. The students observe that the food jumbles in the storage box which they bring to put their remaining food at lunch because it does not have dividers in it. The demoralized students think that the storage box should have internal dividers. However, the food and the amount of it differs from person to person. Therefore, they realize that the design of the dividers can vary in itself. According to this, we want you to make a division for four kinds of food on the visual materials belonging to a storage box that has been given you. While doing this, please answer the following questions:
1-In how many percent of the storage box and which food do you want to keep in it? Please give an answer using fractional expressions and illustrate this on the visual material provided to you. Paint the dividers using three primary colors and one of the secondary colors you like, that is to say, four colors in total. For your answers, fill in the related fields on the worksheets.

The Menu: Soup, Meatballs and Potato, Pasta, Yoghurt, Ice cream, Bread

	1.The name of the food	2.The English name of the food	3. Which colour? (You can show painting here with the same colour)	4. In how many percent of the storage box is it kept?
1. Food				
2. Food				
3. Food				
4. Food				



THE STORAGE BOX

EVALUATION of QUESTION 2
Mathematics (20 points):
Visual arts (10 points):
English speaking (10 points):
Total (40 points)
Time management: (Rewarding with Stickers)

Question 3
The names of the students in the group:

When they think about how to divide the storage box, they think about the ice cream they cannot eat for lunch because it melts due to the freezer's getting out of order. When considering the reasons for melting ice cream and how they can prevent it, they try to answer the following questions by discussing them among themselves.
1-What are the reasons for the melting of ice cream after the freezer's getting out of order? (5 minutes)
2-What kind of solution/system do you suggest to prevent ice cream from melting?

For finding a solution, please follow the stages written on the worksheets given to you.
Materials: Aluminum foil, adhesive agent, a ruler, cardboard, wooden skewers, a sticky tape, scissors, pipettes, a colored paper, a white A4 paper, sticky notes, felt, a toilet paper or paper towel roll, colored pens, envelopes

2a- IDEA GENERATION: (15 minutes) Please brainstorm with your teammates about how to prevent ice cream's melting and illustrate four of the ideas for the solution in the boxes below.

2b-IDEA SELECTION: (10 minutes) Please choose one of these ideas and explain your reason.
2c- PROTOTYPING: (20 minutes) Please make the prototype of the idea chosen with the materials given to you. Besides, please answer the questions below.
While doing this stage, you can share the tasks

a- What is the way of working of this design (prototype)? How does it prevent ice cream melting? (5 minutes)

b- Please answer the question below. (5 minutes)
Elif, who likes to dance to Mozart's classical music, cannot find the opportunity to eat so as not to be late for the dance and painting course that will start immediately after school. Therefore, while going with the service, she eats the food she takes in the storage box that she carries with her. Today, Elif bought three scoops of her favorite kinds of ice cream from the school cafeteria. When she went to the course, it took ten

more minutes to start the lesson. Thus, she wanted to eat her ice cream. However, until she came to the course, from three scoops of her ice cream, 1/2 of the one scoop and 1/3 of the one scoop melted. According to this, how many percent of Elif's ice cream remained?

c-Prepare an informative English poster regarding your design (prototype) on a 50x70 cm sized paper. (15 minutes)
P.S: You can use pictures of the models you created in the previous phase in this poster.

d- While solving the question asked to you, what information about which lessons did you need to use? (5 minutes)
Mathematics:
Science:
Visual arts:
English speaking:

e- Make a presentation: (10 minutes)
Please make presentations of your projects to the class.

EVALUATION of QUESTION 3

Time management: (Rewarding with Stickers)
Group work: (Rewarding with Stickers): Most harmonious working group
EVERY TEACHER WILL EVALUATE.

Product evaluation (40 points)
Problem 1 (4 points):

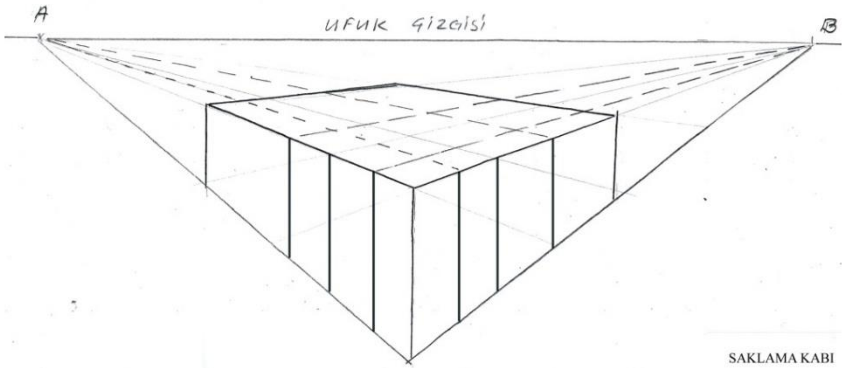
Problem 2:
2a- Idea generation (4 points):
2b- Idea selection (4 points):
2c- Prototyping:
a- Degree of the suitability of solution to the problem (Idea and working principle)
(4 points):
b-Mathematics question (4 points):
c-English poster (4 points):
d- To be able to relate between courses (4 points):
EVERY TEACHER WILL EVALUATE.
e-Self-reflection (4 points):
EVERY TEACHER WILL EVALUATE.
Quality of Prototype (4 points):
VISUAL ARTS AND SCIENCE TEACHERS
The authenticity of the prototype (4 points):
VISUAL ARTS AND SCIENCE TEACHERS
PEER REVIEW: (In a closed envelope, let each group write the name of the other group they like the idea of)
P.S: The group with the most votes will receive + 1 bonus point.

Mathematics (6 points):
Science (14 points):
Visual arts (14 points):
English speaking (Poster) (6 points):
Peer review (+ 1 bonus point)
Total (40 + 1 points)

R. Developed STEM Activity in Main Study I (Turkish)

Tarih: 9 Ocak 2018, Salı **Tema (5 dakika):** Öğrenciler yemekhane sırasında beklemektedir. Bu sırada 2 öğrenci dün yaşanmış olan Samsun, Canik teki sel felaketinden bahsetmektedir. Çünkü bu felakette arkadaşlarından 1 tanesi olumsuz anlamda etkilenmiştir. Bu sırada yemekhanede kendilerine sıra gelir ve yemeklerini almaya başlarlar. Fakat o günkü menüde çıkan dondurmanın yemekhanedeki buzdolabının bozulması sebebiyle erimiş olduğunu fark ederler. Dondurmayı çok seven bu iki arkadaş dondurmanın erimemesi için bir sistem kurulması gerektiğini düşünürler. Sonra yemeklerini alıp masaya geçerler ve yemeklerini yemeye başlarlar. Fakat sırada çok zaman kaybettikleri için yemeklerini vaktinde bitiremezler ve yemeklerinin de ziyan olmasını istemezler. Bu sebeple bir saklama kabına ihtiyaç duyduklarını fark ederler ve öğleden sonraki derse yetişmek için hızlıca sınıflarına geri dönerler. **Yemek Menüsü:** Çorba, Köfte ve Patates, Makarna, Yoğurt, Dondurma, Ekmek
Soru 1 (15 dakika) **Ad-Soyad:**
Samsun Canik'te sel felaketi: 4'ü çocuk, 8 ölü… Samsun'un Canik ilçesinde sağanak yağmur nedeniyle Mert ırmağı taştı, Kuzey Yıldızı TOKİ konutlarındaki apartmanların zemin katlarını su bastı. Samsun'da gündüz başlayan ve gece ilerleyen saatlerde şiddetini artıran sağanak yağmur sele neden oldu. Mert Nehri'nin taşması sonucu Kuzey Yıldızı TOKİ Konutlarında 4'ü çocuk, 8 kişi hayatını kaybetti. Samsun-Ordu Karayolunda ise, sel sularının dereye sürüklediği bir araçta mahsur kalan 4 kişi, son anda iş makineleriyle kurtarılarak hastaneye kaldırıldı. Derbent mevkiinde ise, yağmur nedeniyle yola heyelan düştü. Sel nedeniyle çok sayıda ev ve iş yeri sular altında kalırken, bölgede iş makinelerinin çalışmalarının devam ettiği açıklandı. Diğer taraftan, çatılarda ve araçlarda mahsur kalan vatandaşları kurtarmak için, iş makinelerinin bölgeye gönderildiği, ancak helikopterlerin gece görüş özelliği olmadığı için ve sağanak yağmur nedeniyle uçamadığı açıklandı. Mahsur kalan vatandaşların kurtarılmaları için çalışmaların aralıksız olarak devam ettiği belirtildi.
Sınıflarına dönmüş olan öğrencilerin aklı Canik teki sel felaketini yaşayan arkadaşlarında kalmıştır. Bu sebeple ilk fırsatta arkadaşlarını ararlar ve aşağıdaki soruları ona sorarlar: 1-Canik'te yaşanan bu sel felaketinin olmasının sebepleri nelerdir? 2-Bu felaketin bir daha yaşanmaması için neler yapılabilir? 3-Öğrencilerin telefonda konuştukları arkadaşları sel felaketinde az kalsın odadan çıkamayacağını ve suyun odada neredeyse boyu kadar yükseldiğini söylemiştir. Odasında mahsur kalan öğrencinin boyu: 1,5 m ve odanın tavan yüksekliği de: 2,5 m dir. Odada ki suyun miktarı, sizce tavan yüksekliğinin kaçta kaçının üzerine denk gelseydi, öğrencilerin arkadaşı odasından çıkamazdı? 4-Aşağıdaki kelimelerin İngilizcelerini lütfen karşısına yazın. Sel: Çığ: Deprem: Yangın: **<u>1. SORU DEĞERLENDİRME:</u>** Matematik (5 puan): Sosyal Bilgiler ve Fen Bilgisi (10 puan): English speaking (5 puan): **Toplam (20 puan)** **Zaman Kullanımı:** (Sticker ile değerlendirme)
Soru 2 (20 dakika) **Ad-Soyad:**
Arkadaşları ile telefonda konuştuktan sonra öğrenciler, acıktıklarını fark ederler. Öğlen artan yemeklerini koymak için aldıkları saklama kabının içinin bölmeli olmaması sebebiyle, konulan yemeklerin birbirine karıştığını fark ederler. Moralleri bozulan öğrenciler saklama kabını istedikleri gibi bölümlendirilmesi gerektiğini düşünürler. Fakat herkesin almak istediği yemekler ile miktarları farklı olduğu için bölümlendirmeye ait tasarımın kendi içinde değişiklik gösterebileceğini fark ederler. Buna göre size dağıtılacak olan saklama kabına ait görsel üzerinde 4 çeşit yemek için bölümlendirme yapmanızı istiyoruz. Bunu yaparken lütfen aşağıdaki sorulara cevap veriniz: 1-Saklama kabının kaçta kaçına hangi yemekleri koymak istersiniz? Lütfen kesirli ifade kullanarak cevap veriniz ve size verilen görsel üzerinde bunu çizerek gösteriniz. Ayrıca çizdiğiniz bölmeleri 3 ANA RENK ve sevdiğiniz 1 ARA RENGİ yani toplamda 4 rengi kullanarak boyayınız. Cevaplarınız için çalışma kâğıdı üzerindeki ilgili alanları doldurunuz. **Yemek Menüsü:** Çorba, Köfte ve Patates, Makarna, Yoğurt, Dondurma, Ekmek

	1- Yemek Adı	2- Yemeğin İngilizce Adı	3- Hangi Renk (Aynı renkte boyayarak gösterebilirsiniz)	4- Saklama Kabının Kaçta Kaçında bulunmakta
1. Yemek				
2. Yemek				
3. Yemek				
4. Yemek				



SAKLAMA KABI

2. SORU DEĞERLENDİRME:
Matematik (20 puan):
Görsel Sanatlar (10 puan):
English speaking (10 puan):
Toplam (40 puan)
Zaman Kullanımı: (Sticker ile değerlendirme)

Soru 3
Gruptaki Öğrencilerin İsimleri:

Saklama kabının nasıl bölümlendirileceğini düşünürken, akıllarına yemekhanedeki buzdolabının bozulması sebebiyle eridiği için öğlen yiyemedikleri dondurmaları gelir. Dondurmanın erimesindeki sebepleri ve bunu nasıl önleyebileceklerini düşünürken, aşağıdaki soruları kendi aralarında tartışarak cevaplamaya çalışırlar.
1-Buzdolabı bozulduktan sonra dondurma sizce neden erimiştir? (5 dakika)

3-Yemekhanede dondurmanın erimesini engellemek için nasıl bir çözüm/sistem önerirsiniz? Çözüm için lütfen, size dağıtılan çalışma kâğıdındaki aşamaları takip edelim.

Malzemeler: Alüminyum folyo, yapıştırıcı, cetvel, karton, çöp stik, bant, makas, pipet, renkli kâğıt, A4 beyaz kâğıt, yapışkanlı not kâğıdı, keçe, tuvalet kâğıdı veya havlu peçete rulo kartonu, renkli kalemler ve Zarf.

2a- FİKİR ÜRETMEK: (15 dakika) Lütfen dondurmanın erimesini engellemek için takım arkadaşlarınız ile beyin fırtınası yapın ve aşağıdaki kutucuklara 4 çözüm fikrini içeren çizim yapın.

2b- FİKİR SEÇMEK: (10 dakika) Lütfen bu fikirlerden birini seçin ve nedenini açıklayın.
2c- PROTOTİP YAPMAK: (20 dakika) Lütfen seçtiğiniz fikrin prototipini size verilen malzemeler ile yapın. Ayrıca aşağıdaki sorularıda lütfen cevaplayın.
Bu aşamayı yaparken, görev paylaşımı yapabilirsiniz.

a-Bu tasarımın (prototipin) çalışma şekli nedir? Dondurmanın erimesini nasıl engeller?
(5 dakika)

b-Lütfen aşağıdaki soruyu cevaplandırınız. (5 dakika)

Mozart'ın klasik müzikleri eşliğinde dans etmeyi seven Elif, okul çıkışından sonra hemen başlayacak olan dans ve resim kursuna geç kalmamak için yemek yemeğe fırsat bulamıyordur. Bu yüzden, servisle giderken, yanında taşıdığı saklama kabına aldığı yemekleri yiyordur. Bugün Elif okulun yemekhanesinde çıkan dondurmanın en çok sevdiği çeşitlerinden 3 top almıştı. Kursuna gittiğinde, dersin başlamasına daha 10 dk. olduğu için dondurmasını yemek istedi. Ancak kursa gelene kadar, 3 top dondurmadan bir topunun 1/2 si, diğer bir top dondurmanın da 1/3 ü erimişti. Buna göre Elif'in geriye dondurmasının kaçta kaçı kalmıştır?

c-50-70 kâğıt üzerine tasarımınıza (prototipinize) ait tanıtıcı bir İngilizce poster hazırlayın. (15 dakika)

NOT: Bir önceki aşamada oluşturduğunuz modellerin resimlerini bu posterde kullanabilirsiniz.

d-Size verilen problemi çözerken hangi derslere ait bilgileri kullanma ihtiyacı duydunuz? (5 dakika)

Matematik:

Fen Bilgisi:

Görsel Sanatlar:

English speaking:

e-Sunum yapmak: (10 dakika)

Lütfen projelerinizi sınıfa sunun.

3. SORU DEĞERLENDİRME:

Zaman Kullanımı: (Sticker ile değerlendirme)

Grup Çalışması: (Sticker ile değerlendirme): En uyumlu çalışan grup

HER ÖĞRETMEN DEĞERLENDİRECEK.

Ürün Değerlendirme (40 puan)

Soru 1 (4 puan):

Soru 2:

2a- Fikir Geliştirme (4 puan):

2b- Fikir Seçmek (4 puan):

2c- Prototip Yapmak:

a- Çözümün probleme uygunluk derecesi (fikir ve çalışma prensibi) (4 puan):

b-Matematik sorusu (4 puan):

c-İngilizce Broşür (4 puan):

d-Dersler arasında ilişki kurabilme (4 puan):

HER DERS DEĞERLENDİRECEK.

e-Sunum becerisi (4 puan):

HER DERS DEĞERLENDİRECEK.

Prototip Kalite (4 puan):

GÖRSEL SANATLAR VE FEN BİLGİSİ

Prototip Özgünlük (4 puan):

GÖRSEL SANATLAR VE FEN BİLGİSİ

AKRAN DEĞERLENDİRMESİ: (Kapalı zarf içinde her grup fikrini beğendiği diğer grubun adını yazsın)

Not: En çok oy alan grup + 1 bonus puan alacak.

Matematik (6 puan):

Fen Bilgisi (14 puan):

Görsel Sanatlar (14 puan):

English speaking (Broşür) (6 puan):

Akran Değerlendirmesi (+ 1 puan):

Toplam (40 + 1 puan)

S. Developed STEM Activity in Main Study II (English)

3rd May 2018, Thursday, **DURATION:** 30 minutes
Name - Surname:

1- (20 points)

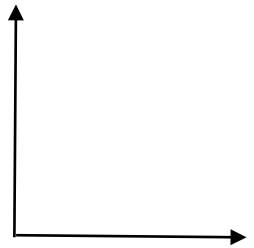
We know that a lot of animal species have already been extinct, and some of them are now in danger of extinction. According to the researches done about this topic, below has been given the average number of some animals in danger of extinction between the years 2010 and 2017.

Table: The number of animals in danger of extinction

The animals in danger of extinction	**The number**
Panda bears	2.000
Polar bears	20.000
Sea turtles	2.000
Gorillas	1.500
Pangolins (Scaly anteaters)	10.000

Please answer the following questions below, according to the table given above.

1-Which animal is in the most danger of extinction?
2- Which animal is in the least danger of extinction?
3-Which two of the endangered animals are equal in number?
4-What is the total number of animals in danger of extinction?
5-Please draw a column graph using the information given in the table.



2- (15 PUAN)

Imagine that a new living space is reserved for you in the space and you are asked to choose a new job for surviving there. Do you know what these new jobs are?

PLEASE FILL IN THE BLANKS BELOW WITH THE CORRECT NAMES OF THE PROFESSIONS.

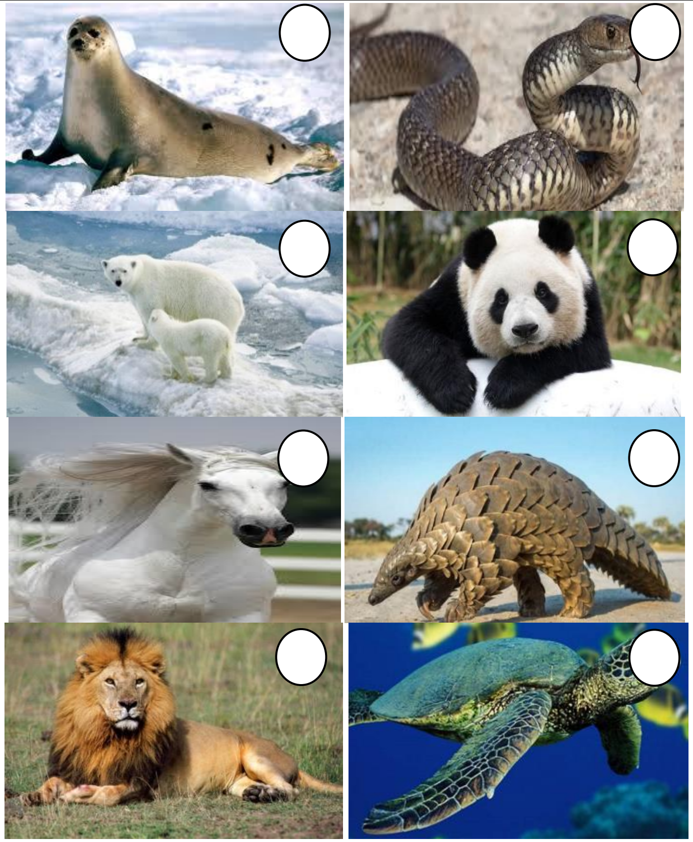
ANIMAL MIGRATION EXPERT - SPACE ARCHITECT - SPACE DOCTOR - SPACE LAWYER - SPACE TOURIST GUIDING

a) The two articles: “The moon and the other celestial bodies should be used exclusively for peaceful purposes’’ and ‘’any government cannot claim sovereignty on the moon’’ belong to Moon Treaty. The field of profession concerning this treaty is called ………………….
b) With the protocol signed between Eskişehir Anadolu University and Azerbaijan, it was the first time to make a plan for bringing up this professional group. At the moment, only nine people are professing this in Turkey to eliminate psychological and physical disorders of people during flights. The name of this profession is called ………………...
c) In the near future, we will be able to travel between the planets. The profession which will show us around Mars, Uranus, or Jupiter is called ………………...
d) Imagine that we move from the earth to the moon. We are taking three animals in danger of extinction together with us. These are ……………, ……………, ……………. The field of the profession which will work for the adaptation of these animals to the system in the space and the ecological conditions is called ………………...
e) In the outer space where we will create a new life, the field of the profession which design solar-powered houses, plan cities and coordinates the galaxies is called ………………...

3- (15 PUAN)

Imagine that a new living space has been reserved for you in space, and you were asked to take with the animals in danger of extinction while going there. The language spoken in these living spaces where people from different countries are living is English. So, do you know the English names of the animals in danger of extinction?
Match the pictures with the correct animal names and put a tick (√) on animals in danger of extinction.

a) lion c) panda d) horse e) seal f) snake
g) pangolin h) caretta caretta i) polar bear



3rd May 2018, Thursday

The names of the students in the group:

Question: Design a new living space in the space for yourself, considering the area reserved for Turkey. While designing this living space, please do not forget to involve the new profession you will choose and the animals in danger of extinction (at least three animals) you will take with you.

TO DO THIS, PLEASE FOLLOW THE STEPS IN THE WORKSHEETS GIVEN TO YOU. YOUR DESIGNS CAN BE TWO OR THREE DIMENSIONAL.

4a- IDEATING (15 points): Considering the new living space you will design for space, draw two sketches that reflect your ideas in the boxes below by brainstorming with your teammate. Do not forget: The new living space should involve you, the three animals in danger of extinction and the new profession you will choose. (15 minutes)

4b- PROTOTYPING (5 points):
Please choose an idea from your sketches and make a prototype of this idea with the materials given to you. At this stage, you can share the tasks. (35 minutes)

"You will welcome your new neighbors in the space with the ''WELCOME'' cards you have designed.''

1-Preparing a poster (10 points):
Prepare an introductory POSTER about your design (your prototype) on an A3 paper. (10 minutes)

2-Making a presentation (20 points):
(20 minutes)

T. Developed STEM Activity in Main Study II (Turkish)

3 Mayıs 2018, Perşembe, **SÜRE:** 30 dakika
Ad - Soyad:

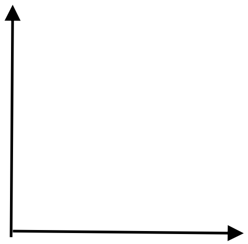
1- (20 PUAN)

Şu an dünya üzerindeki birçok hayvan türünün neslinin tükendiğini ve bazılarının da nesillerinin tükenmek üzere olduğunu biliyoruz. Bu konuyla ilgili yapılan araştırmalara göre, aşağıdaki tabloda nesli tükenmekte olan bazı hayvanların, 2010 - 2017 yılları arasındaki ortalama sayıları verilmiştir.

Tablo: Nesli tükenmekte olan hayvanların sayısı

Nesli tükenmekte olan hayvanlar	**Sayısı**
Panda	2.000
Kutup Ayısı	20.000
Deniz Kaplumbağası	2.000
Goril	1.500
Pangolin	10.000

Yukarıda verilen tabloya göre aşağıdaki soruları cevaplayınız?
1.Hangi hayvanın neslinin tükenme tehlikesi en fazladır?
2.Hangi hayvanın neslinin tükenme tehlikesi en azdır?
3.Nesli tükenen hayvanların hangi ikisi sayıca birbirine eşittir?
4.Nesli tükenen hayvanların toplam sayısı nedir?
5.Tablodaki verileri sütun grafiği ile gösteriniz?



2- (15 PUAN)

Uzayda size yeni bir yaşam alanı tahsis edilmiş ve orada hayatlarınızı sürdürebilmeniz için sizden bir meslek seçmeniz istenmiştir. Bu yeni mesleklerin neler olduğunu biliyor musunuz?

AŞAĞIDAKİ BOŞLUKLARA, DOĞRU MESLEK ADINI LÜTFEN YAZINIZ.

HAYVAN GÖÇ UZMANLIĞI - UZAY MİMARLIĞI - UZAY HEKİMİ – UZAY HUKUKÇUSU –
UZAY TURİZM REHBERLİĞİ

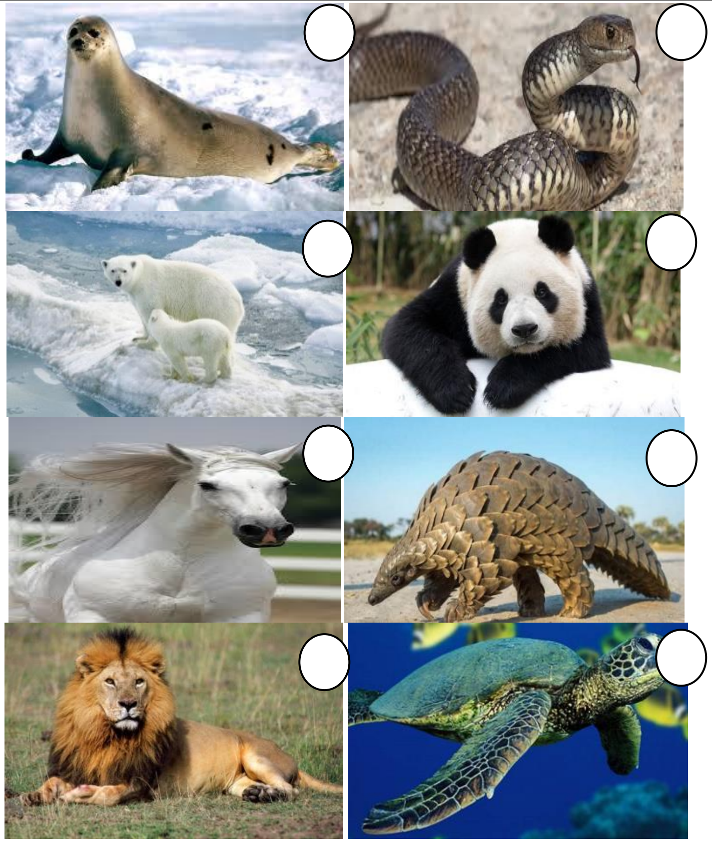
a) “Ay ve diğer gök cisimleri yalnızca barışçıl amaçlarla kullanılabilir” ve “hiçbir devlet uzay üzerinde mülkiyet iddia edemez’’ maddeleri Ay Antlaşması’ na aittir. Bununla ilgilenen meslek dalı …………………
b) Eskişehir Anadolu Üniversitesi ile Azerbaycan arasında imzalanan protokolle, ilk kez bu meslek grubunun yetiştirilmesi planlandı. Şu an, uçuş sırasında, insanlardaki psikolojik ve fizyolojik rahatsızları gidermek için, Türkiye’de sadece 9 tane insan bu mesleği yapmaktadır. Bu mesleğin adı …………………
c) Yakın gelecekte gezegenler arasında seyahat edebileceğiz. Bize Mars’ı, Uranüs’ü, Jüpiter’i gezdirecek meslek …………………
d) Dünya’dan uzaya taşındığımızı düşünelim. Yanımıza nesli tükenmekte olan 3 hayvan alıyoruz. Bunlar ………………… , ………………… , ………………… . Bu hayvanların uzaydaki sisteme adapte olması ve ekolojik şartlara uyum sağlaması için çalışacak meslek kolu …………………
e) Yeni bir yaşam yaratacağımız uzayda, güneş enerjisiyle çalışan evler tasarlayan, şehir planlayan ve galaksileri koordine eden meslek …………………

3- (15 PUAN)

Uzayda size yeni bir yaşam alanı tahsis edilmiş ve oraya giderken yanınızda nesli tükenmekte olan hayvanları da götürmeniz istenmiştir. Farklı ülkelerden insanların yaşadığı yeni yaşam alanın da konuşulan dil İngilizcedir. Buna göre, nesli tükenmekte olan hayvanların İngilizce isimlerini biliyor musunuz?

Match the pictures with the correct animal names and put a tick (√) on animals in danger of extinction.

a) lion c) panda d) horse e) seal f) snake
g) pangolin h) caretta caretta i) polar bear



3 Mayıs 2018, Perşembe

Gruptaki Öğrencilerin İsimleri:

Soru: Türkiye'ye tahsis edilen yer için uzayda **kendinize yeni bir yaşam alanı** tasarlayınız. Bu yaşam alanını tasarlarken, lütfen **seçeceğiniz yeni mesleği** ve yanınızda götürdüğünüz **nesli tükenmekte olan hayvanları (en az 3 hayvan)** dâhil etmeyi unutmayınız.

BUNUN İÇİN LÜTFEN SİZE DAĞITILAN ÇALIŞMA KÂĞIDINDAKİ AŞAMALARI TAKİP EDİN. TASARIMLARINIZ 2 BOYUTLU YA DA 3 BOYUTLU OLABİLİR.

4a-FİKİR GELİŞTİRMEK (15 PUAN): Uzayda tasarlayacağınız yeni yaşam alanı için takım arkadaşınız ile beyin fırtınası yaparak aşağıdaki kutucuklara fikirlerinizi içeren 2 çizim yapın. Unutmayalım! Uzaydaki yeni yaşam alanı, sizi, nesli tükenmekte olan 3 hayvanı ve seçeceğiniz yeni mesleği içermelidir. (15 dakika)

4b- PROTOTİP YAPMAK (5 PUAN):
Lütfen, yaptığınız çizimler arasından bir fikir seçiniz ve bu fikrin prototipini size verilen malzemeler ile yapınız. Bu aşamada, görev paylaşımı yapabilirsiniz.
(35 dakika)

"Uzaydaki yeni komşularınızı, tasarladığınız "WELCOME" kartları ile karşılayacaksınız☺

1-Afiş hazırlayın (10 PUAN):
A3 kâğıt üzerine tasarımınıza (prototipinize) ait tanıtıcı bir AFİŞ hazırlayın.
(10 dakika)
2-Sunum yapmak (20 PUAN):
(20 dakika)

U. STEM activity design guide

TASARIM ODAKLI DÜŞÜNME YAKLAŞIMIYLA STEM ETKİNLİĞİ TASARIMI: ORTAOKUL ÖĞRETMENLERİ İÇİN BİR KILAVUZ

AHSEN ÖZTÜRK

2020

İÇİNDEKİLER

1. ÖNSÖZ

Doç. Dr. Fatma Korkut'a bu kılavuzun oluşturulmasında verdiği destek için en derin şükranlarımı sunuyorum. Ayrıca, bu kılavuzu oluşturmamda bana önerileriyle destek olan Prof. Dr. Gülay Hasdoğan, Prof. Dr. Kürşat Çağıltay ve Doç. Dr. Pınar Kaygan'a ve bu kılavuza değerli zamanlarını ayırarak katkıda bulunan katılımcılara minnettarım.

Son olarak ve en önemlisi, aileme verdikleri destek için teşekkür etmek istiyorum: annem Ayşe Öztürk, babam Hüseyin Öztürk ve kardeşim Esen Öztürk Aydın.

Hocam ve aynı zamanda iş arkadaşım olan merhum Prof. Dr. Memduh Erkin'i burada anmak istiyorum. Huzur içinde yat hocam; desteğiniz, bana olan inancınız ve daima benim iyiliğimi düşündüğünüz için size minnettarım.

Ahsen ÖZTÜRK
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2. STEM EĞİTİMİ VE TASARIM ODAKLI DÜŞÜNME YAKLAŞIMI

STEM (Fen, Teknoloji, Mühendislik ve Matematik) eğitimi veya Türkçe ifadeyle FeTeMM (**Fe**n, **Te**knoloji, **M**ühendislik ve **M**atematik) eğitimi, ortaöğretim düzeyinde disiplinlerarası iş birliği yaparak çeşitli derslerin harmanlamasını amaçlamaktadır. Tanımından anlaşılacağı üzere, STEM eğitimi sadece dört disiplini kapsamakta ve diğer disiplinler bunun dışında bırakılmaktadır. Türkiye'de öğretmenlere verilen STEM eğitimlerine ve ders materyallerine bakıldığında, bunların fen bilgisi ve matematik branşlarına odaklandıkları, sosyal bilgiler, Türkçe, İngilizce veya görsel sanatlar gibi branşlar için yetersiz kaldıkları gözlenmektedir. Bu durum, farklı branşlardan öğretmenlerin kendi aralarında daha fazla iş birliği yapmaları gerektiğine işaret etmektedir. Öğrencilerin etkin katılımını önceleyen yaratıcı süreçlerin ve bu süreçleri destekleyen tasarım metotlarının eğitimde farklı amaçlar için kullanımı giderek artmaktadır; bu açıdan bakıldığında tasarım, disiplinlerarası eğitime katkı sağlayacak en önemli alanlardan bir tanesidir.

Bu kılavuz, ortaokul öğrencileri için farklı disiplinlerden öğretmenlerin, disiplinlerarası iş birliğiyle çalışarak ve tasarım odaklı düşünme yaklaşımını kullanarak STEM etkinliği tasarlaması için gerekli olan aşamaları ve bunlara ait açıklamaları içermektedir. STEM etkinlik tasarımıyla ilgili olan bu kılavuz, STEM eğitimi hakkında bilgi sahibi olan eğitimciler için tasarlanmıştır. Bu kılavuzun uygulanabilmesi için, disiplinlerarası bilgi sahibi olmak ve öğretmenler arasında devamlı iş birliğini sağlamak önemli olacaktır. Ayrıca bu kılavuzun STEM eğitimi hakkında bilgi sahibi profesyonel bir tasarımcı eşliğinde uygulanması önerilmektedir.

3. STEM ETKİNLİK TASARIMI

Bu kılavuz, ortaokul öğrencileri için farklı disiplinlerden öğretmenlerin, disiplinlerarası iş birliğiyle çalışarak ve tasarım odaklı düşünme yaklaşımını kullanarak STEM etkinliği tasarlaması için oluşturulmuştur. Buna göre, ihtiyacınız doğrultusunda, STEM etkinliği tasarlama kılavuzundan bazı aşamaları çıkarabilir veya tamamını uygulayabilirsiniz.

Bu kılavuzda ki aşamaların birer hafta arayla yapılacak iki günlük bir çalışmayla gerçekleştirilmesi önerilmektedir (Tablo 1). <u>Çünkü "Gözlem yapmak" aşamasında bilgi toplamak için yaklaşık bir hafta ara verilmesi tavsiye edilmektedir. Bu kısım dışında iş yükünüz doğrultusunda, STEM etkinlik tasarımındaki aşamaları istediğiniz şekilde uygulayabilirsiniz.</u>

Tablo 1. *STEM etkinlik tasarımı programı*

STEM etkinlik tasarımı	
Birinci gün	**İkinci gün**
• Tasarım odaklı düşünme yaklaşımı nedir? • Konuları belirlemek (50 dak.) • Paydaşları belirlemek (60 dak.) • Gözlem yapmak (50. dak.) **Not:** "Gözlem yapmak" aşamasında bilgi toplamak için yaklaşık bir hafta ara verilmesi tavsiye edilmektedir.	• Bakış açısı geliştirmek (85 dak.) • Fikir geliştirmek (120 dak.) • Prototip yapmak (35 dak.) • Sınamak

Bu plan doğrultusunda, çalışma öncesi ve sırasında aşağıdaki hazırlıkların yapılması önerilmektedir:[4]

[4] Çalışma öncesi ve sırasında yapılması önerilen bazı hazırlıklar HPI (t.y.) dan faydalanarak hazırlanmıştır.

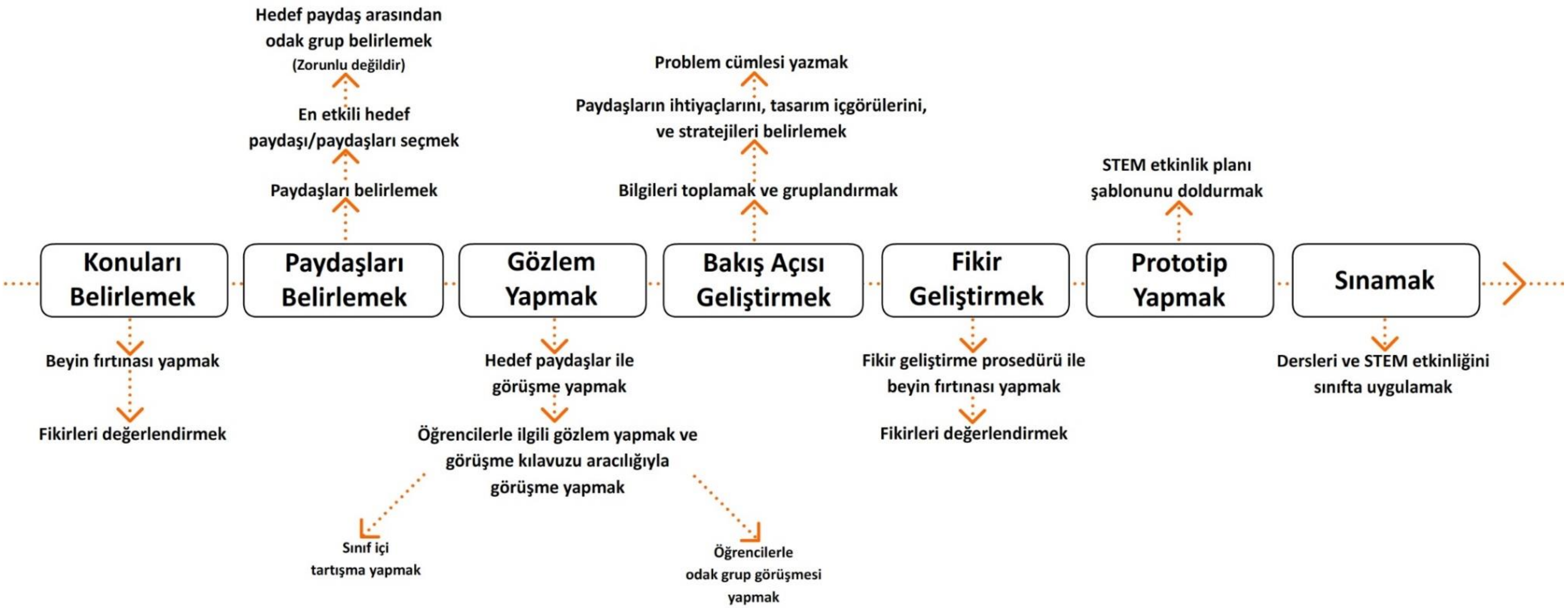
- STEM etkinlik tasarımına başlamadan önce kılavuzu mutlaka okuyun.
- STEM etkinlik tasarımına, farklı disiplinlerden STEM eğitimi hakkında tecrübeli olan öğretmenlerin yanı sıra tecrübesiz öğretmenleri veya stajyer öğretmenleri de STEM eğitimini öğretmek adına dâhil etmeye çalışın.
- Kendinize rahat ve iş birlikli çalışabileceğiniz bir çalışma ortamı yaratın. (Toplantı odası, kütüphane vb.)
- Gerekli malzeme ve dokümanları hazırlayın.
- STEM etkinlik tasarımında sizi yönlendirmesi adına içinizden birini yönetici olarak atayın.
- Her toplantıya başlamadan önce toplantı için ne kadar vakit ayıracağınızı ve bu zaman dilimi içinde neler yapmayı hedeflediğinizi belirleyin.
- Takımdan bir kişiyi, (mümkünse) etkinlik tasarımı aşamalarında zaman tutması için görevlendirin.
- Kronometreyi zaman için ayarlayın ve herkese görünür kılın.
  Her aşama için size ideal bir çalışma zamanı verilmiştir. Bu zamana uymak için, sizden her aşamada hazırlık için istenen detaylara lütfen dikkat edin.
- Çalışma esnasında takım çalışmasının verimliliği için yüz yüze bakacak şekilde oturun.
- Tüm takımı sürece katkıda bulunması için teşvik edin.
- Birbirinizden geribildirim alma veya vermeye özen gösterin.

Buna göre Tablo 2'de size sunulan yedi aşamalı tasarım odaklı düşünme yaklaşımını kullanarak STEM etkinliği tasarlayacaksınız.

Tablo 2. *STEM etkinliği tasarlamak için kullanılan tasarım odaklı düşünme yaklaşımı*

STEM etkinlik tasarımı basamakları	**Konuları belirlemek (50 dakika)**	**Paydaşları belirlemek (60 dakika)**	**Gözlem yapmak (50 dakika)**	**Bakış açısı geliştirmek (85 dakika)**	**Fikir geliştirmek (120 dakika)**	**Prototip yapmak (35 dakika)**	**Sınamak**
Nedir?	Müfredat ekseninde etkinliğe / derse dahil edilecek konuları belirlemek.	Paydaşları belirlemek, en etkili hedef paydaşı/paydaşları seçmek ve hedef paydaş arasından gerekli görülürse odak grup belirlemek.	Paydaşları tanımak için gözlem ve görüşme yapmak.	Önceki aşamalarda elde edilen bilgilere göre STEM etkinlik tasarımı/ dersler için ihtiyaçları belirlemek, analiz yapmak ve buna göre bir problem cümlesi tanımlamak	STEM etkinlik tasarımı/ dersler için fikir geliştirmek.	“Fikir geliştirmek” aşamasında tasarlanan STEM etkinliği/dersleri farklı prototipleme yöntemlerini kullanarak “STEM etkinlik planı” şablonuna yazmak.	Tasarlanan etkinlikleri/dersleri sınıf ortamında uygulayarak öğrenciden geri bildirim almak ve gerekliyse düzeltmeler yaparak etkinlik planını tekrar gözden geçirmek.
Yöntemler	Beyin fırtınası yapmak.	Beyin fırtınası yapmak.	Görüşme yapmak, gözlem yapmak, beyin fırtınası yapmak.	N.I.S. (Need/Insight/Strategy) haritası oluşturmak, beyin fırtınası yapmak.	Beyin fırtınası yapmak.	Planlama, model yapmak, zaman çizelgesi, şema oluşturmak, web tabanlı prototipleme araçları	Akran değerlendirmesi

Not: STEM etkinlik tasarımını gerçekleştirmek için benimsenmesi gereken ve bazıları STEM eğitiminde de önemli yer tutan, tasarım odaklı düşünme yaklaşımına ait on düşünce tarzı 4.6 da size anlatılmıştır. STEM etkinlik tasarımı öncesinde bunları okumanız tavsiye edilmektedir. Düşünce tarzlarının benimsenmesi zaman alan bir süreçtir ve bu sebeple, etkinlik tasarımı süresince bir endüstriyel tasarımcıyla çalışmak size ayrıca yardımcı olacaktır.



Hedef paydaş arasından
odak grup belirlemek
(Zorunlu değildir)
En etkili hedef
paydaşı/paydaşları seçmek
Paydaşları belirlemek
Problem cümlesi yazmak
Paydaşların ihtiyaçlarını, tasarım içgörülerini,
ve stratejileri belirlemek
Bilgileri toplamak ve gruplandırmak
STEM etkinlik planı
şablonunu doldurmak
Konuları Belirlemek
Paydaşları Belirlemek
Gözlem Yapmak
Bakış Açısı Geliştirmek
Fikir Geliştirmek
Prototip Yapmak
Sınamak
Beyin fırtınası yapmak
Fikirleri değerlendirmek
Hedef paydaşlar ile
görüşme yapmak
Öğrencilerle ilgili gözlem yapmak ve
görüşme kılavuzu aracılığıyla
görüşme yapmak
Sınıf içi
tartışma yapmak
Öğrencilerle
odak grup görüşmesi
yapmak
Fikir geliştirme prosedürü ile
beyin fırtınası yapmak
Fikirleri değerlendirmek
Dersleri ve STEM etkinliğini
sınıfta uygulamak

3.1 Aşama 1: Konuları belirlemek (50 dakika)

Kullanılacak Materyaller: Renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt, A4 kâğıt
Yöntem: Beyin Fırtınası yapmak

İki kısımdan oluşan bu aşamada, müfredat ekseninde etkinliğe dâhil edilecek konuları belirlemenizi istiyoruz.

- Beyin Fırtınası Yapmak
- Fikirleri Değerlendirmek

Bu aşamada aşağıdaki hususları dikkate almanızı öneriyoruz;

- Seçilen konular STEM etkinlik tasarımı sürecinde değişebilir.
- Lütfen kendinizi rahat hissedeceğiniz ve hazırlık için zaman ayırabileceğiniz konuları seçmeye çalışın.
- Konuların müfredatta hangi sırayla ve ne zaman işleneceğine ve STEM etkinliği öncesi seçilmiş tüm konuların işlenmiş olmasına dikkat edin.
- Bu aşamayı kolaylaştırmak için bir araya gelmeden önce, haftalık ders planlarınızı, müfredatlarınızı ve boş saatlerinizle ilgili bilgileri lütfen birbirinizle paylaşın.
- Okulda STEM etkinliği ilk defa uygulanacaksa, hem öğrencilerin hem de öğretmenlerin adaptasyonunu kolaylaştırmak adına akademik olarak kolay ve eğlenceli konuları seçmeye çalışın.

1- Beyin fırtınası yapmak (40 dakika)

Müfredatınızda işleyeceğiniz/işlediğiniz hangi konuları STEM etkinliğine dâhil edeceğinize dair beyin fırtınası yapacaksınız. Bunun için, gerekli materyalleri hazırlayın ve kendinize 40 dakika süre ayırın. Beyin fırtınası yapmanızı kolaylaştırmak adına, beyin fırtınasıyla ilgili size sunulmuş yöntem ve kuralları lütfen dikkate alın (4.1).

- Grubunuzda hangi derslerin olduğunu büyük bir kâğıda yan yana gelecek şekilde yazın (Şekil 1).
- STEM etkinliğine hangi konuların dâhil edilebileceğine dair beyin fırtınası yapın.
- Konuları seçerken ve takım arkadaşlarınızla paylaşırken diğer dersler ile hangi noktada bağlantı kurabileceğinizi grup olarak araştırın. Dolayısıyla **“bu konuları bir arada ele alarak öğrencilere etkinlikte nasıl bir problem sorulabilir veya bu konular probleme çözüm bulma esnasında öğrencilere nasıl yardımcı olabilir”** noktasına odaklanın.
- Bu derslerin altına beyin fırtınasında ortaya çıkan konularınızı not kâğıdı ile yapıştırın ve sözlü olarak birbirinizle paylaşın.
- Çok fikir üretmeye çalışın ve fikirlerinizin kalitesini değerlendirmeyin.

Şekil 1. “Konuları belirlemek” aşamasında beyin fırtınası yapımına dair bir örnek

2- Fikirleri değerlendirmek (10 dakika)

- Herkesten kendisi için favori olan konuya oy vermesini isteyin.
- Takımınızla bir A4 kâğıt üzerine en çok oy alarak seçilen konuları yazın.

3.2 Aşama 2: Paydaşları belirlemek (60 dakika)

Kullanılacak materyaller: Renkli kalem, tükenmez kalem, renkli yapışkanlı not kağıdı, 50-70 cm kâğıt, A4 kâğıt
Yöntem: Beyin fırtınası yapmak

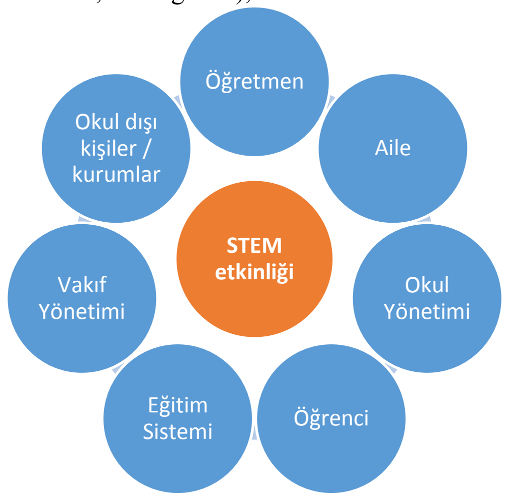
Bu aşamada, belirlediğiniz konular doğrultusunda etkinlik için önem arz eden paydaşlar belirlenecektir. Eğer bu çalışmayı yöneten kişi, okul dışından ya da okulda işe yeni başlamış biri ise, bu aşama, üzerinde çalıştığı kurumu ve kişileri tanımasına yardımcı olacaktır. Bu aşama 3 kısımdan oluşmaktadır:

- Paydaşları belirlemek.
- STEM etkinliği uygulaması için en etkili hedef paydaşı/paydaşları seçmek.
- Bir sonraki "Gözlem yapmak" aşamasını kolaylaştırmak için, hedef paydaş/paydaşlar arasından maksimum 8 kişilik bir odak grup belirlemek.

1- Paydaşları belirlemek (20 dakika)

Bu kısımda STEM etkinliğinin tasarlanması ve okulda uygulanmasından etkilenecek/etkileyecek paydaşları belirlemeniz beklenmektedir. Beyin fırtınası esnasında dikkat edilmesi gereken kurallar ve beyin fırtınasıyla ilgili bazı yöntemler 4.1'de anlatılmıştır. Buna göre:

- 4.3'te bulunan tabloyu 50-70 cm kâğıt üzerinde yatay bir şekilde oluşturun.
- STEM etkinliğine aktif olarak dâhil edilecek ve etkinliğin gerçekleşmesine yardımcı olacak paydaşlar üzerine Şekil 2'de bulunan görseli örnek alarak beyin fırtınası yapın ve bu esnada seçtiğiniz paydaşları grup arkadaşlarınızla (sebeplerini de belirterek) paylaşın.
- Beyin fırtınasında ortaya çıkan paydaşların isimlerini, yapışkanlı not kâğıdına yazarak 50-70 cm bir kâğıda yapıştırın ve sözlü olarak birbirinizle paylaşın.
- Herkesten kendileri için favori olan paydaşa oy vermesini isteyin.
- Seçilen paydaşları ve onların seçilme nedenlerini elinizdeki bilgilere göre tablo üzerinde (Bknz. örnek: Tablo 4) doldurun. Bu noktada, paydaşların projedeki rolü, eğer biliniyorsa projeye karşı olan tavırları, proje hakkındaki endişeleri, onlardan proje kapsamında beklenenler ve STEM etkinliğinin uygulanması için onlara dair ihtiyaçlar belirlenecektir. Tablodaki belirli kısımları aşağıdaki gibi doldurabilirsiniz:
    1. Proje hakkındaki tavrı: Destekleyici, Nötr, Orta derecede destekleyici, Orta derecede karşı, Karşı
    2. Projedeki Rolü: Aktif katılımcı, Orta derecede katılımcı, Destekleyici (STEM etkinliğinin uygulanması için yer, malzeme, vb. sağlama), Nötr



Şekil 2. STEM etkinlik tasarımı ve uygulamasındaki muhtemel paydaşlar

2- STEM etkinliği uygulaması için en etkili hedef paydaşı/paydaşları seçmek (20 dakika)

İkinci kısımda STEM etkinliği uygulaması için en etkili hedef paydaşın/paydaşların seçilmesi sizden beklenmektedir. Bu kısımda, STEM etkinliğinin tasarlanması ve uygulanması üzerindeki etkilerine dair paydaşlara bir etki düzeyi biçilecektir. Bu şekilde, STEM etkinliğinin okulda uygulanmasından en fazla etkilenecek ve en az etkilenecek paydaş/paydaşlar ortaya çıkacaktır.

- Seçtiğiniz paydaşların etki düzeyini (Yüksek, Orta, Düşük) belirleyin. Bu noktada, STEM etkinliği uygulamasından en yüksek düzeyde etkilenecek paydaşlardan birinin öğrenciler olması beklenmektedir. Diğerlerini belirlemek için aşağıdaki örnek (Tablo 3) size fikir verebilir.

Tablo 3. *Paydaşlar için örnek etki düzeyi belirlemesi*

STEM etkinliği uygulamasını etkileyecek paydaşlardan biri ailelerdir. Bazı aileler çocuklarının derslerdeki başarısına çok önem verdiği için STEM etkinliği uygulamasının onların başarısını olumsuz etkileyeceğini düşünebilir. Bu durumda, onların STEM etkinliği uygulamalarına karşı çıkması beklenebilir. Bu sebeple, STEM etkinliğinin okulda uygulanmasında **yüksek** düzeyde bir etkiye sahip olabilirler.

- Tabloya göre STEM etkinliği uygulaması için en etkili hedef paydaşı/paydaşları etki düzeyi yüksek olan paydaşlar arasından seçin.

3- Hedef paydaş/paydaşlar arasından odak grup belirlemek (20 dakika) (Bu aşama zorunlu değildir)

Bir sonraki "Gözlem yapmak" aşamasında, etki düzeyi yüksek paydaş/paydaşların hepsi ya da bazıları hakkında bilgi toplamak için görüşme ve gözlem yapılacaktır. Eğer hedef paydaş/paydaşlar içerikte sayı olarak fazla ise (30 kişilik sınıf) veya bilgi toplamak için ayrılan zaman kısıtlıysa rahat çalışabilmek adına (istenirse) içlerinden maksimum 8 kişilik bütün paydaşı/paydaşları temsil eden bir odak grup belirlenebilir.

Bu kısımda öncelikle hangi paydaşlar için bilgi toplanacağına karar verilmelidir. Sonrasında odak grup belirleme noktasında öğrenciler ve diğer paydaşlar için iki ayrı yol izlenmektedir:

3a- Öğrenciler için

- Farklı tutum/başarı düzeyine sahip olduğunu düşündüğünüz veya sınıfa yeni gelen öğrencileri beyin fırtınası yaparak tespit edin.
- Sonrasında bir kâğıt üzerine yapışkanlı not kâğıdı yardımıyla bu öğrencileri ve neden seçildiklerini not edin ve nihai karara varmak için nedenleriyle birlikte takımınızla paylaşın.
- Bu aşamada herkes kendi dersini dikkate alarak odak grup belirlemeye başlayabilir ve sonrasında diğer öğretmenler ile birlikte ortak bir karara varılabilir.
- Odak grup seçildiği takdirde, "Gözlem yapmak" safhasında kimlerle iletişime geçileceğini Tablo 4'te gösterildiği gibi gerekli yerlere yazın.

3b- Diğer paydaşlar için

- Hedef paydaş/paydaşlar arasından iletişim kurmak istediklerinizi lütfen beyin fırtınası yaparak tespit edin.
- Sonrasında bir kâğıt üzerine yapışkanlı not kâğıdı yardımıyla bu kişileri ve neden seçildiklerini not edin ve nihai karara varmak için nedenleriyle birlikte takımınızla paylaşın.
- Odak grup seçildiği takdirde, "Gözlem yapmak" safhasında kimlerle iletişime geçileceğini Tablo 4'te gösterildiği gibi gerekli yerlere yazın.

NOT: Tabloda bulunan paydaşlarla ilgili "potansiyel stratejiler", "Gözlem yapmak" ve "Bakış açısı geliştirmek" aşamalarıyla birlikte belirlenmiş olacaktır. Ayrıca paydaşlarla ilgili bazı bilgiler "Gözlem yapmak" safhasında elde edileceğinden ya da netlik kazanacağından, bu aşamadan sonra bazı bilgiler (projedeki rolü, projeye etki düzeyleri, ihtiyaç vb.) değişiklik gösterebilir. Bu durum, oluşturduğunuz tabloyu yeniden düzenlemenize neden olabilir.

Tablo 4. Örnek paydaş analiz tablosu

Paydaş	Projedeki rolü	Beklentiler	Proje hakkındaki tavrı	Proje hakkındaki endişesi	İhtiyaç	Projeye etki düzeyi	Odak grup	Potansiyel stratejiler
Öğrenciler	Aktif Katılımcı	STEM etkinliğine katılması.	Bilinmiyor	Bilinmiyor	STEM etkinlik uygulamasına dâhil olmaları.	Yüksek	Ayşe, Fatma, Ali, Ahmet, Zeynep ve Zeki hakkında bilgi toplanacaktır.	
Öğretmenler	Aktif Katılımcı	STEM etkinliği tasarlaması ve uygulaması.	Destekleyici	Bilinmiyor	STEM etkinlik tasarımı ve uygulamasına vakit ayırması.	Yüksek	Bilgi toplanmasına gerek yoktur.	
Okul yönetimi	Destekleyici	Okulda STEM eğitimi uygulamasına izin vermesi.	Destekleyici		Öğretmenlere STEM etkinlik tasarımı ve uygulaması için gerekli izni/desteği vermek. Veli onayı için öğretmenlere yardımcı olmak.	Yüksek	Bilgi toplanmasına gerek yoktur.	
Aileler	Destekleyici	STEM eğitiminin okulda uygulanmasının desteklemesi.	Bilinmiyor	Çocuklar derslerden geri kalır mı? (bilgi eksikliği var)	STEM etkinliğini uygulamak için ailelerden izin almak.	Yüksek	Sınıf annesi, seçilmiş öğrenci velisi ve gerekirse okul aile birliği yöneticisiyle görüşmek.	
Eğitim sistemi (ulusal/okul sınavları, sistem değişiklikleri)	Nötr (Etkisiz)	Ulusal sınavlar ve okul sınavları için etüt yapılması.			STEM etkinliği için ayrılacak zamanın sınav hazırlığından çalmaması.	Orta		
STEM etkinliğine dışarıdan dâhil olacak kurumlar: Müze	Aktif katılımcı	STEM etkinliğinin uygulanması sırasında Müze’nin mekân olarak kullanılmasına izin vermesi.			Müze ye gitmek için veliler ve okul yönetiminden izin almak, müze yetkililerinden izin almak, öğrencilerin okuldan müzeye nakli için gerekli ayarlamaları yapmak.	Düşük	Tasarlanacak etkinliğe göre, sonrasında gerekli görülürse müze ile iletişime geçilecektir.	

3.3 Aşama 3: Gözlem yapmak (50 dakika)

Kullanılacak Materyaller: Görüşme yapmak için hazırlanmış form, Gözlem yapmak için hazırlanmış form, renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt, A4 kâğıt
Yöntem: Görüşme yapmak, Gözlem yapmak, Beyin fırtınası yapmak

Bu aşamada, gözlem ve görüşme yaparak paydaşlar hakkında bilgi toplamak amaçlanmaktadır. Özellikle çok disiplinli STEM etkinlik tasarımında veya STEM eğitiminin ilk defa uygulandığı okullarda bu yöntem, sizin bütün paydaşlara hitap eden bir STEM etkinliği tasarlamanıza yardımcı olacaktır. Paydaşlarla ilgili bilgi toplamanız için yaklaşık bir hafta süre ayırmanız tavsiye edilmektedir. Bu kısımda önce hangi hedef paydaşlar için bilgi toplanacağına karar verilmelidir. Sonrasında öğrenciler ve diğer paydaşlar için iki ayrı yol izlenecektir:

- Öğrenciler ile gözlem ve görüşme yapmak (görüşme soruları hazır verilecektir)
- Diğer hedef paydaşlar ile görüşme yapmak (görüşme soruları sizin tarafınızdan hazırlanacaktır)

Öğrenciler ile görüşme ve gözlem yapmak (20 dakika)

1- **Görüşme yapmak**

Bu kısımda 4.4'te size sunulan soruları kullanarak öğrencilerle görüşme yapmanız beklenmektedir. Buna göre, sizden aşağıdaki hususları dikkate alarak görüşme yapmanızı istiyoruz.

- Size hazır olarak öğrenciler için verilen soruları gözden geçirin ve gerekli gördüğünüz noktada sorulara ekleme veya çıkarma yaparak soruları revize edin. Soruların kapsamının geniş olması sebebiyle onları seçerken **öğrencilerin yaş aralığını da** göz önünde bulundurmayı unutmayın.
- Zaman sıkıntısınız varsa "STEM etkinliği için problem/tema belirleme" başlığı altındaki son iki soruya cevap aramak etkinlik tasarlamanıza yardımcı olabilir. Tüm öğrencilerden bilgi almak istenirse bu sorular anket olarak sınıfa dağıtılabilir. Bu sorularda ayrıca, etkinlik için seçilen konulara göre temalar revize edilebilir.
- Takımınızdan soruları sorması için bir öğretmen arkadaşınızı seçin (varsa sınıf öğretmeni ya da rehberlik öğretmeni olabilir).
- Görüşme yapmak için aşağıda ayrıntılı olarak anlatılan yöntemlerden birini seçin.

1a- Sınıf içi tartışma yapmak

Sınıf hakkında bilgi edinmek için, sınıf içi tartışma ortamı yaratılarak sorular öğrencilere toplu halde sorulabilir. Bu noktada, aşağıdaki hususlara dikkat edilmelidir:

- Sınıf içi tartışma sırasında, öğrencinin yüz ifadesine, ses tonuna ve vücut diline, verdiği bilgilerin doğruluğunu kontrol etmek için dikkat edin (MIT MOOCs course, t.y.).
- Tartışma esnasında veya hemen sonrasında sürekli not alın ve hemen ardından notlarınızla ilgili kendi düşüncelerinizi de yazmayı unutmayın (MIT MOOCs course, t.y.).
- Bir sonraki aşamada yapılacak olan veri analizinde size yardımcı olması için, elde ettiğiniz bilgileri, sorduğunuz sorular altında toplayarak görüşme için hazırlanmış form (EK 9) üzerine not edin.

1b- Öğrencilerle odak grup görüşmesi yapmak

Sınıf mevcudu fazla ise veya bilgi toplamak için ayrılan zaman kısıtlıysa bütün sınıf yerine "Paydaşları belirlemek" aşamasında seçilmiş olan ve bütün sınıfı temsil ettiği düşünülen **odak grup öğrencileri** ile görüşme yapılabilir. "Sınıf içi tartışma yaparak görüşme yapmak" kısmındaki kurallar burada da geçerlidir. Görüşmelerden elde edilen veri miktarı öncekine nazaran daha az olacağından, bu durum bir sonraki aşamada yapılacak olan veri analizinde size zaman açısından kazanç sağlayacaktır.

2- **Gözlem yapmak**

Bu kısımda öğrencilerinizin sınıf içinde nasıl davrandıklarını, birbirleriyle nasıl iletişime geçtiklerini izleyerek gözlem yapmanızı istiyoruz. Bu kısımda amaç, görüşmelerden elde edilen cevapları doğrulamaktır. Buna göre;

1. STEM etkinlik tasarımına dâhil bütün öğretmenlerden gözlem yapmaları beklenmektedir. Buna göre, Tablo 5'deki sorular size yol gösterebilir.
2. Gözlem yapma kısmında elde ettiğiniz bilgileri, belli başlıklar altında gruplayarak (sosyal ilişkiler, derse katılım vb.) gözlem yapmak için hazırlanmış form (4.10) üzerine not edin.

Tablo 5. *Gözlem yaparken cevap aranacak örnek sorular*

-Öğrencileriniz ne tür etkinlikleri seviyorlar veya ilgi alanları nelerdir?
-Öğrencileriniz nasıl öğrenmeyi seviyorlar?
Örnek: Dinleyerek, okuyarak, izleyerek, oyunla, bilgisayarla, yaparak ve yaşayarak, bireysel çalışarak, grup çalışmasıyla, akran öğrenmesi vs.
-Öğrencileriniz, öğrendikleri bilgileri en rahat nasıl ifade ediyorlar?
Örnek: Rapor/hikâye yazarak, proje odaklı çalışarak, sanatsal çalışmalar yaparak, drama, medya (video-sunum), konuşarak, poster vb. gösterimi
-Öğrencilerinizin sınıftaki deneyimlerine veya kendi hayatlarına dair dile getirdiği şikâyetlerden/problemlerden bazıları nelerdir?
-Öğrencileriniz sizin ders işleyişiniz hakkında ne düşünüyorlar?
-Öğrencilerinizin sınıftaki çalışmalara/derse katılım düzeyi nedir?
-Öğrencilerinizin birbirleriyle etkileşimi/iletişimi nasıldır?

Diğer hedef paydaşlar ile görüşme yapmak (30 dakika)

Bu kısımda, diğer paydaşları tanımak için görüşme yapmanız beklenmektedir. Buna göre, sizden aşağıdaki hususları dikkate alarak görüşme yapmanızı istiyoruz:

- Görüşme sorularınızı grup arkadaşlarınızla beyin fırtınası yaparak hazırlayın.
- Grubunuzdan, soruları sorması için bir öğretmen arkadaşınızı seçin (varsa sınıf öğretmeni ya da rehberlik öğretmeni olabilir).
- Yapılan görüşme sonucu elde edilen bilgileri, sorduğunuz sorular altında toplayarak, görüşme için hazırlanmış form (4.9) üzerine not edin.

Not: Bu aşamada sizden gözlem yapmanız beklenmemektedir. Fakat daha önceki deneyimlerinizi, gözlem yapmak için hazırlanmış form üzerine not etmeniz istenmektedir. Örneğin, paydaşınız aileler ise, veli toplantıları ya da birebir görüşmelerden elde edilen bilgiler ya da paydaşınız okul yönetimi ise, onların eğitimle ilgili yaklaşımları bu form üzerine not edilebilir.

1- Soruları hazırlamak

Kullanılacak Materyaller: Görüşme yapmak için hazırlanmış form, renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt, A4 kâğıt

Bu kısımda amaç, hedef paydaşlara yönelik STEM etkinliği tasarlamanıza yardımcı olacak sorular hazırlamaktır (8 soru olabilir). Buna göre;

- Görüşme sorularınızı hazırlamak için grup arkadaşlarınızla beyin fırtınası yapın ve bu esnada aklınıza gelen soruları, sebeplerini de belirterek grup arkadaşlarınızla paylaşın. Beyin fırtınası esnasında dikkat edilmesi gereken kurallar ve kullanılabilecek yöntemler 4.1'de anlatılmıştır. Bu noktada, aşağıdaki sorular (Tablo 6) size yol gösterebilir:

Tablo 6. *Diğer paydaşlarla ilgili örnek sorular*

-Paydaşınız aile ise, çocuğuyla ilgili beklentileri nelerdir? (Daha başarılı/sosyal/mutlu olması, belirli mesleklere sahip olması)
-Paydaşlar okulda verilen eğitim hakkında ne düşünmektedir?
-Paydaşların okulda STEM etkinliği yapılmasına dair düşünceleri nedir?
-Paydaşların, çocuklarının etkinlik için okul dışına çıkarılmaları (etkinlik için müzeye gitmek) hakkındaki tavrı nedir?

- Beyin fırtınasında ortaya çıkan soruları yapışkanlı not kâğıdına yazarak 50-70 cm kâğıda yapıştırın ve sözlü olarak birbirinizle paylaşın.
- Herkesten, kendileri için favori olan soruya oy vermesini isteyin.
- Takımınızla beraber, seçilen soruları görüşme yapmak için hazırlanmış form (4.9) üzerine not edin. Görüşme sonrasında elde ettiğiniz veriler doğrultusunda cevaplarınızı karşısına not etmeyi unutmayın.

Konuları belirlemek | Paydaşları belirlemek | Gözlem yapmak | Bakış açısı geliştirmek | Fikir geliştirmek | Prototip yapmak | Sınamak

3.4 Aşama 4: Bakış açısı geliştirmek (85 dakika)

Kullanılacak Materyaller: 50-70 cm kâğıt, renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, A4 kâğıt ve kâğıt bant
Yöntem: N.I.S. haritası, Beyin fırtınası yapmak

Bu aşamada katılımcılardan, önceki aşamalarda elde edilen bilgilere göre STEM etkinlik tasarımı için ihtiyaçları ve iç görüleri belirlemeleri ve buna göre bir problem cümlesi oluşturmaları beklenir. Bunun için üç aşamada N.I.S. (Need/Insight/Strategy) haritası oluşturmanız gerekmektedir.

1- "Gözlem Yapmak" ve "Paydaşları Belirlemek" aşamalarında elde edilen bilgiler bir araya getirilerek gruplandırılır.
2- Bu bilgiler doğrultusunda, STEM etkinliği uygulaması için, ihtiyaç ve analizler belirlenir ve buna göre stratejiler geliştirilir.
3- Ortaya çıkan ihtiyaç ve analizler doğrultusunda bir problem cümlesi yazılır.

1- Bilgileri toplamak ve gruplandırmak (35 dakika)

N.I.S. haritasını oluşturmadan önce paydaşlarla ilgili bilgiler gruplandırılacaktır.

- 50-70 cm kâğıt üzerine paydaşlara görüşmede sorduğunuz soruları yazın.
- Bu sorular dışında gözlemlerinizden/deneyimlerinizden elde ettiğiniz başka bilgiler varsa (örneğin, öğrencilerin birbirleriyle sosyal ilişkileri, derse katılım düzeyi vb.), bunlara dair ana başlıkları da aynı kâğıda ekleyin.
- Bu başlıkların altına, elde ettiğiniz bilgileri yapışkanlı not kâğıdı ile özetleyerek yapıştırın ve sözlü olarak birbirinizle paylaşın.
- "Konuları belirlemek" aşamasında seçtiğiniz konulara göre, gereksiz bilgileri eleyin.
- Takımınızla, -eğer varsa- benzer cevapları bir araya getirerek birleştirin ve işe yaramayan kısımları eleyin.

Buna göre, Şekil 3'de olduğu gibi, görüşme soruları dikkate alınarak (4.4) öğrencilerle ilgili üç ana başlık oluşturulmuş (STEM etkinliğinin içeriğini oluşturma, konular veya dersler arasındaki bağlantılar, STEM etkinliği için problem/tema belirleme), sonrasında başlıklara ait soruların cevapları, yapışkanlı not kâğıdı yardımıyla o başlıkların altlarına yapıştırılmıştır. Ayrıca, öğrenciler dışında belirlenen diğer iki paydaş için (aileler ve okul yönetimi) elde edilen bilgiler, yine gruplandırılarak yapışkanlı not kâğıdı yardımıyla kâğıt üzerine yapıştırılmış ve bu şekilde bilgiler gruplandırılarak bir araya getirilmiştir.

2- İhtiyaç/analiz/strateji belirlemek (35 dakika)

Bu aşamada, elde edilen verilere göre tespitlerinizin ne olduğu takım arkadaşlarınızla tartışılacak, sonrasında bunun doğrultusunda STEM etkinliği için ihtiyaç ve analizleriniz belirlenecek ve buna göre potansiyel stratejiler geliştirilecektir. İhtiyaç/analiz/strateji belirlemenin ne anlama geldiği Tablo 7'de özetlenmiştir. Ayrıca, ihtiyaç ve analiz 4.6 da detaylı olarak anlatılmıştır. Bu noktada ihtiyaç/analizleri belirlemek için kendinize şu soruyu sorabilirsiniz:

"Paydaşların STEM etkinliği uygulamasına destek vermeleri/aktif olarak katılmaları için neye ihtiyaç (gereksinim) vardır? Bu ihtiyaçlar doğrultusunda nasıl bir yol/strateji izlenmelidir?"

Tablo 7. *İhtiyaç/analiz/strateji tanımları*

İhtiyaç: Bu aşamada, STEM etkinlik tasarımını, öğrencileri, aileleri, okul imkânlarını ve yönetimini düşündüğünüzde, elinizdeki veriye göre STEM etkinliği için ihtiyaçları belirlemeniz gerekmektedir. Belirlediğiniz ihtiyaçların, STEM etkinlik tasarımı için size yardımcı olacak ipuçlarını vermesi beklenmektedir.
Analiz: Analizler, araştırmalarınızdan öğrendiklerinizin özlü bir ifadesidir ve her zaman size yeni bir perspektif sunar. Bu noktada, lütfen öğrencilerinize, diğer paydaşlara ve STEM etkinliğine dair elde ettiğiniz bilgileri ve ihtiyaçları göz önünde bulundurun. Analizlerinizi tanımlamak için bu bilgilere bakın ve en şaşırtıcı, ilginç veya takip etmeye değer bulduğunuz bilgileri seçin. Analizlerinizi elde ettiğiniz bilgilerin sentezi olacak şekilde yapmaya çalışın (IDEO, 2012).
Strateji: Strateji, STEM etkinliğini tasarlamak ve uygulamak için atılacak adımlar, uygulanacak yöntemleri ifade etmektedir. Buna göre, ihtiyaç ve analizler ortaya konduktan sonra sizden stratejiler belirlemeniz beklenmektedir.

Şekil 3. Bilgileri gruplandırma

İhtiyaç/analiz/stratejileri belirlemek için aşağıdaki süreç takip edilmelidir:

- 50-70 cm kâğıt üzerine öncelikle "Konuları belirlemek" aşamasında karar verdiğiniz konuları yapışkanlı not kâğıdı yardımıyla yapıştırın. Konularınızın ne olduğu, ihtiyaç ve analizleri belirlemenizde size bir çerçeve çizecektir.
- STEM eğitimini okulda uygulamak için kâğıt üzerinde üç ana başlık oluşturun. Bu başlıklar: *aynı tema altında düzenlenen dersler*, *disiplinlerarası dersler (ekip öğretim yöntemi ve/veya bireysel öğretim yöntemiyle verilen disiplinlerarası dersler)* ve *STEM Etkinliği* (Şekil 4). Lütfen unutmayalım, **STEM eğitimini okulda uygulamak için STEM etkinliği öncesi ders uygulanması bir zorunluluk değildir.**
- Eldeki verilere göre, bu üç ana başlık altında beyin fırtınası yaparak öncelikle ihtiyaçlarınızı ve bunun doğrultusunda analizlerinizi belirleyin, sonrasında ihtiyaç/analizlerinize göre potansiyel stratejilerinizi oluşturun. Bu aşamada 4.5'te sunulan bilgiyi lütfen önceden okuyun.
- STEM etkinliğini okulda uygulamak için, diğer paydaşlarla ilgili nasıl bir yol izlemek gerektiğine dair çıkarımlar da bulunun. Buna göre, Tablo 8'de, Şekil 4'deki ihtiyaç/analiz/stratejilerin nasıl oluşturulduğu örnek olarak gösterilmiştir.

Tablo 8. *İhtiyaç/analiz/strateji belirlenmesine dair bir örnek*

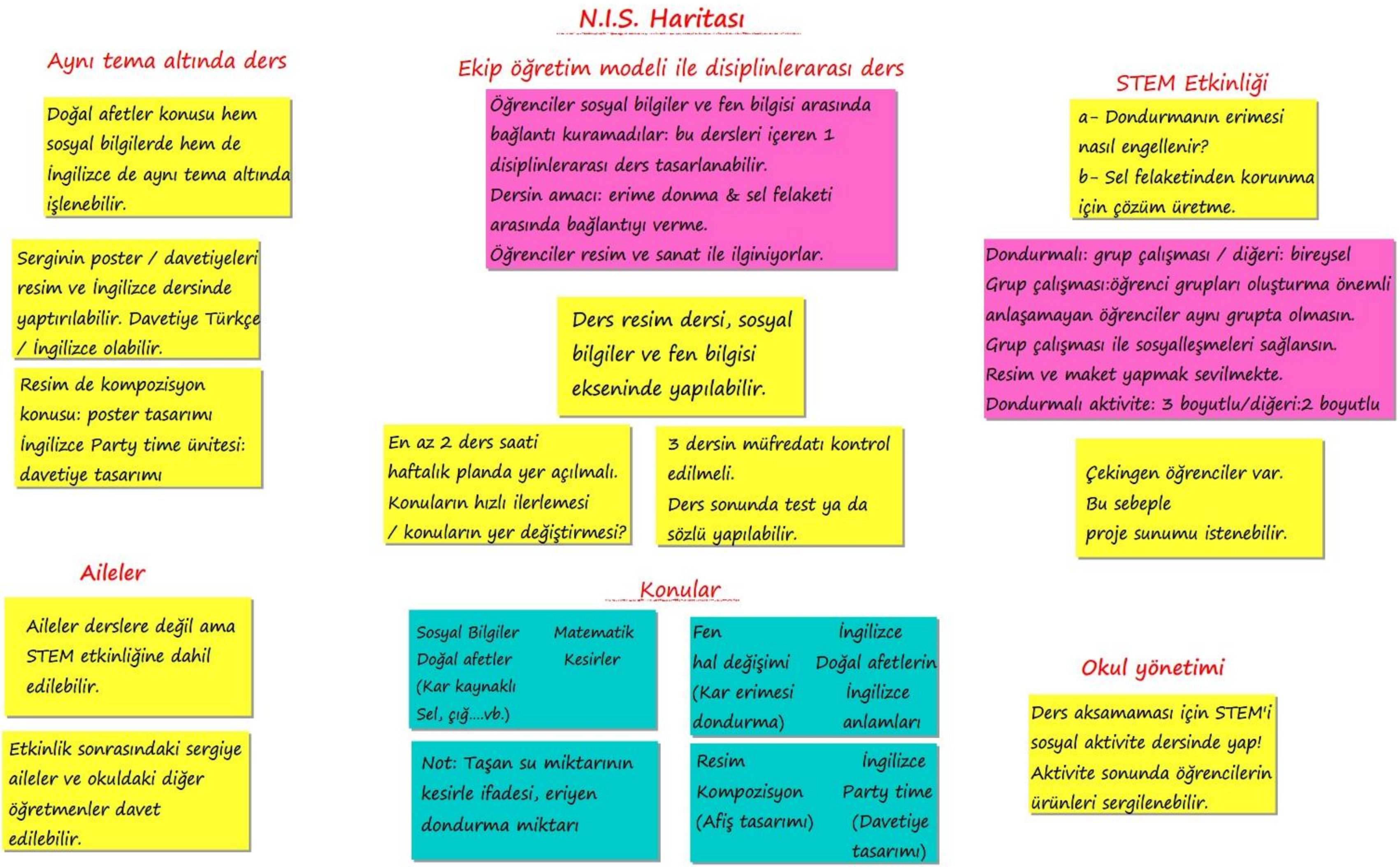
Çocuklar ailelerinin derslerine katılmasına sıcak bakmamakta, hatta endişe duymaktadır (**Analiz**). Aileler de, STEM'den dolayı çocuklarının başarılarının negatif olarak etkilenmesini istememektedir. Bu sebeple, dersler yerine ailelerin STEM etkinliğine dâhil edilmesine karar verilmiştir (**Strateji**). Böylelikle, aileler çocuklarıyla beraber vakit geçirme şansına sahip olabilir ve bu durum da, çocuklarda korku yerine sevgi ihtiyacının beslenmesine yardımcı olabilir (**İhtiyaç**).
Elde edilen verilere göre *aynı tema altında düzenlenen dersler* ile *disiplinlerarası derslerin* işlenmesi gerektiği ortaya çıkmıştır (**Strateji**). *Disiplinlerarası ders,* sosyal bilgiler ile fen bilgisi arasında bağlantı kurulamadığından gerekli görülmüştür (**İhtiyaç**). Yapılacak *disiplinlerarası derse,* öğrencilerin sosyal bilgilerle görsel sanatlar arasında bağlantı kurması sebebiyle (**Analiz**) görsel sanatlar da eklenmiştir (**Strateji**).
Seçilen konular sebebiyle, doğal afetler konusunun hem sosyal bilgilerde hem de İngilizcede işlenmesine karar verilmiştir (**Strateji**). Aynı zamanda bu iki ders, fen bilgisindeki maddenin hal değişimine de değinecektir. STEM etkinliği sonunda yapılacak serginin -içeriğindeki konular sebebiyle- (**Analiz**) poster ve davetiyelerinin, görsel sanatlar ve İngilizce derslerinde yapılmasına karar verilmiştir (**Strateji**).

3- Problem cümlesini yazmak (15 dakika)

İhtiyaç/analiz/stratejileri belirledikten sonra, "Fikir geliştirmek" aşamasında bize yardımcı olması için problem cümlesi oluşturulacaktır. Bu noktada, STEM etkinliğini, tasarlanacak dersleri, ders konularını, öğrencileri, diğer paydaşları içine alan ve etkinliğe dair elde edilen ihtiyaç/analiz/stratejileri özetleyen bir problem cümlesi oluşturmanız ve bunu yapışkanlı not kâğıdı üzerine yazmanız beklenmektedir. Eğer tek bir cümle içinde kendinizi ifade edemiyorsanız, iki farklı cümle kurabilirsiniz.

Tablo 9. *Problem cümlesi yazımı için bir örnek*

STEM etkinliklerini okulda gerçekleştirmek için erime-donma ve doğal afetler arasındaki bağlantıyı gösterecek bir *disiplinlerarası ders* ile (fen bilgisi, sosyal bilgiler ve görsel sanatlar) doğal afetler teması altında iki adet *aynı tema altında düzenlenen ders* (İngilizce ve sosyal bilgiler dersleri) tasarlanması, *disiplinlerarası derse* haftalık planda yer açmak için planlama yapılması, STEM etkinliklerine ailelerinde dâhil edilmesi ve hem bireysel, hem de sosyal gelişimleri öğrencilere için grup çalışması yaptırılması, etkinliklere ayrılacak süreler de dikkate alınarak öğrencilerden çözüm olarak iki veya üç boyutlu ürün istenmesi, etkinliklerin okulun işleyişini bozmaması için sosyal aktivite dersinde düzenlenmesi ve etkinlik sonrası aileler de dâhil olmak üzere tüm okulun davet edileceği, poster ve davetiyelerin öğrenciler tarafından görsel sanatlar ve İngilizce derslerinde yapılacağı, bir sergi organize edilmesi amaçlanmaktadır.



Şekil 4. İhtiyaç/analiz/strateji belirleme haritası (N.I.S. haritası)

3.5 Aşama 5: Fikir geliştirmek (120 dakika)

Kullanılacak Materyaller: Renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, A4 kâğıt ve kâğıt bant
Yöntem: Beyin fırtınası yapmak

Bu aşamada, STEM etkinlik tasarımı/dersler için fikir üretmek amaçlanmaktadır. Buna göre, N.I.S. haritası, seçilen konular ve STEM Etkinlik Planı şablonu dikkate alınarak beyin fırtınası yapılacaktır. Bu aşamada iki yol izlenecektir:

- Beyin Fırtınası Yapmak
- Fikirleri Değerlendirmek

1a- Beyin Fırtınası Yapmak: (60 dakika)
Bu kısımda, takım arkadaşlarınızla beyin fırtınası yaparak STEM etkinlik tasarımı/dersler için fikir geliştirmenizi istiyoruz. Beyin fırtınası esnasında dikkat edilmesi gereken kurallar ve ilgili bazı yöntemler 4.1'de anlatılmıştır. Beyin fırtınası yapmanızı kolaylaştırmak ve yönetmek adına size bir prosedür (**gerekirse prosedüre eklemeler de yapılabilir**) sunulmuştur. Burada amaç, etkinlik/ders tasarımının tamamına odaklanmak yerine ayrıntıları, prosedürü dikkate alarak tek tek düşünmek, üzerine fikir geliştirmek ve daha sonra ayrı fikirleri birleştirerek bir sonuca ulaşmaktır. Prosedür Tablo 10'daki başlıklardan oluşmaktadır;

Tablo 10. *Fikir geliştirme prosedürü*

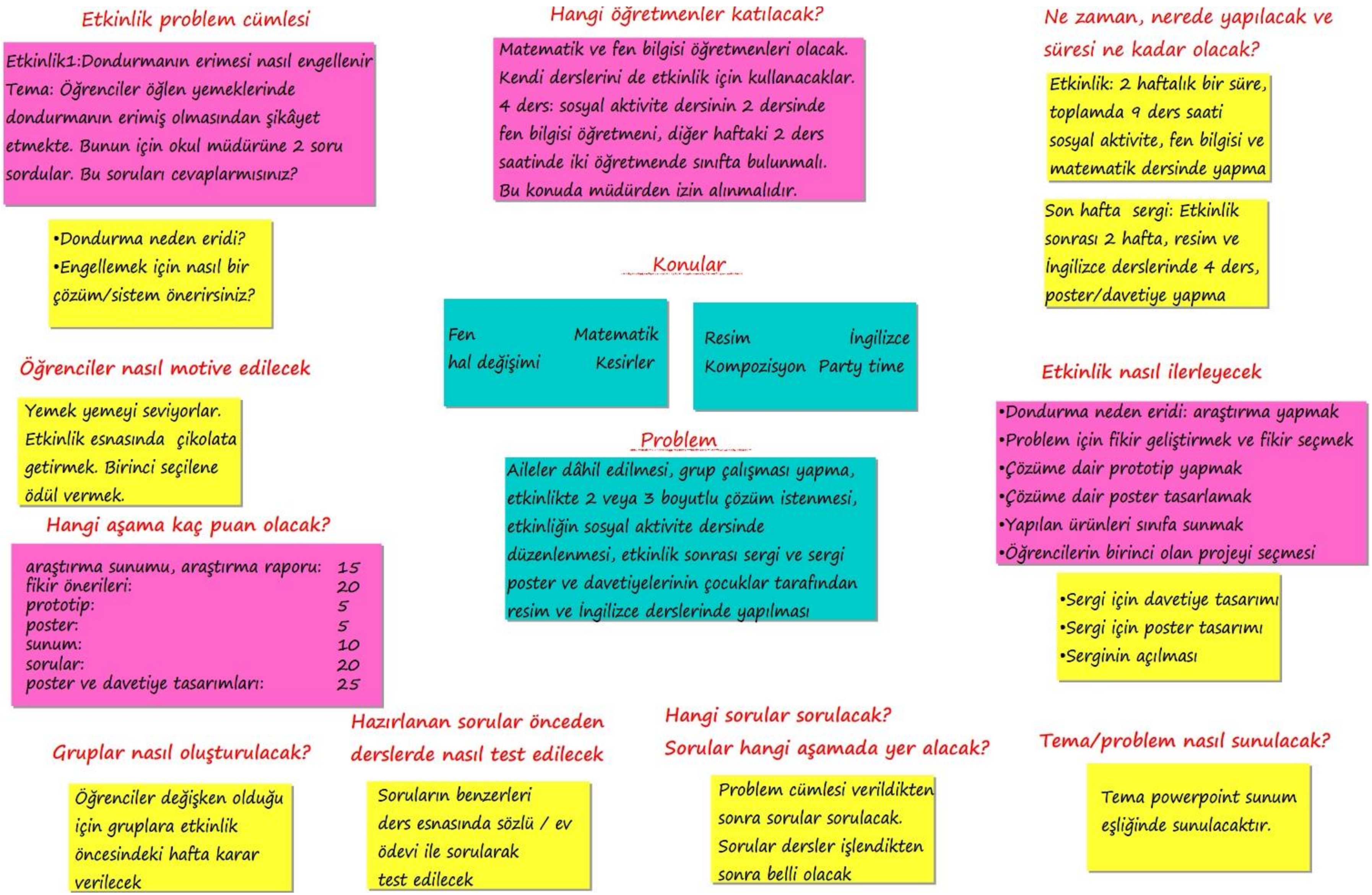
STEM ETKİNLİK PLANI
• STEM etkinliği içindeki disiplinlerin birbirleriyle ilişkileri nasıl olacak?
• Etkinliğin tema veya problem cümlesi ne olacak?
• Etkinliğe hangi öğretmenler katılacak?
• Etkinlik ne zaman yapılacak ve süresi ne kadar olacak?
• Etkinlik nasıl ilerleyecek?
1. Tema/problem nasıl sunulacak?
2. Hangi sorular sorulacak? Sorular hangi aşamada yer alacak?
3. Hazırlanan sorular önceden derslerde nasıl test edilecek?
4. Etkinlikte grup çalışması varsa, gruplar nasıl oluşturulacak?
5. Etkinlikte hangi aşama kaç puan olacak?
6. STEM etkinliği için öğrenciler nasıl motive edilecek?
STEM ETKİNLİĞİNE HAZIRLIK AŞAMASI (AYNI TEMA ALTINDA DÜZENLENEN DERS / DİSİPLİNLERARASI DERS PLANLARI)
• Ekip öğretim yöntemiyle yapılacak disiplinlerarası derse hangi öğretmenler katılacak?
• Ekip öğretim veya bireysel öğretim yöntemiyle yapılacak olan disiplinlerarası ders, hangi derste işlenecek?
• Ders ne zaman yapılacak ve süresi ne kadar olacak?
• Ders planı nasıl olacak?
STEM ETKİNLİĞİ / DERSLER İÇİN İHTİYAÇ LİSTESİ HAZIRLAMAK

Not 1: Bu aşamada 4,5'te sunulan bilgiyi lütfen önceden okuyun.
Not 2: Bu aşamada, ihtiyaç duyduğunuz noktada (tema veya problem cümlesi oluştururken) STEM etkinliğini uygulayacağınız öğrencilerden bazılarının (veya odak grup olarak seçilen öğrencilerin) katılımını sağlayabilirsiniz.

1b- Fikirleri Değerlendirmek (20 dakika)

- Takımınızla (eğer varsa) benzer cevapları bir araya getirerek birleştirin ve işe yaramayan kısımları eleyin.
- Herkesten kendileri için favori olan fikre oy vermesini isteyin.
- Bir sonraki "Prototip yapmak" aşamasında, takımınızla STEM Etkinlik Planı şablonu üzerine fikirlerinizi özetleyin.

Örnek: N.I.S. haritasında iki etkinlik önerisi ortaya çıkmıştır. Fikir geliştirme prosedürüne göre Etkinlik 1 için (dondurmanın erimesi) STEM etkinlik planı (Şekil 5, Şekil 6) ve Etkinlik 2 için (Sel felaketi) *aynı tema altında düzenlenen ders/disiplinlerarası ders* planları (Şekil 7) ve her ikisi için de ihtiyaç listesinin nasıl geliştirildiği (Şekil 7) örnekler/görsellerle aşağıda size sunulmuştur. "Fikir geliştirmek" aşamasında örnek olarak sunulan bu görsellerde yapışkanlı not kâğıdı üzerine bilgiler özetlenerek yazılmıştır.



Şekil 5. Etkinlik 1 için, fikir geliştirme prosedürüne göre, etkinlik içeriğiyle ilgili nasıl beyin fırtınası yapıldığına dair bir örnek

ÖRNEK
STEM ETKİNLİK PLANI:
Etkinlik 1

Fikir geliştirme prosedürüne göre geliştirilen örnek STEM etkinlik planı aşağıda sunulmuştur.

- **STEM etkinliği içindeki disiplinlerin birbirleriyle ilişkileri nasıl olacak?**

Bu kısımda, N.I.S. haritasına göre etkinliğin içeriğinde hangi konuların olduğu ayrıntılı olarak yazılır ve beyin fırtınası için 50-70 cm kâğıt üzerine yapıştırılır.

Etkinlik 1: Dondurmanın erimesi nasıl engellenir: Fen bilgisi: Maddenin hal değişimi (Dondurmanın erimesi) Matematik: Kesirler (Eriyen dondurma miktarı) **Etkinlik sonrası düzenlenecek olan sergi:** Görsel Sanatlar: Kompozisyon (Poster tasarımı) İngilizce: Party time (İngilizce ve Türkçe davetiye tasarımı)

- **Etkinliğin tema veya problem cümlesi ne olacak?**

Bu kısımda, genel hatları belli olan etkinliğin, problem/tema cümlesini oluşturmak amaçlanmaktadır. Bu noktada, problem/tema cümlesinin etkinlik içeriğine dâhil edilmek istenen tüm derslere ait bilgileri içermesine dikkat edilmelidir. Eğer etkinlik sonunda öğrencilerden bir ürün istenecekse, problem/tema cümlesini oluştururken, istenecek ürün ve bunun için verilecek malzemeler önceden düşünülmelidir. Bu noktada lütfen, Tablo 11'de belirtilen problem/tema cümleleri arasındaki farkı okumadan beyin fırtınasına geçmeyelim.

Tablo 11. *Problem ile tema cümlesi arasındaki fark*

Tema: Öğrenciler kütüphanede raflardan kitap almakta güçlük çekmekte ve istedikleri kitaplara ulaşamamaktadır. Öğrencilerin kitaplara ulaşmak için neye ihtiyaçları olabilir?
Bu tür tema odaklı sorularda, cevaba bir yönlendirme yapılmaz ve öğrenciler verilen tema için araştırma yaparak, tespit ettikleri probleme göre bir çözüme ulaşmaya çalışırlar. Burada problem, kütüphanenin ergonomik olmaması ya da başka sebeplerden kaynaklanabilir. Dolayısıyla, istenen çözüm merdiven, alçak raf tasarımı olabileceği gibi tamamen başka bir çözüm de ortaya çıkabilir.
Problem: Öğrencilere, kütüphanede raflara ulaşabilmeleri için bir merdiven tasarlayınız.
Burada, tema odaklı soruların aksine, problem direkt olarak verildiği için, soru öğrenciyi sadece merdiven tasarlamaya yöneltmektedir.

Buna göre, Etkinlik 1'e ait soruda, direkt bir ürün istenmemiş ve öğrencilerin kendilerinin bir çözüm bulması beklenmiştir. Burada öğrenciler çözüm için bir buzluk önerebilir, yeni bir buzdolabı/soğutucu modeli geliştirebilir, taşınabilir soğutucu/termos çanta yapabilir veya dondurmayı getiren aracın soğutma sistemi için bir çözüm önerebilirler. Çözüm önerileri, araştırma yaptıkça dondurmanın erimesine sebep olan sorun/sorunlara göre daha da değişiklik gösterebilir.

Etkinlik 1: Dondurmanın erimesi nasıl engellenir: **Tema:** Öğrencilerimiz son zamanlarda öğlen yemeklerinde, dondurmanın erimiş olarak önlerine gelmesinden şikâyet etmektedirler. Bu noktada, okul müdürüne iki soru sormuşlardır. Sizler bu soruları cevaplamamıza yardımcı olabilir misiniz? -Dondurmanın erimesindeki sebepler nelerdir? -Dondurmanın erimesini engellemek için nasıl bir çözüm/sistem önerirsiniz?

- **Etkinliğe hangi öğretmenler katılacak?**

Çok disiplinli STEM etkinlikleri, farklı disiplinlerden öğretmenlerin iş birlikli çalışmasıyla tasarlanmaktadır. Tasarlanan etkinlik, tek bir öğretmen tarafından uygulanabileceği gibi, birden fazla öğretmen de etkinliğin uygulanmasında görev alabilir. Eğer etkinlikte birden fazla öğretmen görev alacaksa, etkinliğin ne zaman ve nasıl yapılacağı planlanırken, etkinliğe katılacak öğretmenlerin haftalık planları ve müfredattaki durumları dikkate alınmalıdır.

Etkinlik 1'e matematik ve fen bilgisi öğretmenlerinin dâhil olmasına ve kendi derslerini de etkinlik için kullanmalarına karar verildi. Müfredatta ileride oldukları için, onlardan etkinlik için 1'er haftalık yer açmaları istendi.

- **Etkinlik ne zaman, nerede yapılacak ve süresi ne kadar olacak?**

Bu kısımda, etkinliğin ne zaman, nerede (ders, okul bahçesi veya okul dışı yerler) ve ne kadar süre dâhilinde yapılacağına karar verilecektir. STEM etkinliğinin tarihini belirlerken şunlara dikkat edilmelidir: Etkinlik zamanına denk gelen okul ya da ulusal bir sınav olmaması, etkinliğin dönem sonuna bırakılmaması, etkinlik öncesi mümkünse zor bir ders/konu olmaması, öğrenciler ve öğretmenler için haftalık plan dikkate alınarak, en uygun ve rahat olan bir zaman aralığı ve dersin seçilmesi. Bu noktada etkinlik aynı gün yapılabileceği gibi bir hafta, bir ay ya da bir dönem içine de yayılabilir. Ayrıca etkinliğin belli kısımları (mesela araştırma yapmak) ev ödevi olarak verilebilir.

Etkinlik 1 için iki haftalık bir süre verilmesi ve bu etkinliğin dört ders saatinin sosyal aktivite dersinde, beş ders saatinin fen bilgisi ve matematik dersinde yapılması uygun görüldü. Ayrıca, dört ders saatlik sosyal aktivite dersinin iki ders saatinde fen bilgisi öğretmeninin, diğer haftaki iki ders saatinde ise her ikisinin sınıfta bulunması istendi. Etkinlikte yapılan ürünlerin sergileneceği serginin poster ve davetiye tasarımları için, etkinlik sonrasındaki iki hafta ve toplamda dört ders saati görsel sanatlar ve İngilizce derslerinde ayrıldı.

- **Etkinlik nasıl ilerleyecek?**

Bu kısımda etkinliğin içeriğinin nasıl olacağı belirlenecektir. Bunun için öncelikle, etkinliğin ana başlıklarını çıkararak işe başlanmalı, sonra bu başlıkların nasıl uygulanacağı ayrıntılı olarak düşünülmelidir. Buna göre, aşağıdaki hususlar dikkate alınarak etkinlik içeriği oluşturulabilir:

- Hangi aşamalar etkinlikte olacak?
- Her aşamadan hangi öğretmen sorumlu olacak?
- Hangi ders/derslerde/yerde bu aşamalar gerçekleşecek?
- Her aşamaya ne kadar süre verilecek?
- Bu aşamalarda ne yapılacak? (Bireysel veya grup çalışması var mı?)
- Öğrencilerden ne istenecek? (Prototip yapma, rapor/sunum hazırlama, poster tasarımı, sistem tasarımı paftası vb.)
- Öğrenciler birbirlerinin projelerini değerlendirecek mi?
- Etkinlik sonunda sergileme olacak mı? (Sergi poster ve davetiyesi nasıl hazırlanacak?)

Herhangi bir STEM etkinliğinde genellikle problem belirleme, araştırma, çözüm için fikir geliştirme, bunun prototipini yapma ve test etme aşamaları bulunur. Biz bu kısımda, etkinliğin rahat tasarlanabilmesi için *HPI tasarım odaklı düşünme* yaklaşımından (4.6'da açıklanmıştır) faydalanmayı düşündük. Bu noktada, bu yaklaşıma ait altı aşama (anlamak, gözlem yapmak, bakış açısı geliştirmek, fikir geliştirmek, prototip yapmak ve test etmek) etkinlik içinde kullanılabileceği gibi, bu aşamalardan bazılarının birleştirilerek ya da aşama sayısı azaltılarak kullanılması, hem zaman hem de öğrencilere kolaylık sağlama açısından tercih edilebilir. Buna göre, **Etkinlik 1**, *HPI tasarım odaklı düşünme* yaklaşımına ait "Anlamak", "Gözlem yapmak" ve "Bakış açısı geliştirmek" aşamaları birleştirilerek, altı aşama yerine dört aşamada aşağıdaki gibi uygulanmıştır.

-Dondurmanın neden eridiğini anlamak için araştırmak yapmak (anlamak, gözlem yapmak ve bakış açısı geliştirmek)
-Problem için fikir geliştirmek ve fikir seçmek (fikir geliştirmek)
-Çözüme dair prototip yapmak ve poster tasarlamak (prototip yapmak)
-Yapılan ürünleri sınıfa sunmak ve akran değerlendirmesi (test etmek)
-Sergi için davetiye ve poster tasarımı
-Serginin açılması

1. Tema/problem nasıl sunulacak?

Tema/problem sunumu, öğrencilerin ilgisini etkinliğe çekme açısından önem taşımaktadır. Bu sebeple, sözlü bir sunum yerine, powerpoint/animasyon/film eşliğinde bir sunum yapılabilir.

2. Hangi sorular sorulacak? Sorular hangi aşamada yer alacak?

Etkinlik için hazırlanan soruların, hem tema/problem çerçevesinde olması, hem de disiplinlerin birbirleriyle ilişkisini göstermesi gerekmektedir. Bu aşamada hangi tip sorular sorulacağı, soruların nasıl bir içeriğe sahip olacağı, etkinliğin hangi aşamasında soruların yer alacağı (sorular problem/tema cümlesi verilmeden önce mi veya verildikten sonra etkinliğin belli aşamalarında mı sorulacak?) önceden konuşulmalıdır. Dersler henüz işlenmemişse, sorular dersler işlendikten sonra öğrencilerin durumu gözetilerek hazırlanabilir.

3. Hazırlanan sorular önceden derslerde nasıl test edilecek?

STEM etkinliğinde amaç, öğrenilen bilgilerin nasıl kullanıldığını test etmektir. Bu sebeple, tasarlanan etkinliğin türüne göre, ders işleme ve etkinlik aynı anda yapılmayacaksa, etkinlik öncesi öğrencilerin bilgi düzeyinin sınav ya da sözlü yoluyla test edilmesi önem taşımaktadır.

4. Etkinlikte grup çalışması varsa, gruplar nasıl oluşturulacak?

Eğer etkinlikte grup çalışması varsa, öğrenci grupları, birbirleriyle olan ilişkileri ve başarı durumları göz önüne alarak oluşturulmalıdır. Ancak, öğrenciler ilişkileri bakımından değişken oldukları için, etkinlik gününe kadar öğrencilerin gözlenmesi ve kişisel ilişkilerinde bir sorun varsa gruplandırmaların tekrardan gözden geçirilmesi tavsiye edilir.

5. Etkinlikte hangi aşama kaç puan olacak?

Öğretmenler bir araya gelerek, hangi aşamayı nasıl ve hangi kriterlere göre değerlendireceklerine karar vermelidirler (Tablo 12). Öğrencilerin daha önce yapılan STEM etkinliklerinde, prototip yapımına, problem çözümüne yönelik sağladığı faydadan daha çok önem verdiği tespit edilmiştir. Bu sebeple, etkinlik puanlamalarında prototip yapımına yüksek bir puan verilmemesi önerilmektedir. Ayrıca akran değerlendirmesi, STEM etkinliklerinde kullanılan değerlendirme yöntemlerinden biridir. Bu kısımda, öğrencilerin seçimlerinin doğru olması adına öğrencileri yönlendiren bir değerlendirme tablosu verilebilir (Tablo 13).

6. STEM etkinliği için öğrenciler nasıl motive edilecek?

Öğrencilerin etkinlikte öğrenirken eğlenmeleri de amaçlanmalıdır. Bu sebeple, etkinlik esnasında öğrencilere çikolata vb. yiyecekler dağıtılabilir, etkinlik sonunda birinci seçilen öğrenciye ödül verilebilir (kitap, madalya, bilgisayar oyunu vb.).

Buna göre, etkinliğin ne zaman yapılacağı, nasıl ilerleyeceği ve kimlerin katılacağı düşünülerek, Şekil 6'daki gibi bir etkinlik içeriği hazırlanmıştır (4.8'de etkinliğin tamamı verilmiştir).

Tablo 12. *Örnek değerlendirme tablosu (Çorlu, & Çallı, 2017)*

Değerlendirme aşamaları	**Değerlendirme kriterleri**	**Değerlendirme türü**
Araştırma yapma ve araştırma raporu	Elde edilen bilgiler, bilginin kalitesi ve kullanılan kaynaklara göre değerlendirilebilir.	Not verme veya 1 ile 4 arasında bir değer verme
Fikir geliştirme	Fikrin anlaşılabilirliği, içerdiği bilgiler	″
Çözümün probleme uygunluk derecesi	Çözümün probleme uygunluğu, ayırt edilebilir özellikleri, işlevselliği ve çalışma prensibi	″
Poster tasarımı	Kâğıt üzerinde oluşturulan kompozisyon (Çözüm özelliklerini ve bunların probleme olan katkısını içermelidir.)	″
Disiplinler arasında ilişki kurabilme	Çözümde, istenilen/beklenen bilgiler ve/veya bunun dışında başka bilgiler kullanılmış mı?	″
Sunum becerisi	Çözümün açık ve anlaşılır bir biçimde sunulması, sunum esnasında problemin ne olduğundan bahsedilmesi	”
Prototip kalite	Prototipin, çözüme uygun olarak doğru ve tam bir şekilde yapılması, estetik görünümü.	”
Materyal kullanımı	Materyal ve araç-gereçlerin doğru kullanımı, kullanılan materyal miktarı (Aşırı materyal kullanımının olup olmaması)	”
Prototip özgünlük	Ürünün özgün düşünce, yaratıcı fikir, farklı bakış açısı içermesi veya benzerlerinin gelişmiş bir versiyonu olması (Benzerlerinin taklidi olmaması)	”
Zaman kullanımı	Verilen sürelerde istenilen görevleri yerine getirmesi	(Not verme veya Sticker ile değerlendirme)
Grup çalışması	Görev paylaşımı, grup arkadaşlarının uyumu, fikir paylaşımı	(Not verme veya Sticker ile değerlendirme)
Akran değerlendirmesi		(+ 1 puan olarak sonuca ekleme veya ödül verme)
Not: 1 en düşük, 4 en büyük puan olarak verilir.		

Tablo 13. *Örnek öğrenci değerlendirme tablosu*

Ad/Soyad:	**1**	**2**	**3**
Malzeme kullanımı nasıl? (az, orta, çok)			
Tasarlanan ürün probleme çözüm sağlıyor mu?			
Prototip/ürün estetik olarak çekici mi?			
Etkili bir ürün sunumu yapıldı mı?			
Poster ürünü anlatıyor mu?			
Toplam Puan			
	1: kötü 2: orta 3: iyi		

İlk hafta:
Etkinlik

2 derslik fen bilgisi dersi: Tema sunumu, araştırma nasıl yapılır, elde edilen bilgiler nasıl sunulur. 2'li gruplar olacak.
Onlardan dondurmanın erimesine sebep olan sorunları tespit etmeleri ve çözüm önerileri geliştirmeleri beklenecek.

1 derslik matematik dersi:
Tema'yı pekiştirmek için matematik ve fen bilgisi soruları öğrencilere sorulacak.

2 derslik sosyal aktivite dersi:
Gruplar tespit edilen sorunları ve önerdikleri çözümleri sınıfa sunacak. Bununla ilgili 1 sayfalık rapor hazırlancak.
Öğrenciler ve fen bilgisi öğretmeni kritik verecek ve gerekliyse değişiklikler çözüm de yapılacak.

Etkinlik nasıl ilerleyecek

•Dondurma neden eridi: araştırma yapmak
•Problem için fikir geliştirmek ve fikir seçmek
•Çözüme dair prototip yapmak
•Çözüme dair poster tasarlamak
•Yapılan ürünleri sınıfa sunmak
•Öğrencilerin birinci olan projeyi seçmesi

•Sergi için poster tasarımı
•Sergi için davetiye tasarımı
•Serginin açılması

İkinci hafta: Etkinlik

2 derslik sosyal aktivite dersi: Prototipler posterlerle beraber sınıfa sunulacak. Projelerle ilgili öğretmenlerden ve öğrencilerden kritik alacaklar.
Öğrenciler birinci olan projeyi seçecekler.
Sınıfta matematik ve fen bilgisi öğretmeni olcak.

2 derslik matematik dersi:
Prototipler yapılacak. Derste resim ve matematik öğretmeni olacak.

Poster tasarımı ev ödevi:
Çözümleri anlatan poster tasarımı ailelerle birlikte yapılacak.

Dördüncü hafta:
Sergi

1 derslik resim dersi:
öğrenciler en beğendikleri posteri seçecekler.

1 derslik İngilizce:
öğrenciler en beğendikleri davetiyeyi seçecekler.

Üçüncü hafta:
Sergi

1 derslik resim dersi:
Kompozisyon: Sergi için poster tasarlama

1 derslik İngilizce: Party time
İngilizce ve Türkçe
sergi için davetiye tasarlama

Şekil 6. Etkinlik 1'in içeriğinin nasıl olacağına dair beyin fırtınası

ÖRNEK
STEM ETKİNLİĞİNE HAZIRLIK AŞAMASI (AYNI TEMA ALTINDA DÜZENLENEN DERS / DİSİPLİNLERARASI DERS PLANLARI): Etkinlik 2

Bu kısımda, Etkinlik 2 için derslerin fikir geliştirme prosedürüne göre nasıl planlandığı açıklanmıştır. Buna göre, Etkinlik 2 için iki farklı problem cümlesi (Tablo 14) geliştirilmiş, içlerinden ikincisi seçilerek dersler buna göre tasarlanmıştır.

Tablo 14. *Etkinlik 2 için geliştirilen problem cümleleri*

Etkinlik 2: Sel felaketinden korunmak için çözümler üretmek
Fen Bilgisi: Maddenin hal değişimi (Karların erimesi ve sel olması)
Matematik: Kesirler (Taşan su miktarının kesirle ifadesi)
Sosyal Bilgiler: Doğal afetler (Sel, çığ)
İngilizce: Doğal afetlerin İngilizce karşılıkları

Problem 1: Kar yağışının bol olduğu Erzurum ilinde, kış mevsiminden ilkbahara geçerken, baraj su miktarında kapasitenin üstünde bir artış olduğu gözlenmekte ve ayrıca sel baskınlarına da rastlanmaktadır.

• Kış mevsiminden ilkbahara geçiş sel baskınlarını nasıl tetiklemiştir?
• Mevsimsel geçiş sonrasında meydana gelen sel felaketini, maddenin hal değişimine göre açıklayınız.
• Sel felaketlerinin tekrar olmaması için taşan su miktarını dikkate alarak baraj kapasitesi yüzde kaç arttırılmalıdır?
• Baraj kapasitesi arttırılsa bile, yapılan incelemeler, çarpık şehirleşme sebebiyle sel felaketinin engellenemeyeceğini bize göstermektedir. Buna göre, Erzurum'u sel felaketinden korumak için nasıl bir şehir planı oluşturmak gereklidir. Lütfen tasarımınızı oluştururken, yerleşim yerleri, okullar, yollar, alışveriş merkezi, dağlar, ormanlık alan, şehir içindeki dere yatakları ve baraj unsurlarının planda yer almasına dikkat ediniz.

Problem 2: Ülkemizde her sene, sel, heyelan, çığ başta olmak üzere çeşitli doğal afetler yaşanmaktadır. Fakat doğal afetlerle ilgili bilinçli insan sayısının az olduğu gözlenmiştir.

• İlkbahar yağmurları ve karların erimesi, sel ve çığ felaketlerinin ortak oluşma sebepleri arasında sayılabilir. Buna göre, sel ve çığ'ın oluşma sebeplerini maddenin hal değişimine göre açıklayınız.
• Sel ve çığ felaketinden nasıl korunabiliriz?
• Doğal afetlere dikkat çekmek ve önlemleriyle ilgili halkı ve özellikle çocukları bilinçlendirmek için, Ankara'da bir Doğal Afetler Müzesi kurulacaktır. Müze aşağıdaki gibi 2 kat olarak planlanmakta iken, bu alanın yetmeyeceği tespit edilmiş ve 100 m^2 alana daha ihtiyaç olduğu saptanmıştır. Buna göre, müzenin alanı yüzde kaç arttırılmalıdır?
• Bu müzede, Türkiye'de yaşanmış belli başlı doğal afetlerle ilgili bilgiler olacağı gibi, doğal afetlerin sebepleri ve bunlardan korunma yolları da sunulacaktır. Bu noktada, çocukların fikri alınmak istenmiştir. Türkiye'de kurulacak Doğal Afetler Müzesi'nin yabancı ziyaretçileri de olacağı için, sizden İngilizce/Türkçe müze yerleşim planı istenmektedir. Bu plan aşağıdaki üç unsuru içinde mutlaka barındırmalıdır:

1. Türkiye'de yaşanmış belli başlı doğal afetlerle ilgili bilgi, görsel ve filmler
2. Doğal afetler ve sebepleri
3. Doğal afetlerden korunma yolları

Yukarıdaki bilgiler ışığında dersler tasarlanırken, derslerin ne zaman yapılacağına, süresine ve ders planının nasıl olacağına dikkat edilmelidir. *Disiplinlerarası ders* için bunlara ek olarak, derse hangi öğretmenlerin gireceği ve hangi derste bu dersin işleneceği de düşünülmelidir (Şekil 7).

- **Ekip öğretim yöntemiyle yapılacak disiplinlerarası derse hangi öğretmenler katılacak?**

Disiplinlerarası derslerde derse katılacak öğretmenlerin boş zamanlarının birbirine uyması ve müfredattaki ilerleme durumları önem taşımaktadır.

- **Ekip öğretim veya bireysel öğretim yöntemiyle yapılacak olan disiplinlerarası ders hangi derste işlenecek?**

Disiplinlerarası derslerde birden fazla öğretmenin, hem dersi tasarlarken hem de *ekip öğretim yöntemi* varsa dersi uygularken görev alması sebebiyle, dersin hangi derste yapılacağı önem taşımaktadır. Bu noktada, öğretmenlerin programları birbirine uyduğu takdirde öğretmenlerden biri diğerlerini dersine davet edebilir. Eğer müfredat yetiştirme anlamında öğretmenler sorun yaşıyorsa ders, sosyal aktivite dersi, bilim dersi vb. ders dışı etkinlik saatinde işlenebilir.

- **Ders ne zaman yapılacak ve süresi ne kadar olacak?**

Aynı tema altında verilen dersler ya da *disiplinlerarası verilen dersler* için kaç ders saatlik zaman ayrılacağı planlama açısından önem taşımaktadır. Ayrıca derslerin, STEM etkinliğinden önce yapılması gerekmektedir.

- **Ders planı nasıl olacak?**

Etkinlik 2 için *aynı tema altında verilen dersler* ile *ekip öğretim yöntemiyle verilen disiplinlerarası ders* tasarlanması uygun görülmüştür. Bu derslerin işlenebilmeleri için, dersin içeriğinde bulunan konuların öğretmenler tarafından önceden işlenmeleri gerekmektedir.

Ekip öğretim yöntemiyle disiplinlerarası verilen ders: Etkinlikten bir önceki hafta, sosyal aktivite dersinin 1 ders saatinde, ders içeriğinde fen bilgisi, sosyal bilgiler ve görsel sanatların olduğu, bir *ekip öğretim yöntemiyle verilen disiplinlerarası ders* tasarlanmıştır. Burada görsel sanatlar öğretmeni alçı ve strafor kullanarak içinde nehir, üzerinde orman ve kar olan bir dağ modeli yapacaktır. Bu noktada fen bilgisi öğretmeni, kar ve yağmurun oluşumundan bahsederek maddenin hal değişimine değinecek, sosyal bilgiler öğretmeni de doğal afetlerden özellikle selin nasıl oluştuğunu, maddenin hal değişimiyle birleştirerek (karların erimesiyle sel olması) anlatacaktır. Aynı zamanda görsel sanatlar öğretmeni, model yapımında kullanılan alçının donarken, sıvı halden katı hale geçişte dışarıya nasıl ısı verdiğini öğrencilere gösterecektir. Böylece üç ders birbiriyle ilişkilendirilmiş olacak ve öğrencilere canlı model yapımı eşliğinde ders anlatılacaktır. Ders sonunda konuyla ilgili sözlü yapılacaktır. Ayrıca görsel sanatlar öğretmeni, STEM etkinliğine hazırlık için öğrencilerden, doğal afetleri içeren bir müze tasarımı yapmalarını, ev ödevi olarak isteyecektir.

Aynı tema altında verilen dersler: Etkinlikten iki hafta önce, bir ders saati süren ve hem sosyal bilgilerde hem de İngilizcede doğal afetler konusunu işleyen, *aynı tema altında verilen dersler* tasarlanmıştır. Sosyal bilgiler dersinde, doğal afetler konusu işlenirken, sosyal bilgiler öğretmeni fen bilgisine de (maddenin halleri) konu itibariyle değinecektir. Bu sebeple, konuyla ilgili olarak, karların erimesini ve bundan kaynaklı sel oluşumunu anlatan videolar/animasyonlar derste gösterilecektir. Ders sonunda, sözlü yapılacaktır. İngilizce öğretmeni de aynı konuya değinerek, doğal afetlerin ne olduğunu ve bunların İngilizcelerini öğrencilere anlatacaktır. Ayrıca, doğal afetlerden bahsederken maddenin hal değişimine de değinerek, erime, donma vb. kelimeleri sınıfta deney yaparak gösterecektir. Örneğin, mumu ısı verip eritecek ve buz tutmuş bir suyun oda sıcaklığında katı halden sıvı hale geçişini öğrencilere gösterecektir. Derste, öğretmen konuyla ilgili soru dağıtacak ve cevaplara ders esnasında beraber bakılacaktır.

STEM ETKİNLİĞİ / DERSLER İÇİN İHTİYAÇ LİSTESİ HAZIRLAMAK:

Etkinlik 1 ve Etkinlik 2

STEM etkinliği ve dersler planlandıktan sonra, onları uygulamak için neye gereksinim olduğuyla ilgili hazırlık yapmak açısından bir liste yapılmasında fayda vardır. Örneğin, Etkinlik 1 için prototip malzeme listesini çıkarmak, poster ve davetiyelerin basımı ve kaç adet olacağıyla ilgili bilgi ve fen bilgisi ile matematik sorularının hazırlanması gerekmektedir. Etkinlik 2'deki İngilizce dersi için de doğal afetlerle ilgili animasyon bulunması ve sınıfa mum ile buz tutmuş su getirilmesi gerekmektedir. Sosyal bilgiler dersi için karların erimesini ve bundan kaynaklı sel oluşumunu gösteren videolar/animasyonlar bulunmasına gerek vardır. Ayrıca disiplinlerarası ders için alçı, strafor ve boya temin edilmelidir (Şekil 7).

Aynı tema altında ders

Dersler ne zaman yapılacak ve süresi ne kadar olacak?

Sosyal ve İngilizce de doğal afetler konusu: 1'er ders. Etkinlikten 2 hafta önce yapılacak.

Ders planı nasıl olacak?

Sosyal bilgiler: doğal afetleri işlerken fen bilgisinede değinme. Derste sözlü. İngilizce: Doğal afetlerin ne olduğunu ve İngilizcelerini anlatma. Maddenin hal değişimine değinme. deney yapma.

Deney: Mum'u eriterek katı halde sıvı hale geçişi göstermek.

Dersler için ihtiyaç listesi hazırlamak

İngilizce dersi: doğal afetlerle ilgili animasyon bulma, sınıfa, mum ve buz tutmuş su getirme

Konular

Etkinlik2: Selden korunmak için çözüm üretmek
Fen bilgisi: Maddenin hal değişimi
Matematik: Kesirler
Sosyal bilgiler: Doğal afetler
İngilizce: Doğal afetlerin İngilizceleri

Problem cümlesi

Problem2: Ülkemizde her sene doğal afetler yaşanmakta. Fakat doğal afetlerle ilgili bilinçli insan sayısının az olduğu gözlemlenmekte. Buna göre;

- sel ve çığ'ın oluşma sebeplerini maddenin hal değişimine göre yaz.
- Sel ve çığ felaketinden nasıl korunulur
- Ankara'da bir Doğal afetler müzesi kurulacaktır. Müze 2 kat olarak planlanırken 100 m2 alana daha ihtiyaç olmuştur. Müzenin alanı yüzde kaç arttırılmalıdır.
- İngilizce/Türkçe müze yerleşim planı istenmektedir. Buna göre;

1. Türkiye'de yaşanmış doğal afetlerle ilgili bilgi, görsel ve filmler
2. Doğal afetler ve sebepleri
3. Doğal afetlerden korunma yolları

Ekip öğretim modeli ile disiplinlerarası ders

Derse hangi öğretmenler katılacak?

fen bilgisi, sosyal bilgiler, resim öğretmenleri katılacak.

Disiplinlerarası ders hangi derste yapılacak?

Sosyal aktivite dersi: Resim öğretmeni için müdürden izin alıncak.

Dersler ne zaman yapılacak ve süresi ne kadar olacak?

Etkinlik öncesindeki hafta yapılacak. 1 ders saati olacak.

Ders planı nasıl olacak?

Resim: alçı ve strafor ile içinde karlı dağ, nehir ve orman olan bir model yapacak. Fen bilgisi: kar yağmur oluşumuyla maddenin hal değişimini anlatacak. sosyal bilgiler: selin nasıl oluştuğunu hal değişimiyle anlatacak.

Resim: modeldeki alçı donarken sıvıdan katı hale geçişini gösterecek

Şekil 7. Etkinlik 2'nin ders planlarının ne olacağına dair beyin fırtınası örneği

3.6 Aşama 6: Prototip yapmak (35 dakika)

Kullanılacak Materyaller: STEM etkinlik planı şablonu, renkli kalem, tükenmez kalem.
Yöntem: Planlama, model yapmak, zaman çizelgesi, şema oluşturmak, web tabanlı prototipleme araçları

STEM etkinliği tasarlama, onu uygulayarak test etme ve uygulama sonrası gerekirse üzerinde değişiklikler yapma bir öğrenme sürecidir. Bu sebeple, STEM etkinliği tasarlamada ilk seferde doğru bir sonuca ulaşılamayabilir veya etkinlik tasarımları zamanla değişebilir. Örneğin, etkinliği uygulayacağınız öğrenci grubunun aynı yaş grubu olsa dahi her sene değişmesi, okulda, sizin çalışma planınızda veya eğitim sisteminde değişiklik olması, bu değişikliklere sebep olabilir. Sonuç olarak, STEM etkinlik tasarımları, öğrencilerle veya diğer paydaşlarla etkileşime girdikçe, onlar ve siz öğretmenler tarafından deneyimlendikçe daha başarılı olurlar.

Bu aşamada sizden, "Fikir geliştirmek" aşamasında tasarladığınız STEM etkinliği ile dersleri, STEM Etkinlik Planı şablonuna (4.7) yazmanız beklenmektedir. Bu noktada 4.2'de size sunulan çeşitli prototipleme yöntemlerinden faydalanabilirsiniz.

1- STEM Etkinlik Planı'nı doldurmak (35 dakika)

Bu aşamada, tasarladığınız STEM etkinliği ile dersleri, STEM Etkinlik Planı şablonuna yazmanız beklenmektedir. Bunlar için gerekli yönlendirme şablon üzerinde yapılmış ve 4,8'de ise size örnek olarak doldurulmuş bir etkinlik planı sunulmuştur. Bu örnekte, Etkinlik 1 için STEM etkinlik planı, Etkinlik 2 için ise STEM etkinliğine hazırlık amacıyla düzenlenecek derslerle ilgili bölüm doldurulmuştur.

3.7 Aşama 7: Sınamak

Yöntem: Akran değerlendirmesi

Sınama, geri bildirim sağlayan tekrarlı bir işlemin parçasıdır. Bu aşamada, tasarladığınız etkinlikler/dersler öğrenciler üzerinde uygulanacak, sonuçlarına ve alınan geribildirime göre eğer gerekli görülürse, 'STEM etkinlik planı' üzerinde değişiklik yapılacaktır.

Bu aşamada, STEM etkinlikleri ile dersleri uygularken süreci gözlemlemek ve etkinliğin nasıl geliştirilebileceğini düşünmek önemli olacaktır. Bu sebeple, öğrencilerin tepkisine ve kendi tecrübelerinize dair lütfen notlar alın. STEM etkinliği/dersleri değerlendirirken aşağıdaki soruları diğer öğretmenlere ve kendinize sorabilirsiniz (MIT MOOCs course, t.y.):

- Bu etkinlik hakkında neyi sevdiniz/sevmediniz? Neden?
- Bu etkinlikte hangi değişiklikleri yapmak isterdiniz?
- Etkinliğe dair olan açıklamalar anlaşılır mıydı?
- İçerik ile ilgili öğrenciler için karışık bir nokta var mıydı? Etkinliğe veya konuya dair aklınızda sorular var mı?

Öğrencilerin ayrıca etkinliği nasıl buldukları hakkında yorumlarını, soru sorarak veya etkinlik değerlendirme için bir "Öğrenci yorum kartı" hazırlayarak (içeriğinde; etkinlik ilginçti/faydalıydı, …zorlandım, yeni bilgiler öğrendim vb.) öğrenebilirsiniz.

4. YARDIMCI MATERYALLER

4.1 Beyin fırtınası nasıl yapılır

STEM etkinliği tasarlarken birçok aşamada sizden beyin fırtınası yapmanız istenecektir. Beyin fırtınası sırasında uymanız gereken kurallar ile beyin fırtınası yapmak için uygulayabileceğiniz üç yöntem aşağıda size sunulmuştur.

1a- Beyin fırtınası esnasında uyulması gereken kurallar (MIT MOOCs course, t.y.):

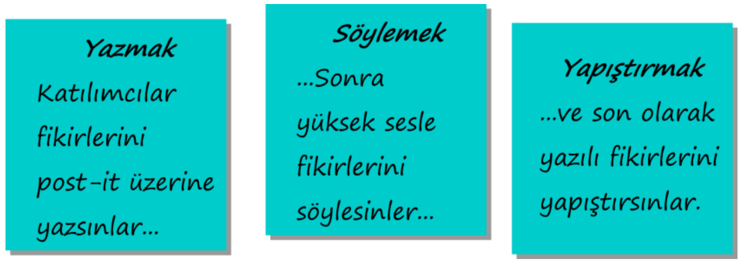
- Bir kişiyi beyin fırtınasını yönetmesi için seçin.
- Beyin fırtınası esnasında uyulması gereken kuralları herkese anlatın.
    1. Önyargılı olmamak.
    2. Fikirlerin kalitesini/değerini sorgulamamak.
    3. Uçuk veya farklı fikirler üretmeye teşvik etmek.
    4. Diğerlerinin fikri üzerine kendi fikirlerini geliştirmek.
    5. Konudan sapmamak.
    6. Düşündüklerinizi yazmak yerine çizerek de paylaşmak.
    7. Probleme olası çözüm olacak tek bir fikre odaklanmak yerine birçok fikir üretmeye çalışmak.
    8. Beyin fırtınası oturumuna verilen süre için zamanı ayarlamak ve herkesin görebileceği bir yere saati/kronometreyi koymak.
    9. Zaman baskısı altında daha fazla fikir üretilmesini sağlamak.
- Beyin fırtınası yaparken her yapışkanlı not kâğıdına büyük harfler ile sadece bir veya iki cümle yazın (tek kelime veya liste değil).
- Unutmayın, bu aşamada kötü fikir diye bir şey yoktur!

Beyin fırtınasında kullanılabilecek bazı yöntemler:

1b- Yazmak, söylemek, yapıştırmak

<u>Kullanılacak Materyaller:</u> Renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt

Beyin fırtınasında kullanılabilecek yöntemlerden biri “yazmak, söylemek ve yapıştırmak”tır. Bu yöntemi uygulamak için yapışkanlı not kâğıdı üzerine aklınıza gelen fikirleri hemen yazın, standart beyin fırtınasındaki gibi sıranızı beklemeden sesli olarak onları diğer katılımcılarla hemen paylaşın ve yazılı fikirlerinizi 50-70 cm kâğıda yapıştırın. Bu yöntem, insanların rahat hareket etmesine yardımcı olmakta, kendilerini engellemelerini azaltmakta ve çekingen grup üyelerinin fikirlerini rahat ifade etmelerine olanak sağlamaktadır (Ambrose, & Harris; 2010, s. 67).



Şekil 8. “Yazmak, söylemek ve yapıştırmak” yönteminin aşamaları (Ambrose, & Harris; 2010, s. 67)

1c- Hot Potato

<u>Kullanılacak Materyaller:</u> Atılabilecek bir obje, renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt, A4 kâğıt ve kâğıt bant

Beyin fırtınası için kullanılabilecek yöntemlerden biride Hot Potato yöntemidir. Bu yöntem üç farklı şekilde uygulanabilir. Bunlardan ilkinde, ne üzerine beyin fırtınası yapılacaksa (Örneğin “Fikir geliştirmek” aşamasında fikir geliştirme prosedüründeki başlıklar) o başlık/başlıklar **A4 kâğıt üzerine yazılır** ve grup arasında kâğıt dolaştırılarak herkesten bir dakika içinde bir fikir yazması istenir. Böylelikle herkes diğerlerinin fikrini görerek onun üzerine başka fikirler geliştirebilir. Bu süreç, kâğıt başlangıç noktasına dönene kadar ya da tatmin edici bir fikir ortaya çıkana kadar devam eder. Bu noktada, kâğıdı dolaştırmak için zaman tutmak önem taşımaktadır. Sonra, fikirler arasında oylama yapılabilir (Hot potato, t.y.).

İkinci yöntemde ne üzerine beyin fırtınası yapılacaksa, o başlık/başlıklar 50-70 cm kâğıda yazılır ve duvara asılır. Sonrasında, sırayla her öğretmene söz vererek bir dakika içinde o başlık/başlıklar için kendilerinden fikir beyan etmeleri istenir. Bu süreç, fikri ilk geliştiren kişiye dönene kadar ya da tatmin edici bir fikir ortaya çıkana kadar devam eder. Sonra, fikirler arasında oylama yapılabilir (Hot potato, t.y.).

Üçüncü yöntem ise, ne üzerine beyin fırtınası yapılacaksa o başlıklar üzerine teker teker beyin fırtınası yapmaktır. Bunun için, grup üyeleri birbirine yüzleri dönük olarak daire şeklinde oturur. Üzerine fikir geliştirilecek başlık için, bir takım üyesi bir fikri sesli söyleyerek elindeki objeyi (top, oyuncak vb.) diğer takım üyesine atarak beyin fırtınasına başlar. Diğer takım üyesi, atılan objeyi yakalar ve hemen yeni bir fikri sesli olarak söyler ve beyin fırtınası verilen süre içinde bu şekilde devam eder. Bu yöntemde, fikir söylemek için takım üyelerinin hızlı hareket etmesine önem verilmelidir. Bu yüzden, takım üyeleri fikirlerini söyleyip ellerindeki objeyi attıktan sonra, fikirlerini yapışkanlı not kâğıdı üzerine yazarak biriktirir ve en sonunda herkes 50-70 cm kâğıt üzerine fikirlerin yazılı olduğu not kâğıtlarını yapıştırır. Zaman kaybı olmaması adına bir kişi, fikirleri not kâğıtlarına yazıp yapıştırması için görevlendirebilir (Bleuel, Weinreich, & Puget, 2017) ya da takım üye sayısı az ise beyin fırtınasını ses kayıt cihazı ile kaydedebilirsiniz.

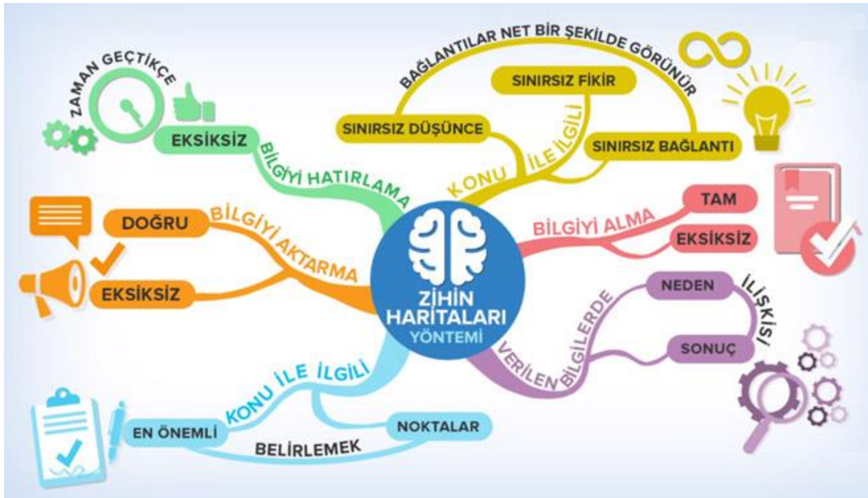
1d- Zihin Haritası

Kullanılacak Materyaller: Renkli kalem, tükenmez kalem, renkli yapışkanlı not kâğıdı, 50-70 cm kâğıt ve kâğıt bant

Zihin Haritası, merkezî bir temanın etrafındaki fikirlerin ve bakış açılarının grafiksel bir temsilidir ve bunların birbirleriyle nasıl ilişkili olduğunu gösterir. Zihin Haritası ile bir konunun tüm ilgili yönlerini ve fikirlerini eşleştirebilir ve bir soruna yapı, genel bakış ve netlik kazandırabilirsiniz.

Yöntem:

- Ne üzerine fikir geliştirmek amaçlanıyorsa, o başlık/başlıkları 50-70 cm bir kâğıdın ortasına yazın ve etrafına bir daire çizin.
- Düşüncelerinizi, merkez düşüncenin dışına çekilmiş çizgilere yerleştirerek, bu başlığın her ana boyutuna beyin fırtınası yapın. Örneğin, beyin fırtınası fikir geliştirme aşaması için yapılıyorsa, fikir geliştirme prosedüründeki başlıkların her biri için bu yöntemi kullanın.
- Hatlara gerektiğinde yeni dallar ekleyerek haritanızı genişletin.
- Yapışkanlı not kâğıdı, kelimeler veya resimleri kullanın.
- Hangi ilişkilerin var olduğunu ve hangi çözümlerin önerildiğini görmek için Zihin Haritasını inceleyin.
- Gerekirse Zihin Haritasını yeniden şekillendirin veya yeniden yapılandırın (Van Boeijen & Daalhuizen, 2010).



Şekil 9. Zihin haritası örneği (Mind map, t.y.)

4.2 Prototip nasıl yapılır

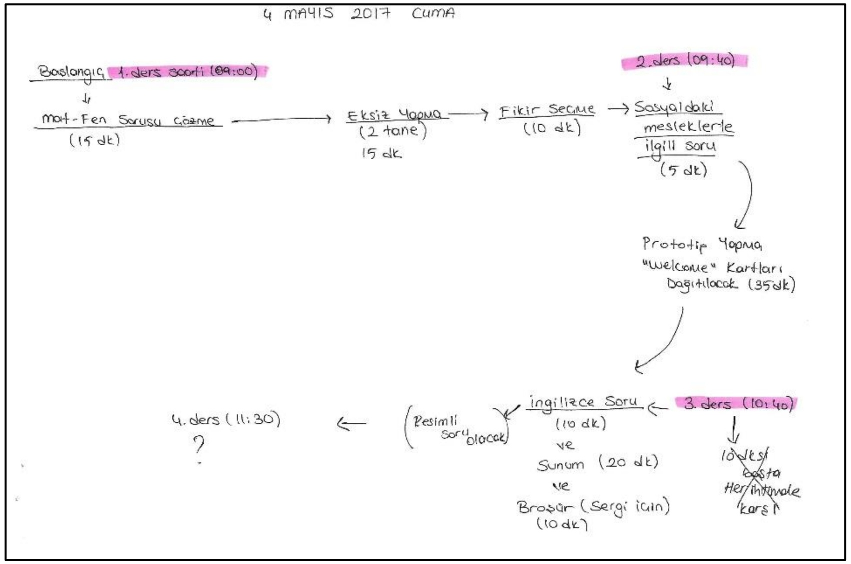
STEM etkinliği tasarlarken, aşağıdaki prototipleme yöntemler size yardımcı olabilir.

Model yapmak: Çeşitli malzemeleri kullanarak (karton, strafor, kağıt vs.) ders/etkinlik için üç boyutlu bir model yapılabilir. Örneğin, uzay temasının işlendiği bir STEM etkinliğinde, öğrencilerin uzay için tasarladıkları yaşam alanlarını proje sunumu esnasında kullanmaları için, aşağıdaki model yapılmıştır (Şekil 10).

Şekil 10. Uzay temasının işlendiği bir STEM etkinliği için hazırlanan bir model (Öztürk, A. 2020)

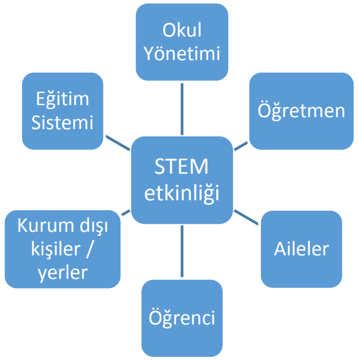
Zaman Çizelgesi: Zaman çizelgesi, bir sürecin basamaklarını sistematik olarak düşünmek için bir yol haritası oluşturmaya yardımcı olur. Buna göre, derslerin zaman ve içerik planlarının oluşturulması ile etkinlik planının nasıl ilerleyeceği konusunda bu yöntem kullanılabilir (Şekil 11).

Not: Drupal (https://www.drupal.org/project/dipity) web sitesini kullanarak ücretsiz dijital zaman çizelgeleri oluşturabilirsiniz.

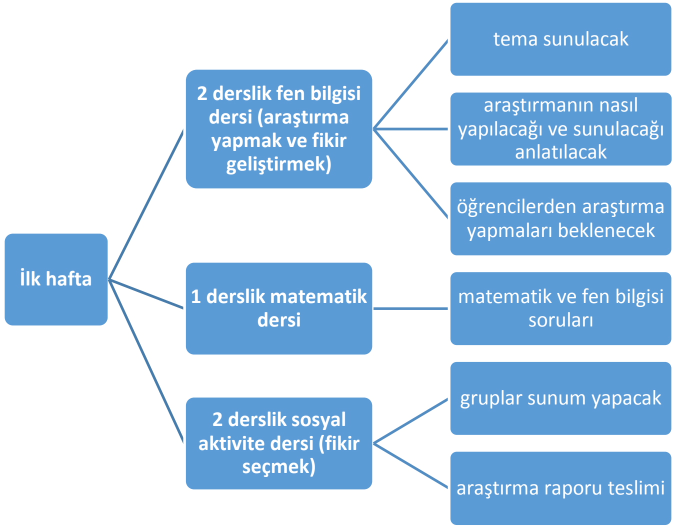


Şekil 11. Bir STEM etkinliğinin nasıl ilerleyeceği ile ilgili oluşturulmuş zaman çizelgesi (Öztürk, A. 2020)

Şema oluşturmak: Fikrin yapısına veya sürecine ilişkin bir süreç haritası çıkarır. Bu yöntemi, paydaşları belirlerken ya da STEM etkinliğinin/derslerin içeriğini oluştururken kullanabilirsiniz (Şekil 12 ve Şekil 13).

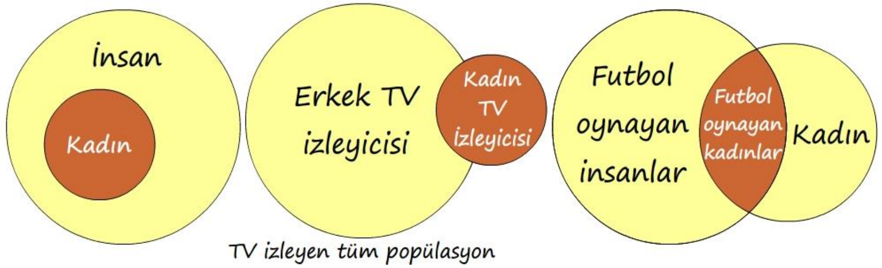


Şekil 12. "Paydaşları belirlemek" aşamasında şema yöntemi ile paydaşları belirlemek



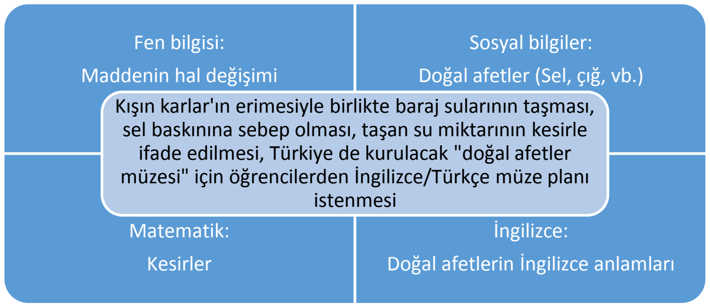
Şekil 13. Etkinlik 1 de ilk hafta yapılacak dersler ve içeriklerinin şema yöntemi ile gösterimi

Venn şeması: Birkaç önemli tema ile onların birbirleri arasındaki ilişkiyi açıklamanıza yardımcı olabilir. Venn şeması, Şekil 14 de görüldüğü gibi, ilişkiler arasındaki bağı ifade etmek için farklı şekillerde kullanılabilir.



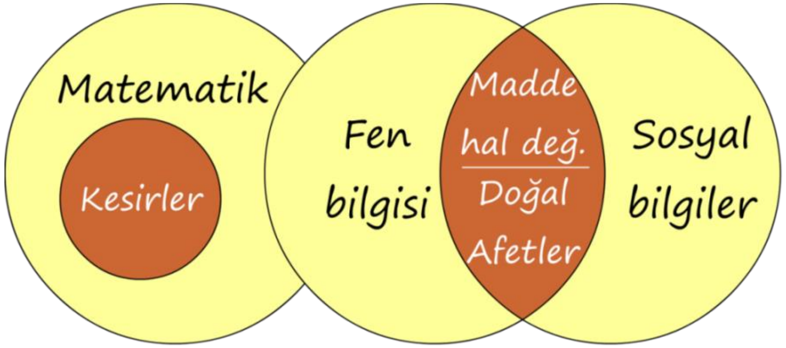
Şekil 14. Venn şeması çeşitleri (Ambrose, & Harris; 2010, s.40)

Bu yöntem "Konuları belirlemek" aşamasında derslerin birbirleriyle nasıl ilişkilendirilebileceği konusunda veya "Fikir geliştirmek" aşamasında tema/problem cümlesini oluşturmada size yardımcı olabilir (Şekil 15 ve Şekil 16).



Şekil 15. Etkinlik 2 de "Fikir geliştirmek" aşaması için Venn şeması kullanımı.

Etkinlik 2 için "Konuları belirlemek" aşamasında, kesirler konusu matematik dersinin bir alt kümesi olarak sol tarafta ifade edilmiş, fen ve matematik bilgisi kümeleri birleştirilerek maddenin hal değişimi, doğal afetler ile kesirler konuları arasında bir bağ kurulabileceği gösterilmiştir. Son olarak da fen bilgisi ve sosyal bilgiler derslerinin ortak kesişim kümesi olarak doğal afetler ve maddenin hal değişimi konuları arasındaki bağ gösterilmiştir. Bütüne baktığımızda Etkinlik 2 için seçilen konular Venn şeması ile disiplinler altında ifade edilmektedir.



Şekil 16. Etkinlik 2 de "Konuları belirlemek" aşaması için Venn şeması kullanımı.

Web tabanlı şema, tablo, harita, grafik ve infografik oluşturma araçları: Web temelli etkileşimli şema, venn şeması, grafik, tablo, slayt, kavram haritaları ve infografik gösterge/haritalar oluşturma araçları aşağıda sunulmuştur. Bu araçları STEM etkinlik tasarımında kullanabileceğiniz gibi, ders ve etkinlik için materyal geliştirmede de onlardan faydalanabilirsiniz.

- http://chartsbin.com/
- https://infogr.am/
- http://visual.ly/
- https://magic.piktochart.com/
- http://www.spicynodes.org/
- https://www.draw.io

Web tabanlı öğrenci cevaplama sistemleri: Etkileşimli soru hazırlama araçları aşağıda sunulmuştur. Bu araçları, interaktif STEM etkinlik/ders içeriği oluşturmak için kullanabilirsiniz.

- **Addpoll**

Çevrimiçi anket, form oluşturma aracıdır (www.addpoll.com/).

- **Answergarden**

İzleyicilere gerçek zamanlı katılım, çevrimiçi beyin fırtınası ve sınıf içi geribildirim sağlayan web tabanlı bir araçtır (answergarden.ch/).

- **Poll Everywhere**

Gerçek zamanlı olarak öğrencilere açık uçlu veya çoktan seçmeli etkileşimli soru hazırlama aracıdır (http://www.polleverywhere.com/).

- **Socrative**

Öğretmenlerin o günün dersi ya da etkinliği hakkında, öğrencileri web tabanlı değerlendirme aracıdır. Gerçek zamanlı sorular ve cevaplar ile öğretmenler sınıfın anlık dersi anlama düzeyini ölçebilir (www.socrative.com/).

- **Kahoot**

Öğrenmeyi eğlenceli hale getiren oyun tabanlı öğrenme platformudur (https://kahoot.it/).

Web tabanlı diğer araçlar: STEM etkinlik/ders tasarımında veya tasarlanan ders ve etkinlikler için materyal hazırlamada kullanılabilecek web tabanlı bazı araçlar aşağıda sunulmuştur.

- **Story bird**

Web tabanlı görsel öyküler oluşturmanıza yardımcı olur (https://storybird.com/).

- **Wordle**

"Kelime bulutları" oluşturmak için kullanılan web tabanlı bir araçtır (http://wordle.net/).

- **Pew research center**

Pew Araştırma Merkezi, dünyayı şekillendiren güncel konular, tutumlar ve eğilimler hakkında halkı bilgilendiren demografik araştırmalar, kamuoyu yoklamaları, içerik analizi ve diğer veri odaklı sosyal bilimler araştırmaları yapmaktadır (http://www.pewinternet.org/).

- **Video Editor**

Video düzenleme platformudur (www.nchsoftware.com/videopad/").

4.3 Paydaş analiz tablosu (Stakeholder Analysis toolkit, t.y.)

Paydaş	Projedeki rolü	Beklentiler	Proje hakkındaki tavrı	Proje hakkındaki endişesi	İhtiyaç	Projeye etki düzeyi	Odak grup	Potansiyel stratejiler

Not: Bu tablodaki belli kısımları aşağıdaki gibi doldurabilirsiniz.

- Proje hakkındaki tavrı: Destekleyici, Nötr, Orta derecede destekleyici, Orta derecede karşı, Karşı (Stakeholder Mapping Guide: For Conservation International Country Programs & Partners, 2014)
- Projedeki Rolü: Aktif katılımcı, Orta derecede katılımcı, Destekleyici (STEM etkinliğinin uygulanması için yer, malzeme, vb.), Nötr
- Projeye etki düzeyi: Yüksek, Orta ya da Düşük düzeyde etki (Stakeholder Analysis toolkit, t.y.)

4.4 Öğrenciler nasıl tanınır

STEM etkinliği tasarlarken, öğrencilerinizi tanımanıza yardımcı olacak bazı soruları burada sizinle paylaşıyoruz. Bu sorulara ekleme yapılabileceği gibi, cevaplarla ilgili elinizde bir bilgi varsa ya da sorunun uygun olmadığı düşünülürse sorularda azaltmaya da gidilebilir. Soruların kapsamının geniş olması sebebiyle, onları seçerken lütfen **öğrencilerin yaş aralığını** da göz önünde bulundurun.

STEM etkinliğinin içeriğini oluşturma (Dersler /etkinlik tasarlama vb.)

Dersler

1. Okulda katıldığın en sevdiğin etkinlik neydi?
2. Derslerin en çok nerede işlenmesini istersin? (Sınıfta, bahçede vb.)
3. Derslerin içeriğinde ne olmalı? (Seçenekler arttırılabilir)
   - etkinlik yapmak
   - oyun oynamak
   - deney yapmak
   - animasyon izlemek
   - proje yapmak
   - grup çalışması
   - bireysel çalışma
   - gezi yapmak
   - sunum yapmak
   - maket yapmak
   - poster hazırlamak

4. Bu dersi işlerken, sence başka hangi öğretmenler bana yardımcı olabilir?

Not: Ekip öğretim yöntemiyle ders işlenmesi hakkında öğrencilerin düşünceleri bu soruyla öğrenilebilir.

5. Anne ya da babanın seninle birlikte derse/etkinliğe katılmasını ister misin?

Konular veya dersler arasındaki bağlantılar

6. ……….. konusunu sen olsan nasıl işlerdin?
7. ……..…. konusu ile ……… konusu sence birbiriyle bağlantılı mı? Evet, ise Nasıl? Hayır, ise Neden?

Not: 6. ve 7. sorularda boşluklara, etkinlik için seçtiğiniz konuları yazabilirsiniz.

8. Sence …………. dersi/konusu hangi dersler/konular ile bağlantılı olabilir? Neden?

STEM etkinliği için problem/tema belirleme

Hangi Meslek

1. İleride kendini hangi mesleği yaparken hayal ediyorsun? Neden?

İlgi alanları

2. Şu anda en çok ne yapmaktan hoşlanıyorsun?
3. Şu anda merak ettiğin ya da araştırdığın bir konu var mı? Nedir?

Not: 4. ve 5. sorular, istenirse anket gibi tüm öğrencilere dağıtılabilir.

4. Şu anda senin, ailenin ya da arkadaşlarının yaşadığı veya karşılaştığı en büyük problem nedir?
5. Aşağıdaki konu/temalardan hangileri senin ilgini çekiyor? (Birden fazla seçenek işaretlenebilir.)
   - **Oyun tasarlamak (Dijital oyun, geleneksel oyun vb.)**
   - **Doğal afetlerden korunma yolları**
   - **Doğada kamp yapmak**
   - **Issız bir adada kendi başına yaşamak**
   - **Ben bir mühendisim ve ……………….. kendim tasarlamak istiyorum.**

   - **Sanat**
     - Kendi boyamızı yapalım.
     - Kendi kâğıdımızı yapalım.
     - Meyve ve sebzeleri kullanarak bir sanat eseri yapalım.

- Kendi yemek/sandviç/tatlımızı yapıp onu en estetik şekilde tabaklayıp sunalım. (Dondurma, tatlı, krep vb. yapmak)

- **Sağlıklı yaşamak**
  - Spor
  - Günümüzde hastalıklar, tedaviler ve bunlardan korunma yolları
  - Organik sebze/meyve yetiştirmek ve tüketmek
  - Sağlıklı yaşam ve iş alanları oluşturmak

- **Ekolojik çevre**
  - Hayvanlar (nesli tükenmekte olan hayvanlar)
  - Bitkiler
  - Sürdürülebilir enerji kaynakları ve bunların korunması
  - Doğayı (ekosistemi) korumanın yolları
  - Sürdürülebilir mimarlık
  - Geri dönüşümlü malzeme üretimi ve kullanımı

- **Gelecekte yaşam, ulaşım, yemek, eğitim, barınma, sağlık, sanat**
  - Uzay ve uzayda yaşam
  - Gelecekte yaşam alanı tasarımı
  - Geleceğin meslekleri
  - Gelecekte eğitim
  - Gelecekte hastalıklar, tedaviler
  - Gelecekte sanat
  - Gelecekte çiftçilik (sebze/meyve yetiştirme)
  - Gelecekte ulaşım, ulaşım araçları ve yakıtlar

- **Türkçe veya İngilizce dersinde okuttuğunuz hikâyelere dair temalar verebilirsiniz.**

4.5 STEM eğitiminde, STEM etkinlik ve dersler nasıl yapılır

STEM etkinliğini desteklemek adına, gerekli görülürse, etkinlik öncesi *aynı tema altında verilen dersler* ya da *disiplinlerarası dersler (bireysel öğretim/ekip öğretim yöntemi)* yapılabilir (Tablo 15). *Aynı tema altında verilen dersler,* ders öğretmeni tarafından tek bir konu etrafında disiplinlerarası bağlantılara da değinilerek normal bir ders gibi sunulmakta, fakat *disiplinlerarası dersler* uygulamada ya da ders planlamasında birden fazla öğretmen ve farklı disiplinlerden konuyu içerebilmektedir. Bu sebeple, zaman açısından kısıtlama varsa *aynı tema altında düzenlenen derslerin, disiplinlerarası derslere* nazaran hazırlanması ve uygulanması daha pratik olabilir ve öğretmen açısından daha az iş yüküne sebep olacağından dolayı tercih edilebilir. Fakat ekip öğretim yoluyla işlenen *disiplinlerarası dersler,* hem öğrenciye, hem de ders öncesi ve esnasında iş birliği gerektirmesi nedeniyle, STEM eğitimi veya disiplinlerarası çalışma hakkında tecrübesi olmayan öğretmene, konular arasındaki disiplinlerarası bağlantıyı keşfetme noktasında yardımcı olabilir. Ayrıca, bu iş birliği süresince bilgi paylaşımı olacağı için, öğretmenler ekipteki diğer öğretmenleri mesleki anlamda daha iyi tanıyabilirler. Bu noktada, hangi tür ders tasarlayacağınıza, "Bakış açısı geliştirmek" kısmında tespit edilen ihtiyaç ve analizlere ve haftalık ders yoğunluğunuza göre karar verebilirsiniz.

Tablo 15. A*ynı tema altında düzenlenen ders / disiplinlerarası ders tanımları*

1- Aynı tema/konu altında ders vermek: Farklı derslerde, aynı tema/konu/konular altında, birbirine yakın zamanlarda dersi kendi düzeninde işlemektir. Bu derslerde, bireysel etkinlik yapılabileceği gibi, STEM etkinliğine hizmet etmek için ders içeriğinde çeşitli ürünler veya etkinliğin bir bölümü de yaptırılabilir. (Örneğin düzenlenecek sergi için davetiye tasarımı yaptırmak, görsel sanatlar dersinde STEM etkinliğindeki problemi içeren bir ödev vererek, etkinlik öncesi fikir geliştirme çalışması yaptırmak)
2- Disiplinlerarası ders vermek:
Disiplinlerarası dersler birçok farklı şekilde uygulanabilir. Biz burada ekip öğretim yöntemi ve bireysel olarak verilen dersler üzerinde duracağız.

2a- Bireysel öğretim yoluyla disiplinlerarası ders vermek: Farklı branştan öğretmenlerin, aralarında disiplinlerarası ilişki kurdukları konu/konularla ilgili iş birliğiyle çalışarak ders tasarlaması, fakat uygulamasında dersin tek bir öğretmen tarafından işlenmesidir. Bu derslerde derse ait etkinlik yapılabileceği gibi, STEM etkinliğine hizmet etmek için çeşitli ürünler veya STEM etkinliğinin bir bölümü yaptırılabilir.
2b- Ekip öğretim yöntemiyle disiplinlerarası ders vermek: Farklı branştan öğretmenlerin, disiplinlerarası ilişki kurdukları konu/konularla ilgili iş birliğiyle çalışarak ders tasarlaması, fakat uygulamasında ders tasarımına dâhil olan öğretmenlerin dersi beraber işlemesidir. Bu derslerde derse ait etkinlik yapılabileceği gibi, STEM etkinliğine hizmet etmek için çeşitli ürünler veya STEM etkinliğinin bir bölümü yaptırılabilir.

STEM eğitiminde genel olarak etkinlikler üç farklı yol ile yapılabilir;

- Tek bir ders içinde, bireysel öğretim yoluyla bir konuyu farklı disiplinlerle ilişkilendirerek etkinlik yapmak.
- Birden fazla ders içinde, aynı gün/hafta/ay/dönemde, farklı disiplinlerden konuları birbirleriyle ilişkilendirerek etkinlik yapmak.
- Bir proje çerçevesinde, okul dışı STEM etkinliğiyle problem çözmek.

Disiplinlerarası dersler ile STEM etkinliği tasarımı ve uygulamasında size yardımcı olması adına aşağıdaki stratejiler hazırlanmıştır (Tablo 16 ve Tablo 17).

Tablo 16. *Disiplinlerarası dersler için stratejiler*

Disiplinlerarası ders tasarımı için stratejiler	Disiplinlerarası derslerin planlanmasında, seçilecek konuların öğretim sırası ve zamanlaması ile bunların disiplinlerarası uyumluluğu dikkate alınmalıdır.
	Disiplinlerarası ve etkinlik odaklı bir müfredata sahip olmaları sebebiyle, Görsel sanatların ve İngilizce disiplinlerinin STEM disiplinleri ile birlikte disiplinlerarası derslere entegre edilebilir.
Disiplinlerarası ders uygulaması için stratejiler	Bireysel öğretim yoluyla bir dizi disiplinlerarası ders işlerken, bu dersleri art arda yapmak, öğrencilerin disiplinlerarası öğrenimi için daha verimli olacaktır.
	Disiplinlerarası dersler, öğrencilerin STEM etkinliklerine olan aşinalıklarını arttırmak için kısa veya tanıtıcı bir STEM etkinliği ile bitirilebilir.
Öğretmenler için stratejiler	İş birliği ve zamanlama ile ilgili ekip öğretim yönteminin gerekliliklerinin karşılanamaması durumunda, bireysel öğretim yoluyla disiplinlerarası dersler vermek tercih edilebilir.
	Ekip öğretim yöntemiyle verilen disiplinlerarası derslerde, iş birliği yapan öğretmenlerin iş yükü eşit olarak dağıtılmalıdır.

Tablo 17. *STEM etkinliği için stratejiler*

STEM etkinlik tasarımı için stratejiler	“Gözlem yapmak” aşamasında, öğrencilerin önerilen listeden etkinlik konu/konularını seçmelerini sağlayın.
	Öğrencilerin dikkatini STEM etkinliğine çekecek bir etkinlik teması belirleyin.
	TOD yaklaşımını, prototip oluşturma ve öğrenciler arasında iş birliğini öne çıkaracak şekilde STEM etkinliğine entegre edin.
	STEM etkinliğine, öğrenciler için, grup çalışması ve/veya oyun tabanlı öğrenmeyi dâhil edin.
	Eğer bir zaman kısıtlaması varsa (örneğin, tek derslik uygulama yapmak), birden fazla disiplin kullanarak problem çözümünü içeren çalışma kâğıtlarını öğrenciler için hazırlayın (Şekil 17).
	Malzemelerin gereksiz kullanımını önlemek ve problem çözmede öğrencilerin yaratıcılıklarını tetiklemek adına malzeme kullanımına kısıtlama getirin.
	Eğer uygunsa, STEM etkinlik tasarımına iş tanıtımı ekleyin.
	Uygulama (prototip) bölümünden sonra etkinlikte başka soru sormayın.
	İşbirliği yapan öğretmenlerin programı ile öğrencilerin sınav programını dikkate alarak STEM etkinlik tarihini belirleyin.
	Tasarlanan STEM etkinliğini öğrenciler üzerinde uygulamadan önce, bir başka sınıfta az sayıda öğrenci (3 öğrenci, vb.) üzerinde veya kendiniz/diğer öğretmenler üzerinde uygulayarak deneyin (Uştu, 2019). Eğer bu uygulamalarda tespit edilen problemler olursa, etkinliği revize edin ve ardından kendi sınıfınızda uygulayın.

STEM etkinlik uygulaması için stratejiler	Disiplinlerarası dersleri ve STEM etkinliğini uygulamadan önce, tasarım odaklı düşünme sürecini ve STEM eğitimini öğrencilere tanıtın.
	STEM etkinliğini uygulamadan önce benzer soruları sınıfta test edin.
	STEM etkinliğini uygulamadan önce sınıfta konu tekrarı yapın.
	Öğrencileri, STEM etkinlik tarihinden önce, etkinlik konuları hakkında bilgilendirin.
	Öğrencilerin dengeli bir şekilde etkinliğe konsantre olmalarını sağlamak için “soruları cevaplama” kısmını, uygulama kısmından mekânsal ve bilişsel olarak ayırın.
	Öğrencilerin durumlarındaki değişiklikleri anlamak ve gerekli eylemleri geliştirerek uygulamak için, STEM etkinliği uygulanmasına kadar öğrencileri gözlemleyin.
	Grup çalışması için uygun, öğrencilerin yaratıcılığını teşvik eden ve öğrencilerin yeme ve içmelerine izin verildiği rahat bir çalışma ortamı oluşturun.
	STEM etkinliğinde başarılı bir rehberlik sağlamaları için, iş birliği yapan öğretmenleri etkinliğin gerekli noktaları hakkında önceden bilgilendirin.
	Problem belirleme aşamasında, öğrencileri STEM etkinlik temasını okumaya ve yeniden yorumlamaya ve düşüncelerini bir rapor şeklinde yazmaya teşvik edin.
	STEM etkinliği sırasında “fikir geliştirme” aşamasının önemini vurgulayın ve öğrencileri, “estetik” açıdan güzel prototipler oluşturmaya öncelik verme yerine, yeni ve işlevsel fikirler geliştirmeye teşvik edin.
	STEM etkinliği tamamladıktan sonra, öğrencileri sınıfa çözümlerini sunmaya teşvik edin ve onlara, öğrenci takımlarının performansını değerlendirmek için akran değerlendirme sürecini yapılandıran bir öğrenci değerlendirme tablosu (Tablo 13) veya yorum kartı verin.
	Öğrencilerin etkinliği ciddiye almasını sağlamak için STEM etkinliğini notlandırın.
	Notlandırmada, “soruları cevaplama” kısmına uygulama (prototip) kısmından daha fazla puan verin.

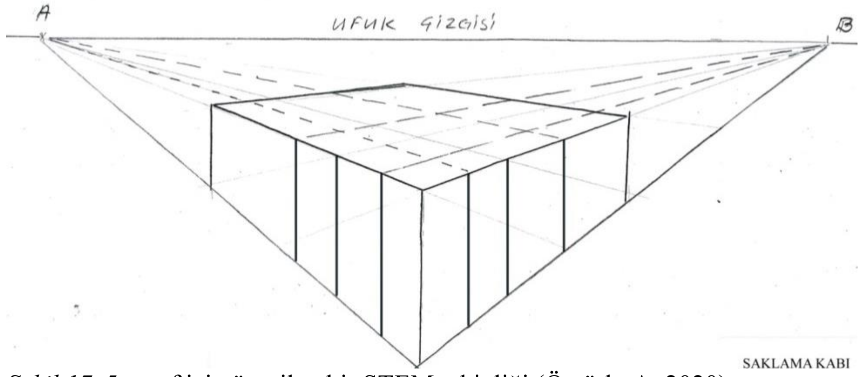
Soru: Öğrenciler, öğlen artan yemeklerini koymak için aldıkları saklama kabının içinin bölmeli olmaması sebebiyle, konulan yemeklerin birbirine karıştığını gözlemlerler. Moralleri bozulan öğrenciler saklama kabını istedikleri gibi bölümlendirilmesi gerektiğini düşünürler. Fakat herkesin almak istediği yemekler ile miktarları farklı olduğu için, bölümlendirmeye ait tasarımın kendi içinde değişiklik gösterebileceğini fark ederler. Buna göre, size dağıtılacak olan saklama kabına ait görsel üzerinde 4 çeşit yemek için bölümlendirme yapmanızı istiyoruz. Bunu yaparken lütfen aşağıdaki sorulara cevap veriniz:

1- Saklama kabının kaçta kaçına hangi yemekleri koymak istersiniz? Lütfen kesirli ifade kullanarak cevap veriniz ve size verilen görsel üzerinde bunu çizerek gösteriniz.

2- Çizdiğiniz bölmeleri 3 ANA RENK ve sevdiğiniz 1 ARA RENGİ, yani toplamda 4 rengi kullanarak boyayınız. Cevaplarınız için çalışma kâğıdı üzerindeki ilgili alanları doldurunuz.

Yemek Menüsü: Çorba, Köfte ve Patates, Makarna, Yoğurt, Dondurma, Ekmek

	1- Yemek Adı	2- Yemeğin İngilizce Adı	3- Hangi Renk (Aynı renkte boyayarak gösterebilirsiniz)	4- Saklama Kabının Kaçta Kaçında bulunmakta
1. Yemek				
2. Yemek				
3. Yemek				
4. Yemek				



Şekil 17. 5. sınıf için önerilen bir STEM etkinliği (Öztürk, A. 2020)

4.6 Tasarım Odaklı Düşünme yaklaşımı nedir

Tasarım odaklı düşünme (TOD) yaklaşımı, disiplinlerarası ve insan odaklı bir yaklaşım olarak tanımlamakta (Brown, 2008) ve eğitimde müfredat tasarımı (IDEO, 2012), öğrenme ortamı tasarımı (Design council, 2005), öğrencilerin becerilerini geliştirme (d.loft STEM) gibi farklı amaçlar için bir araç olarak kullanılmaktadır. Buna göre, TOD ile öğretmenler, yaratıcılıklarını kullanarak eğitimlerinde yenilikçi bir yaklaşım geliştirebilmektedirler (Keane & Keane, 2014). *Tasarım odaklı düşünme* yaklaşımı ayrıca disiplinlerarasılık, yaparak ve yaşayarak öğrenme (Efeoğlu, Møller, Sérié, & Boer, 2013) ve 21. yüzyıl becerilerini (Cooper-Hewitt, 2014) içermekte, bu sebeple STEM eğitimiyle ortak özellikler taşımaktadır. Ayrıca STEM etkinliklerinde etkili bir problem çözme metodu olarak da kullanılmaktadır.

Tasarım odaklı düşünme yaklaşımıyla STEM etkinlik tasarımını gerçekleştirmek için, benimsenmesi önem arz eden on düşünce tarzı bulunmaktadır. Bunlardan bazılarının STEM eğitiminin özellikleriyle ortak olması sebebiyle (iş birliği yapmak, başarısızlıktan ders almak, süreci tekrarlamak), STEM etkinlik uygulaması öncesinde öğrencilere de öğretilebilir.

Tablo 18. *Tasarım odaklı düşünme yaklaşımına ait düşünce tarzları*

Yaratıcılığınıza güven duymak: Bu düşünce tarzı, herkesin tasarım yapabileceğine inanarak dünyaya bir tasarımcı gibi bakmak ve yaratıcı fikirlerin ve bu fikirleri gerçeğe dönüştürecek gücün kendinde olduğuna inanmaktır (The Field Guide to Human-Centered Design, 2015). Yaratıcılığa güveni inşa etmek zaman alan bir süreçtir ve STEM etkinlik tasarımı kılavuzu size bu anlamda yol gösterecektir.
Yapmak: Tasarım odaklı düşünme yaklaşımı, prototip yapıp onları denemekle ilgili bir süreçtir. Prototip yaparken amaç, hangi malzemeyi kullandığınız veya estetik açıdan güzel bir model yapmanız değildir; fikrinizi sunmak, paylaşmak ve onu nasıl daha da iyileştirebileceğinize dair geribildirim almaktır (Field Guide to Human-Centered Design, 2015).
Başarısızlıktan ders almak: Bu düşünce tarzı, birçok fikir üreterek onları kullanıcıyla test etmek ve başarısız olunursa bundan ders alarak uygulamalarınızı geliştirmeyi ifade etmektedir (Brenner, Uebernickel, & Abrell, 2016). Bu yaklaşım, öğretmenler için başarısız bir etkinlik uygulaması karşısında, yeni bir etkinlik uygulaması için stratejiler geliştirmek ve öğrenciler içinse, başarısız olan projelerinden ders alarak yeni fikirler geliştirmeye devam etmek açısından çok önemlidir.
Empati yapmak: Empati yapmak, kendinizi başkasının yerine koyarak, problemleri onların bakış açısına göre çözmektir. Empati yapmak, önyargıları geride bırakmanıza yardımcı olur (Field Guide to Human-Centered Design, 2015).
Belirsizliği benimsemek: Tasarım odaklı düşünme yaklaşımını kullanırken, çözülmek istenen problemin cevabını bilmemek, ilk başta size rahatsızlık hissi verebilir (Field Guide to Human-Centered Design, 2015). Bu sebeple, belirsizlikleri benimseyerek ve STEM etkinlik tasarımı kılavuzuna güvenerek, kendinizi yaratıcı fikirlere açabileceğiniz düşünülmektir.
İyimser olmak: İyimser olmak, probleme dair daha iyi bir çözüm ihtimalinin olduğuna ve ona ulaşabileceğinize inanmaktır (Field Guide to Human-Centered Design, 2015).
Süreci tekrarlamak: Problem çözüm sürecinde ilk veya ikinci seferde doğru sonuca ulaşılamayabilir, ancak süreci tekrar ederek benimsenecek bir çözüm elde edilebilir (Field Guide to Human-Centered Design, 2015). Bu açıdan bakıldığında, doğru çözüme ulaşmak için paydaşlardan sık geri bildirim almak önemlidir.
İş birliği yapmak: Bir problemi anlamak, analiz etmek ve çözüm geliştirmek için, farklı disiplinden insanların iş birliğidir (Tran, 2017).
Risklere açık olmak: Yeni fikirleri araştırmak için, konfor alanını terk ederek şu anki durumu sorgulamak (Chesson, 2017) ve risk alarak ilk seferde başarılı olamayacağınızı kabul etmektir (Kolk, 2012).
Bütüncül bakış açısına sahip olmak: Problemleri, bütüncül düşünmeye dayalı olarak, prosedürlerin, organizasyonel kavramların veya yazılımların vb. entegrasyonunu içerecek sistemik çözümler gerektiren problemler olarak kabul etmektir (Owen, 2007). Etkinliklerde "problem belirleme" aşamasında, sorunun ne olduğunu anlamak için, birçok faktörü değerlendirmeyi içermesi ve bu sayede farklı çözümlere ulaşmayı kolaylaştırması açısından, bütüncül bakış açısına sahip olmak öğrenciler için önem arz etmektedir.

Tasarım Odaklı Düşünme yaklaşımının aşamaları nedir?

Literatüre baktığımızda, farklı tasarım odaklı düşünme yaklaşımlarının uygulandığını görmekteyiz. Bu noktada, süreci daha ayrıntılı ele alması ve STEM etkinlik tasarımı sürecinde kullanılan yöntemin başlangıç noktasını oluşturması sebebiyle, **HPI School of Design Thinking**'in kullandığı tasarım odaklı düşünme yaklaşımı üzerinde duracağız. *HPI tasarım odaklı düşünme* (HPI, t.y.) sırasıyla **anlamak, gözlem yapmak, bakış açısı geliştirmek, fikir geliştirmek, prototip yapmak ve test etmek'** ten oluşan altı aşamalı dönüşümlü bir yaklaşım uygulamaktadır. Bu yaklaşımda, gerekirse önceki aşamalara veya başlangıca geri dönebileceğiniz anlamına gelen bir yineleme vardır (Thoring & Muller, 2011).

- **Anlamak:** Konu ile ilgili araştırma yapmak ve bilgi toplamak.
- **Gözlem yapmak:** Problemi ve kullanıcıyı anlamak için gözlem ve görüşme yapmak.
- **Bakış açısı geliştirmek:** Önceki aşamalarda toplanan bilgileri bir araya getirerek, nelere ihtiyaç ya da gereksinim olduğuna ve buna bağlı olarak neler yapılabileceğine bakmak. Bu bilgilerden anlam çıkararak, probleme dair bakış açısı ortaya koymak ve bir problem cümlesi oluşturmak.
- **Fikir geliştirmek:** Beyin fırtınası yaparak, probleminiz için çözüm olabilecek birçok fikir bulmaya çalışmak ve bunların içinden grup tarafından en çok oy alanı uygulama için seçmek.
- **Prototip yapmak:** Seçilen fikri veya oluşturduğunuz konseptleri denemek için birçok farklı yöntem kullanarak prototipler yapmak.
- **Test etmek:** Yapılan prototipi kullanıcı üzerinde test ederek kullanıcıdan geri bildirim almak ve gerekliyse düzeltmeler yaparak prototipi ya da bütün süreci tekrar gözden geçirmek.

<u>**Daha sistematik bir STEM etkinliği tasarlamak için, *tasarım odaklı düşünme* yaklaşımı STEM etkinliklerine problem çözme metodu olarak dâhil edilebilir.**</u> Bu açıdan bakıldığında, *tasarım odaklı düşünme* yaklaşımının ayrıntılı olarak her aşaması ve bu aşamaların STEM etkinlik tasarımında nasıl kullanılabileceği aşağıda size sunulmuştur.

Not: Tasarım odaklı düşünme yaklaşımıyla ilgili hızlıca fikir sahibi olmak adına, d.school ait olan *Cüzdan Tasarlama Etkinliğini* (Wallet Design Exercise), 90 dakika içinde partnerinizle uygulayabilirsiniz. Bu etkinliğe ait olan doküman ve videolara aşağıdaki web sitelerinden ulaşabilirsiniz.

Tablo 19. *Cüzdan tasarlama etkinliğiyle ilgili web adresleri*

https://dschool-old.stanford.edu/groups/designresources/wiki/4dbb2/The_Wallet_Project.html
https://vimeo.com/33690707
https://www.youtube.com/watch?v=Z4gAugRGpeY

Anlamak ve Gözlem yapmak:
"Tasarım sürecinde "**Anlamak ve Gözlem yapmak"** aşamaları, katılımcıların empati duygusunu geliştirmesine yardımcı olmaktadır" (Taking Design Thinking to Schools, t.y.). İnsan odaklı bir tasarım için önce kullanıcıları anlamanız gerekmektedir. Kullanıcıların kim olduğunu ve onlar için neyin önemli olduğunu öğrenmek için onlar ile empati kurulmalıdır. İnsanları izlemek ve onların çevreleriyle nasıl iletişim içinde olduğunu görmek, size onların ne düşündüğü ve hissettiği ve neye ihtiyacı olduğu hakkında fikir verecektir (d.school at Stanford University, t.y.). <u>"Anlamak ve Gözlem yapmak" aşamaları kullanılarak, öğrencilerin empati duygusunu geliştirmek üzerine kurgulanmış STEM etkinlikleri tasarlanabilir.</u>

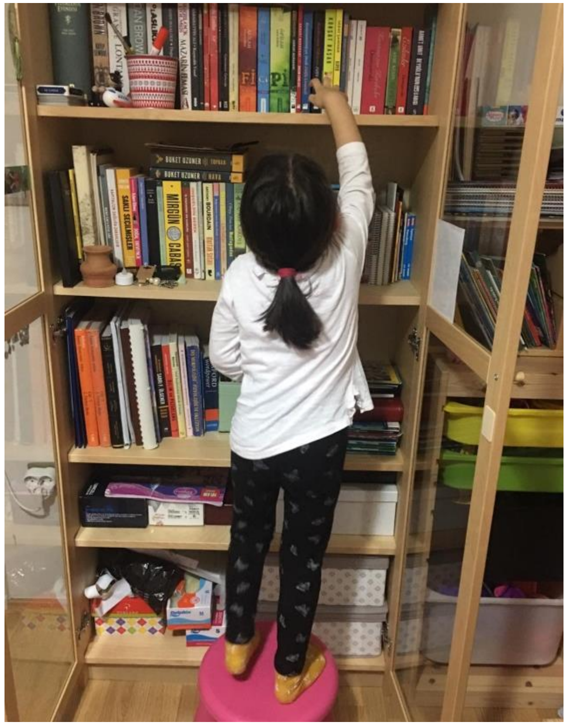
Bakış açısı geliştirmek:
Bu aşamada, katılımcılardan insanların ihtiyaçları konusunda fikir sahibi olmaları ve buna göre bir bakış açısı geliştirmeleri beklenir (Taking Design Thinking to Schools, t.y.). Buna göre, önceki aşamalarda toplanan bilgiler bir araya getirilerek nelere ihtiyaç ya da gereksinim olduğu ve buna bağlı olarak neler yapılabileceğine bakılır. Sonuç olarak, bu bilgilerden anlam çıkarılarak probleme dair bir bakış açısı ortaya konabilir. Bu aşamada amaç, kullanıcıya, ihtiyaçlarına, analizlerinize odaklanan, yönlendirici ve detaylı bir problem cümlesi oluşturmaktır.

Örneğin, **bulgularıma göre … ihtiyaç var, çünkü … olmakta, bu sebeple benim problem cümlem…** dir. <u>Peki, ihtiyaçlar nasıl belirlenir? Analiz nasıl yapılır?</u>

"İhtiyaç" nedir?
'İhtiyaçlar', insanın duygusal veya fiziksel ihtiyaçlarıdır ve tasarım sorununuzu tanımlamanıza yardımcı olur. Kullanıcı özelliklerine veya özellikleri arasındaki çelişkilere (kullanıcının ne söylediği ile yaptığının farklı

olması) dayalı notlara bakarak ihtiyaçlar belirlenebilir (d.school at Stanford University, t.y.).

Örnek: Bu çocuğun kitaplara ulaşmak için neye ihtiyacı var? (Şekil 18)



Şekil 18. Kitaplara ulaşmaya çalışan çocuk görseli

İhtiyaç kelimesini bir 'eylem' olarak düşünün lütfen, 'isim' olarak değil. Çünkü 'isimler' çözüm önerisi demektir (d.school at Stanford University, t.y.). Örneğin; "Küçük kızın **bir merdivene veya bir yetişkine ihtiyacı** var" demek yerine, "Küçük kızın **bir kitaba ulaşmaya ihtiyacı** var" derseniz çözüm bir merdiven, biyonik kol ya da herhangi başka bir şey olabilir (Johnny Ryan, 2013). Dolayısıyla çözüme dair seçenekler artmış olur. <u>'İhtiyaç' kelimesini iyi tanımlamak, özellikle STEM etkinlik tasarımında problem yerine tema cümlesi kurmanızda size yardımcı olabilir.</u>

Analiz nedir?

"Analizler, araştırmalarınızdan öğrendiklerinizin özlü bir ifadesidir" (IDEO, 2012) ve elde edilen bilgilerin sentezidir. Bu sebeple, her zaman size yeni bir perspektif sunar. "Analizler genellikle iki kullanıcı niteliği arasındaki çelişkiyi ya da ilişkiyi inceleyerek veya garip bir davranış fark ettiğinizde kendinize 'niçin' sorusunu sorarak bulunabilir" (d.school at Stanford University, t.y.). Tekrar sorumuza geri dönersek, az önceki resim için aradığımız cevap belki şu olabilir; "**Bu çocuk ailesinin dikkatini çekmek için raflara bu şekilde uzanmaktadır**." Dolayısıyla resimdeki çocuğun, merdiven ya da başka bir şeye ihtiyacı bulunmamakta, arka planda amacı sadece ailesinin dikkatini çekmek olmaktadır. İşte bu bir analizdir ve bu sonuca varmak için sadece fotoğrafa bakmak yerine eldeki diğer verilerinde değerlendirilmesi (küçük kız ile ailesi hakkında bilgi toplamak, onları gözlemlemek vb.), yani derinlemesine bir araştırma yapılması gerekmektedir (Johnny Ryan, 2013).

<u>Sonuç olarak, ihtiyaç ve analizleri iyi tanımlamak problemi tanımlamakta size yardımcı olabilir. Bu noktada, STEM etkinliklerinde, "Anlamak ve Gözlem yapmak" (bilgi toplamak) ile "Bakış açısı geliştirmek" (elde edilen bilgilerle ihtiyaç ve analizleri belirlemek) aşamaları üzerine kurgulanmış etkinlikler, öğrencilerin soruna daha geniş bir perspektiften bakarak problemi tanımlamalarına ve buna göre farklı çözümler üretmelerine yardımcı olabilir. Ayrıca, "Anlamak", "Gözlem yapmak" ve "Bakış açısı geliştirmek" aşamaları birleştirilerek, STEM etkinliklerinde "araştırma yapmak" başlığı altında yeniden düzenlenebilir.</u>

Fikir Geliştirmek:

Bu aşamada, tanımlanan kullanıcı probleminin çözülmesine yönelik beyin fırtınası yaparak fikir üretmek amaçlanmaktadır. Beyin fırtınasında açık uçlu sorular yöneltmek önemlidir. '… Nasıl yapabiliriz?' soruları beyin fırtınasını başlatan kısa sorulardır ve cevap olarak pek çok seçeneğe ulaşmamızı sağlayabilirler (MIT MOOCs course, t.y.). Örneğin, dar kapsamlı bir soru olan, **“Damlatmadan dondurma yemek için nasıl bir külah tasarlayabiliriz?”** ile geniş kapsamlı bir soru olan **“Nasıl bir tatlı tasarlayabiliriz?”** yerine, **“Daha taşınabilir olması için dondurmayı nasıl tasarlayabiliriz?”** sorusu, beyin fırtınasını başlatmak için sorulması gereken uygun bir sorudur (d.school at Stanford University, t.y.).

Örnek:
Problem: Kullanıcının yiyecekleri, işe giderken yolda soğumaya başlar.
Beyin fırtınası esnasında sorulması gereken soru: Kullanıcınızın yiyeceklerini işe giderken yolda sıcak tutmasına nasıl yardımcı olabilirsiniz? (MIT MOOCs course, t.y.)

<u>STEM etkinliklerinde, problem belirlendikten sonra, öğrencilerin farklı çözümlere ulaşmasında bu tür sorular sormak önem taşımaktadır. Bu sebeple, sadece “Fikir geliştirmek” üzerine kurgulanmış STEM etkinlikleriyle, tema/problem cümlesi üzerine nasıl beyin fırtınası yapılıp, farklı, özgün sonuçlara ulaşılabileceği öğrencilere gösterilebilir.</u>

Prototip Yapmak:
Prototipleme, tasarım sürecinde bir fikri karşı tarafa aktarmanın ve “işlevselliği test etmenin” hızlı bir yoludur. Bir prototip yapma, onu test etme ve gerekirse değişiklikler yaparak prototipi yenilemek, bir öğrenme sürecidir ve bu sebeple, ilk seferde doğru bir sonuca ulaşmak gibi bir amaç yoktur (d.school at Stanford University, t.y.). Sonuç olarak, prototip fikrinize ait bir taslaktır ve zamanla değişebilir. (MIT MOOCs course, t.y.)
“Prototip” aşamasında (d.school at Stanford University, t.y.):

- Öncelikle neyin prototipinin yapılacağına karar verilmelidir.
- Daha sonra nasıl bir prototip yapılacağına karar verilmeli ve bu aşamada hangi prototipleme yönteminin kullanılacağı düşünülmelidir.
- Bir prototip yaparken uzun süre harcanmamalı, başarısız olmaktan korkmamalı, sürekli denemeye devam etmeli ve ayrıca hangi malzemelerin kullanılacağı önceden düşünülmelidir.

Test Etmek:
Test, geri bildirim sağlayan tekrarlı bir işlemin parçasıdır. Bu aşama, prototipinize geri dönülmesi ve geribildirime dayalı olarak değiştirilmesi anlamına da gelebilir (Taking Design Thinking to Schools, t.y.). Bu kısımda, prototipinizi hedef kitlenizle paylaşıp test ettikten sonra, onlardan aldığınız geribildirimler ışığında prototipinize dair pozitif ve negatif yönleri öğrenmek, bunlara dair aklınıza takılan soruları not etmek ve daha sonra prototipi geliştirmek amaçlanmaktadır. <u>Test etmek aşaması, proje sunmak, geri bildirim almak ve akran değerlendirmesi yapmak başlıklarını içererek STEM etkinliklerine dâhil edilebilir.</u>

Tasarım odaklı düşünme yaklaşımını kullanan örnek STEM etkinlikleri:
Tasarım odaklı düşünme yaklaşımının problem-çözme metodu olarak harmanlandığı bazı STEM etkinlikleri, siz eğitimcilere örnek olması için aşağıda sunulmuştur.

Sosyal bilgiler eğitimi:

Öğrencilerden, ulusal bayramları içeren bir zaman çizelgesi oluşturmaları istenir. Bu zaman çizelgesinde ayrıca, ulusal bayramlardan en önemli bulduklarının kendileri için ne ifade ettiğini, çizerek anlatmaları beklenir. Bunu yaparken öğrencilerin, hangi ulusal bayramları neden önemli bulduklarına dair bir bakış açısı geliştirmeleri ve bunun doğrultusunda ona ait bilgileri zaman çizelgesinde kullanmaları beklenmiştir. Burada tasarım odaklı düşünme yaklaşımına ait aşamaların tamamı yerine “Bakış açısı geliştirmek” ile “Prototip yapmak” aşamaları kullanılmıştır.

Fen bilgisi eğitimi:

Burada fen bilgisini merkeze alan, fakat aynı zamanda görsel sanatlar, matematik ve İngilizce disiplinlerini de içeren STEM etkinliği (**Etkinlik 1**), tasarım odaklı düşünme yaklaşımını problem çözme metodu olarak kullanmıştır. Bu etkinlikte, “Anlamak”, “Gözlem yapmak” ve “Bakış açısı geliştirmek” aşamaları birleştirilerek, etkinlik altı aşama yerine dört aşamada uygulanmıştır (Tablo 20).

Tablo 20. *Etkinlik 1 için STEM etkinlik tasarımı*

Soru: Öğrencilerimiz, son zamanlarda öğlen yemeklerinde dondurmanın erimiş olarak önlerine gelmesinden şikâyet etmektedirler. Bu noktada okul müdürüne iki soru sormuşlardır. Sizler bu soruları cevaplamamıza yardımcı olabilir misiniz?

• Dondurmanın erimesindeki sebepler nedir?
• Dondurmanın erimesini engellemek için nasıl bir çözüm/sistem önerirsiniz?

Çözüm için lütfen size dağıtılan çalışma kâğıdındaki aşamaları takip edelim.

1- FİKİR ÜRETMEK: Lütfen dondurmanın erimesini engellemek için takım arkadaşlarınız ile beyin fırtınası yapın ve aşağıdaki kutucuklara iki çözüm fikrini içeren çizim yapın.

2- FİKİR SEÇMEK: Lütfen bu fikirlerden birini seçin ve nedenini açıklayın.
3- PROTOTİP YAPMAK: Lütfen size verilen malzemeler ile seçtiğiniz fikrin prototipini yapın. Ayrıca, aşağıdaki soruları da cevaplandırın.

Malzemeler: Alüminyum folyo, yapıştırıcı, cetvel, karton, çöp stik, bant, makas, pipet, renkli kâğıt, A4 beyaz kâğıt, yapışkanlı not kâğıdı, keçe, tuvalet kâğıdı veya havlu peçete rulo kartonu, renkli kalemler ve Zarf.
Not: Bu aşamayı yaparken görev paylaşımı yapabilirsiniz.

a- Bu tasarımın (prototipin) çalışma şekli nedir? Dondurmanın erimesini nasıl engeller?

b-Lütfen aşağıdaki soruyu cevaplandırınız.

Bugün Ayşe, okulun yemekhanesinde çıkan dondurmanın en çok sevdiği çeşitlerinden 3 top almıştı. Fakat dondurmayı öğlen yemeğinde yemek için vakit bulamadı, bu sebeple eve geldiğinde dondurmasını yemek istedi. Ancak eve gelene kadar 3 top dondurmadan iki topunun 1/3 nün ve diğer bir top dondurmanın da 1/2 sinin erimiş olduğunu fark etti. Buna göre, Ayşe’nin geriye dondurmasının kaçta kaçı kalmıştır?

c- 50-70 cm kâğıt üzerine tasarımınıza (prototipinize) ait tanıtıcı bir İngilizce poster hazırlayın.

d- Size verilen problemi çözerken hangi derslere ait bilgileri kullanma ihtiyacı duydunuz?

Matematik:
Fen Bilgisi:
Görsel Sanatlar:
İngilizce:

e- Sunum yapmak:

Lütfen projelerinizi sınıfa sununuz.

f- Akran değerlendirmesi:

Lütfen en çok beğendiğiniz projeyi nedenleriyle birlikte yazın ve kapalı zarf içinde öğretmeninize teslim edin.

4.7 STEM etkinlik planı şablonu[5]

Faaliyeti 2-3 cümle ile anlatın. Etkinlik planınızı ve amacınızı kısaca özetleyin. Öğrencileriniz, bu etkinlik sonunda ne öğreniyor?

Hedef paydaş/paydaşlar: Hedef paydaş/paydaşlar kim?

Etkinlik hangi disiplinleri içerecek? Hedef kazanımlar ne olacak?

	Disiplin 1	Disiplin 2	Disiplin 3	Disiplin 4
Ders adı				
Etkinliğe dâhil edilecek konu/konular				
Hedef kazanım/kazanımlar				

Etkinliğe hangi öğretmenler katılacak?

Etkinlik ne zaman, nerede yapılacak (ders/dersler/okul içi veya okul dışı yerlerde) ve süresi ne kadar olacak?

Etkinlik problem/tema cümleniz nedir? Öğrencilere soracağınız ve etkinlik içeriğindeki tüm derslere ait bilgileri kullanmalarını sağlayacak, problem/tema cümleniz/senaryonuz nedir?

Araştırma sorularınız nedir? (eğer mevcutsa)
Sınırlamalarınız nelerdir? (eğer mevcutsa)

[5] STEM etkinlik planındaki bazı kısımlar MIT MOOCs course (t.y.) dan faydalanarak hazırlanmıştır.

Etkinlik nasıl ilerleyecek? Etkinliğin içeriğinin nasıl olacağı aşama, aşama yazılacaktır. Bu noktada, aşağıdaki hususları lütfen dikkate alalım.

- Her aşamadan hangi öğretmen sorumlu olacak?
- Etkinlik ne zaman yapılacak?
- Hangi ders/derslerde/yerde bu aşamalar gerçekleşecek?
- Her aşamaya ne kadar süre verilecek?
- Bu aşamalarda ne yapılacak? (bireysel veya grup çalışması var mı?)
- Öğrencilerden neler istenecek? (prototip yapma, rapor hazırlama, sunum yapma, poster tasarımı, sistem tasarımı paftası, vb.)
- Öğrenciler birbirlerinin projelerini değerlendirecek mi? (akran değerlendirmesi)
- Etkinlik sonunda sergileme olacak mı (sergi poster ve davetiyesi nasıl hazırlanacak?)

Not: Etkinliğinizin içeriğini oluştururken, *HPI tasarım odaklı düşünme* yaklaşımından (anlamak, gözlem yapmak, bakış açısı geliştirmek, fikir geliştirmek, prototip yapmak, test etmek) faydalanabilirsiniz.

- Tema/problem nasıl sunulacak? (Powerpoint sunum, animasyon hazırlama, film kullanma)
- Hangi sorular sorulacak? Sorular hangi aşamada yer alacak?
- Hazırlanan sorular önceden derslerde nasıl test edilecek?
- Etkinlikte grup çalışması varsa gruplar nasıl oluşturulacak?
- Etkinlikte hangi aşama kaç puan olacak? Değerlendirme ölçütleri ne olacak?
  (Soru cevaplama, akran değerlendirmesi, ödev, fikir geliştirme, prototip yapma, rapor/sunum hazırlama, poster tasarımı, sistem tasarımı paftası vb. çıktıların değerlendirme ölçütleri)

- Etkinlik sırasında öğrencilerin belirli becerileri değerlendirilecek mi? (Takım çalışması, zaman yönetimi, vb. noktaların değerlendirilmesi) Bu değerlendirme nasıl yapılacak?

- STEM etkinliği için öğrenciler nasıl motive edilecek? (Etkinlik esnasında çikolata dağıtma, birinciye hediye verme (kitap, madalya, bilgisayar oyunu, vb.)

- Etkinliğin gerçekleştirilmesi için kaynakça ne olacak? (Kitap, YouTube video, internet sitesi)

- Etkinlik için hangi materyalleri hazırlamanız gerekecek? Nasıl hazırlayacaksınız?

- Öğrencilerin etkinliğe malzeme getirmesi gerekecek mi? Bunlar nelerdir?

- Öğrencilere problem cümlesini de içerecek detaylı bir etkinlik planı verilecek mi? Öğrencileri etkinlik esnasında yönlendirmeniz veya talimat vermeniz gerekecek mi? Evet, ise bunu nasıl yapacaksınız?

- STEM etkinliği için yapılacaklar/ihtiyaç listesi nedir?

- Diğer Bilgiler:

STEM etkinliğine hazırlık aşaması (Aynı tema altında düzenlenen ders / disiplinlerarası ders planları)

- ✓ Ekip öğretim yöntemiyle yapılacak olan disiplinlerarası derse hangi öğretmenler katılacak?
- ✓ Ekip öğretim yöntemiyle veya bireysel öğretim ile yapılacak olan disiplinlerarası ders, hangi derste işlenecek?
- ✓ Dersler ne zaman yapılacak ve ders süresi ne kadar olacak?
- ✓ Derslerde hangi kuramsal bilgiler verilecek ve dersler nasıl işlenecek?
- ✓ Disiplinlerarası derslerde konular birbirine nasıl bağlanacak?
- ✓ Değerlendirme nasıl olacak? (Ödev, sınav, akran değerlendirilmesi)
- ✓ Ders için hangi materyalleri hazırlamanız gerekecek? Nasıl hazırlayacaksınız?
- ✓ Öğrencilerin derse malzeme getirmesi gerekecek mi? Bunlar nelerdir?

Ders 1
Ders türü:
Katılımcılar:
Konu/konular:
Yer / Tarih:
Değerlendirme:

Ders planı

Ders 2
Ders türü:
Katılımcılar:
Konu/konular:
Yer / Tarih:
Değerlendirme:

Ders planı

Ders 3
Ders türü:
Katılımcılar:
Konu/konular:
Yer / Tarih:
Değerlendirme:

Ders planı

Ders 4
Ders türü:
Katılımcılar:
Konu/konular:
Yer / Tarih:
Değerlendirme:

Ders planı

- Dersler için yapılacaklar/ihtiyaç listesi nedir?
- Diğer Bilgiler:

4.8 Örnek STEM etkinlik planı: *ETKİNLİK 1*

Faaliyeti 2-3 cümle ile anlatın. Etkinlik planınızı ve amacınızı kısaca özetleyin. Öğrencileriniz, bu etkinlik sonunda ne öğreniyor?

Matematik, fen bilgisi ve sosyal bilgiler derslerini içeren ve doğal afetler, maddenin hal değişimi ve kesirler konuları arasındaki bağlantıyı öğrencilere sunmayı amaçlayan, bir etkinlik planlanmaktadır.

Hedef paydaş/paydaşlar: Hedef paydaş/paydaşlar kim?

Öğrenciler, öğretmenler, aileler ve okul yönetimi

Etkinlik hangi disiplinleri içerecek? Hedef kazanımlar ne olacak?

	Disiplin 1	Disiplin 2	Disiplin 3	Disiplin 4
Ders adı	*Fen bilgisi*	*Matematik*	*İngilizce*	*Görsel Sanatlar*
Etkinliğe dâhil edilecek konu/konular	*Madde ve değişim*	*Kesirler*	*Party time*	*Görsel İletişim ve Biçimlendirme*
Hedef kazanım/ kazanımlar	*Maddenin ısı etkisiyle hâl değiştirmesine yönelik çıkarımlarda bulunur.*	*Kesirlerle toplama ve çıkarma işlemleri gerektiren problemleri çözer ve kurar.*	*Party vb. kutlamalar, davetler düzenlemeyi ve insanların bunlara nasıl davet edeceğini öğrenir.*	*Görsel sanat çalışmasında kompozisyon birliğini oluşturmak için seçimler yapar.*

Etkinliğe hangi öğretmenler katılacak?

Matematik, fen bilgisi ve görsel sanatlar öğretmenleri

Etkinlik ne zaman, nerede (ders/dersler/okul içi veya okul dışı yerlerde) yapılacak ve süresi ne kadar olacak?

Etkinlik iki hafta içinde ve toplamda dokuz derste gerçekleşecektir. Etkinlik sosyal aktivite dersi, fen bilgisi ve matematik derslerinde olacaktır. Etkinlikle ilgili okulun son haftası düzenlenecek serginin poster ve davetiye tasarımları, etkinlik sonrasındaki iki hafta boyunca, görsel sanatlar ve ingilizce derslerinde toplam dört ders saati içinde yapılacaktır.

Etkinlik problem/tema cümleniz nedir? Öğrencilere soracağınız ve etkinlik içeriğindeki tüm derslere ait bilgileri kullanmalarını sağlayacak, problem/tema cümleniz/senaryonuz nedir?

Tema: Öğrencilerimiz son zamanlarda, öğlen yemeklerinde dondurmanın erimiş olarak önlerine gelmesinden şikâyet etmektedir. Bu noktada okul müdürüne iki soru sormuşlardır. Sizler bu soruları cevaplamamıza yardımcı olabilir misiniz?

Araştırma sorularınız nedir? (eğer mevcutsa)

- *Dondurmanın erimesindeki sebepler nedir?*
- *Dondurmanın erimesini engellemek için nasıl bir çözüm/sistem önerirsiniz?*

Sınırlamalarınız nelerdir? (eğer mevcutsa)

Prototip yapımında malzeme anlamında kısıtlamalar yapılacaktır.

Etkinlik nasıl ilerleyecek? Etkinliğin içeriğinin nasıl olacağı aşama, aşama yazılacaktır. Bu noktada, aşağıdaki hususları lütfen dikkate alalım.

- Her aşamadan hangi öğretmen sorumlu olacak?
- Etkinlik ne zaman yapılacak?
- Hangi ders/derslerde/yerde bu aşamalar gerçekleşecek?
- Her aşamaya ne kadar süre verilecek?
- Bu aşamalarda ne yapılacak? (bireysel veya grup çalışması var mı?)
- Öğrencilerden neler istenecek? (prototip yapma, rapor hazırlama, sunum yapma, poster tasarımı, sistem tasarımı paftası, vb.)

- Öğrenciler birbirlerinin projelerini değerlendirecek mi? (akran değerlendirmesi)
- Etkinlik sonunda sergileme olacak mı (sergi poster ve davetiyesi nasıl hazırlanacak?)

Not: Etkinliğinizin içeriğini oluştururken, *HPI tasarım odaklı düşünme* yaklaşımından (anlamak, gözlem yapmak, bakış açısı geliştirmek, fikir geliştirmek, prototip yapmak, test etmek) faydalanabilirsiniz.

Etkinlik 1 de aşamalar şu şekilde olacaktır;

- Dondurmanın neden eridiğini anlamak için araştırmak yapmak (anlamak, gözlem yapmak ve bakış açısı geliştirmek)
- Problem için fikir geliştirmek ve fikir seçmek (fikir geliştirmek)
- Çözüme dair prototip yapmak ve poster tasarlamak (prototip yapmak)
- Yapılan ürünleri sınıfa sunmak ve akran değerlendirmesi (test etmek)
- Sergi için poster ve davetiye tasarımı
- Serginin açılması
-

Etkinlik 1:

İlk hafta:

2 derslik fen bilgisi dersi (araştırma yapmak ve fikir geliştirmek): Bu derste, tema sunulacak, ardından nasıl araştırma yapılacağı ve elde edilen bilgilerin nasıl sunulacağı anlatılacaktır. Sonrasında öğrencilerden, 2'li gruplar halinde yemekhaneye gidip oradaki görevlilerle konuşmaları, dondurmanın erimesine sebep olan sorunları tespit etmeleri ve buna göre çözüm önerileri geliştirmeleri beklenecektir. İsterlerse fotoğraf ya da video çekebileceklerdir.

1 derslik matematik dersi: Bu derste, temayı pekiştirmek adına hazırlanan matematik ve fen bilgisi soruları, öğrencilere verilecek ve ders esnasında onlardan çözmeleri istenecektir.

2 derslik sosyal aktivite dersi (fikir seçmek): Gruplar tespit ettikleri sorunları ve önerdikleri çözümleri, 50-70 cm kâğıt üzerinde sınıfa sunacak ve önerdikleri çözümle ilgili en fazla bir sayfalık rapor hazırlayacaklardır. Derste sunumlar üzerinden öğrenciler ve fen bilgisi öğretmeni kritik verecek ve gerekliyse çözüm üzerinde değişiklikler yapılması öğrencilerden istenecektir.

İkinci hafta:

2 derslik matematik dersi (prototip yapmak): Bu derste öğrenciler, kendilerine verilen malzemelerle, 2 veya 3 boyutlu prototiplerini yapacaklardır. Prototip yapım aşamasına destek olmak için, görsel sanatlar öğretmeni matematik öğretmeniyle beraber derse katılacak.

Poster tasarımı ev ödevi (prototip yapmak): Probleme dair çözümleri anlatan bir poster tasarımı, öğrencilere ev ödevi olarak verilecektir. Bu noktada, onlara ailelerinin de yardımcı olabileceği söylenecek, ailelerde bu kısım için önceden bilgilendirilecektir.

2 derslik sosyal aktivite dersi (test etmek): Bu aşamada, öğrenciler yapılan prototipleri, hazırladıkları posterlerle beraber sınıfa sunacak ve projeleriyle ilgili öğretmenlerinden

ve arkadaşlarından kritik alacaklardır. Ayrıca, öğrencilerin birbirlerini de değerlendirerek, kendileri açısından birinci olan projeyi seçmeleri istenecektir. Bu aşamada, sınıfta hem matematik hem de fen bilgisi öğretmeni bulunacak ve öğrencilerin projelerini beraber değerlendireceklerdir.

Etkinlikler sonrası düzenlenecek olan sergi

Üçüncü hafta

1 derslik görsel sanatlar dersi: Bu derse hazırlık olması için öncesinde, kâğıt üzerinde kompozisyonun nasıl yapılacağına dair bilgiler verilmiş olacaktır. Buna göre, derste, düzenlenecek sergi için öğrencilerden poster tasarlamaları istenecektir. Öğrenciler, tasarımlarına ders esnasında başlayıp, bir sonraki hafta olan derse onları bitirmiş olarak geleceklerdir.

1 derslik İngilizce dersi: Bu derse hazırlık olması için "Party time" ünitesinde, bir parti nasıl verilir, insanlar nasıl davet edilir ile ilgili konu anlatılmış olacaktır. Buna göre, derste öğrencilerden bu bilgiler ışığında sergi için İngilizce ve Türkçe davetiye tasarlamaları istenecektir. Öğrenciler tasarımlarına ders esnasında başlayıp, bir sonraki hafta olan derse onları bitirmiş olarak geleceklerdir.

Dördüncü hafta

1 derslik görsel sanatlar dersi: Yapılan poster tasarımları sınıfta duvara asılacak ve öğrencilerden en beğendikleri poster için, kapalı zarf içinde değerlendirme yapmaları istenecektir.

1 derslik İngilizce dersi: Yapılan davetiye tasarımları sınıfta masa üzerinde sergilenecek ve öğrencilerden en beğendikleri davetiye için, kapalı zarf içinde değerlendirme yapmaları istenecektir.

- Tema/problem nasıl sunulacak? (Powerpoint sunum, animasyon hazırlama, film kullanma)

Tema powerpoint sunum eşliğinde sunulacak.

- Hangi sorular sorulacak? Sorular hangi aşamada yer alacak?

Problem cümlesi verildikten sonra, öğrencileri etkinliğe hazırlamak için sorular sorulacak.

Soruların ne olacağı, dersler işlendikten sonra belli olacak.

- Hazırlanan sorular önceden derslerde nasıl test edilecek?

Etkinlikte sorulacak soruların benzerleri, önceden ders esnasında sözlü yapılarak veya ev ödevi verilerek test edilecek.

- Etkinlikte grup çalışması varsa gruplar nasıl oluşturulacak?

Öğrenciler değişken olduğu için, grup içeriklerine etkinlik öncesindeki hafta karar verilecek.

- Etkinlikte hangi aşama kaç puan olacak? Değerlendirme ölçütleri ne olacak?
  (Soru cevaplama, akran değerlendirmesi, ödev, fikir geliştirme, prototip yapma, rapor/sunum hazırlama, poster tasarımı, sistem tasarımı paftası, vb. çıktıların değerlendirme ölçütleri)

araştırma sunumu, araştırma raporu: 15
fikir önerileri: 20
prototip: 5
poster: 5
sunum: 10
sorular: 20
poster ve davetiye tasarımlar: 25

Akran değerlendirmesinde, en çok oy alan grup, + 1 bonus puan alacak. Değerlendirme kriterleri, prototip için görsel snatlar öğretmeniyle birlikte sonradan oluşturulacak. Ayrıca, sorular için bir cevap anahtarı hazırlanacak.

- Etkinlik sırasında öğrencilerin belirli becerileri değerlendirilecek mi? (Takım çalışması, zaman yönetimi vb. noktaların değerlendirilmesi) Bu değerlendirme nasıl yapılacak?

Öğrencilerin takım çalışması, etkinlik esnasında sınıfta bulunan, matematik ve fen bilgisi öğretmeni tarafından değerlendirilecek ve takım çalışmasında en uyumlu olan gruplara + 1 bonus puan verilecektir. Öğrencilerin ilk STEM etkinliği olduğu için, Etkinlik 1 de zaman yönetimi değerlendirmeye alınmayacaktır. Fakat Etkinlik 2 için önceki performanslarına bakılarak düşünülebilir.

- STEM etkinliği için öğrenciler nasıl motive edilecek? (Etkinlik esnasında çikolata dağıtma, birinciye hediye verme (kitap, madalya, bilgisayar oyunu vb.)

Etkinlik esnasında, öğrencilere çikolata dağıtılması ve etkinlik sonunda birinci seçilen öğrenciye madalya verilmesi düşünülmektedir.

- Etkinliğin gerçekleştirilmesi için kaynakça ne olacak? (Kitap, YouTube video, internet sitesi)

Ders kitapları ve soru bankaları kullanılacaktır. Sergi davetiyesinin yapılacağı İngilizce dersi için, serginin ne olduğunu anlatan bir video ya da animasyon bulunacaktır.

- Etkinlik için hangi materyalleri hazırlamanız gerekecek? Nasıl hazırlayacaksınız?

Önceden bir materyal hazırlanmasına gerek yoktur.

- Öğrencilerin etkinliğe malzeme getirmesi gerekecek mi? Bunlar nelerdir?

Öğrenciler, prototip yapım aşaması ve poster tasarımı için, belli başlı malzemelerini (cetvel, kalem, tükenmez kalem, renkli kalemler, makas, yapıştırıcı, bant, vb.) kendileri getireceklerdir.

- Öğrencilere problem cümlesini de içerecek detaylı bir etkinlik planı verilecek mi? Öğrencileri etkinlik esnasında yönlendirmeniz veya talimat vermeniz gerekecek mi? Evet, ise bunu nasıl yapacaksınız?

Bir etkinlik planı öğrencilere verilmeyecektir. Etkinlik öncesi öğretmenler bir araya gelerek, etkinlik esnasında neler yapılacağı konuşulacaktır.

- STEM etkinliği için yapılacaklar/ihtiyaç listesi nedir?

Etkinlik 1 için prototip malzeme listesini çıkarmak, poster ve davetiyelerin basımı ve kaç adet basılacağı ile ilgili bilgi, fen bilgisi ve matematik sorularının hazırlanması gerekmektedir.

Diğer Bilgiler:

ETKİNLİK 2

STEM etkinliğine hazırlık aşaması (Aynı tema altında düzenlenen ders / disiplinlerarası ders planları)

- ✓ Ekip öğretim yöntemiyle yapılacak olan disiplinlerarası derse hangi öğretmenler katılacak?
- ✓ Ekip öğretim yöntemiyle veya bireysel öğretim ile yapılacak olan disiplinlerarası ders, hangi derste işlenecek?
- ✓ Dersler ne zaman yapılacak ve ders süresi ne kadar olacak?
- ✓ Derslerde hangi kuramsal bilgiler verilecek ve dersler nasıl işlenecek?
- ✓ Disiplinlerarası derslerde konular birbirine nasıl bağlanacak?
- ✓ Değerlendirme nasıl olacak? (Ödev, sınav, akran değerlendirilmesi)
- ✓ Ders için hangi materyalleri hazırlamanız gerekecek? Nasıl hazırlayacaksınız?
- ✓ Öğrencilerin derse malzeme getirmesi gerekecek mi? Bunlar nelerdir?

Ders 1
Ders türü: Aynı tema altında düzenlenen ders
Katılımcılar: Sosyal bilgiler öğretmeni
Konu/konular: Doğal afetler
Yer / Tarih: Sosyal bilgiler dersi / Etkinlikten 2 hafta önce, 1 ders saati
Değerlendirme: Sözlü yapılacaktır

Ders planı
Sosyal bilgiler dersinde, doğal afetler konusu işlenirken, sosyal bilgiler öğretmeni fen bilgisine de (maddenin halleri) konu itibariyle değinecektir. Bu sebeple, konuyla ilgili derste, karların erimesini ve bundan kaynaklı sel oluşumunu gösteren videolar/animasyonlar gösterilecektir. Ders sonunda, konuyla ilgili sözlü yapılacaktır.

Ders 2
Ders türü: Aynı tema altında düzenlenen ders
Katılımcılar: İngilizce öğretmeni
Konu/konular: Doğal afetler
Yer / Tarih: İngilizce dersi / Etkinlikten 2 hafta önce, 1 ders saati
Değerlendirme: Konuyla ilgili soru sınıfta dağıtılacaktır

Ders planı
İngilizce öğretmeni, doğal afetlerin ne olduğunu ve bunların İngilizcelerini öğrencilere anlatacaktır. Ayrıca, doğal afetlerden bahsederken, maddenin hal değişimine de değinerek, erime, donma vb. kelimeleri sınıfta deney yaparak gösterecektir. Örneğin mumu ısı verip eritecek ve buz tutmuş bir suyun oda sıcaklığında katı halden sıvı hale geçişini öğrencilere gösterecektir. Derste, öğretmen konuyla ilgili soru dağıtacak ve cevaplara ders esnasında beraber bakılacaktır.

Ders 3
Ders türü: Ekip öğretim yöntemiyle disiplinlerarası ders
Katılımcılar: Fen bilgisi, sosyal bilgiler ve görsel sanatlar öğretmenleri
Konu/konular: Doğal afetler, maddenin hal değişimi
Yer / Tarih: Sosyal aktivite dersi / Etkinlikten 1 hafta önce, 1 ders saati
Değerlendirme: Sözlü yapılacaktır

Ders planı
Derste, görsel sanatlar öğretmeni alçı ve strafor kullanarak içinde nehir, üzerinde orman ve kar olan bir dağ modeli yapacaktır. Bu noktada fen bilgisi öğretmeni, kar ve yağmur' un oluşumundan bahsederek maddenin hal değişimine değinecek, sosyal bilgiler öğretmeni de doğal afetlerden özellikle selin nasıl oluştuğunu, maddenin hal değişimiyle birleştirerek (karların erimesiyle sel olması) anlatacaktır. Aynı zamanda görsel sanatlar öğretmeni, model yapımında kullanılan alçının donarken, sıvı halden katı hale geçişte nasıl dışarı ısı verdiğini öğrencilere gösterecektir. Böylece 3 ders birbiriyle bağlanmış olacak ve öğrencilere canlı model yapımı eşliğinde anlatılacaktır. Ders sonunda konuyla ilgili sözlü yapılacaktır. Ayrıca görsel sanatlar dersi öğretmeni, STEM etkinliğine hazırlık için öğrencilerden doğal afetleri içeren bir müze tasarımı yapmalarını ödev olarak isteyecektir.

- Dersler için yapılacaklar/ihtiyaç listesi nedir?

Etkinlik 2 deki İngilizce dersi için, doğal afetlerle ilgili animasyon bulunması ve sınıfa mum ile buz tutmuş su getirilmesi gerekmektedir. Sosyal bilgiler dersi için, karların erimesini ve bundan kaynaklı sel oluşumunu gösteren videolar/animasyonlar bulunacaktır. Disiplinlerarası ders için strafor, alçı ve boya alınması gerekmektedir.

- Diğer Bilgiler:

4.9 Görüşme formu

Görüşme Formu

Ad / Soyad:

Hedef Kitle:

Belirlediğiniz görüşme sorularını aşağıya kaydedin.

Görüşmenize ait notları aşağıya kaydedin.

4.10 Gözlem formu

Gözlem Formu

Ad / Soyad:

Hedef Kitle:

5. KAYNAKÇA

Ambrose, G., & Harris, P. (2010). *Design Thinking (The Basics Design series 08)*. İsviçre: AVA Publishing SA

Bleuel, F., Weinreich, U., & Puget, A. (2017). *CoObeya Design Thinking Toolkit*. 01 Kasım, 2019 tarihinde coobeya.net/download/dtcards_basic_en.pdf adresinden erişilmiştir

Brenner, W., Uebernickel, F., & Abrell, T. (2016). Design thinking as mindset, process, and toolbox. W. Brenner & F. Uebernickel, (Eds.), *Design thinking for innovation: research and practice* içinde (ss. 3-21). İsviçre: Springer International Publishing

Brown, T. (2008). Design thinking. *Harvard Business Review, 86*(6), 84-92

Chesson, D. (2017). *Design thinker profile: Creating and validating a scale for measuring design thinking capabilities* [Yüksek Lisans Tezi, Antioch University, ABD]. AURA: Antioch University Repository and Archive. https://aura.antioch.edu/cgi/viewcontent.cgi?article =1398&context=etds

Cooper-Hewitt. (2014). *What is design? Teacher resource packet*. 08 Eylül, 2016 tarihinde http://uh8yh30l48rpize52xh0q1o6i.wpengine.netdna-cdn.com/wp-content/uploads/2014 /05/DITC-Teacher-Resource-Packet.pdf adresinden erişilmiştir

Çorlu, S., & Çallı, E. (2017). *STEM kuram ve Uygulamaları*. İstanbul: Pusula Yayıncılık

Design Council. (2005). *Learning Environments Campaign Prospectus: From the Inside Looking Out*. 17 Nisan, 2017 tarihinde archive.teachfind.com/ttv/static.teachers.tv/shared /files/2424.pdf adresinden erişilmiştir

d.loft STEM. (t.y.). 6 Eylül, 2016 tarihinde https://dloft.stanford.edu/ adresinden erişilmiştir

d.school at Stanford University (t.y.). 18 Ağustos, 2017 tarihinde https://dschool.stanford.edu /resources/the-bootcamp-bootleg adresinden erişilmiştir

Efeoğlu, A., Møller, C., Sérié, M., & Boer, H. (2013). Design thinking: characteristics and promises. *Business Development and Co-creation: 14th Uluslararası CINet Konferansı Bildiri Kitabı* (ss. 241-256). Nijmegen, Hollanda

Hot potato (t.y.). 02 Mart, 2020 tarihinde https://teaching-strategies.wikispaces.com/Hot+Potato adresinden erişilmiştir

HPI (Hasso Plattner Institut) (t.y.). 18 Mayıs, 2020 tarihinde https://hpi-academy.de/en/design-thinking/what-is-design-thinking.html adresinden erişilmiştir

IDEO (2012). Design Thinking for Educators. 06 Eylül, 2016 tarihinde http://www.designthinkingforeducators.com/toolkit/ adresinden erişilmiştir

Johnny Ryan. (2013, Aralık 13). *Design Thinking workshop with Justin Ferrell from Stanford d. school at The Irish Times* [Video]. YouTube. https://www.youtube.com /watch? v=Z4gAugRGpeY_adresinden erişilmiştir

Keane, L., & Keane, M. (2014). Design is our nature disseminating design practices in K12 education. *International Teacher Education Conference 2014 (ITEC 2014) Bildiri Kitabı* (ss. 253-262). Dubai, UAE

Kolk, M. (2012). *Build 21st century skills with design thinking*. 07 Eylül, 2016 tarihinde http://creativeeducator.tech4learning.com/2012/articles/InterviewDr_Maureen_Carroll adresinden erişilmiştir

MIT MOOCs course (t.y.). 6 Ağustos, 2017 tarihinde https://www.edx.org/course/design-thinking-leading-learning-mitx-microsoft-education-11-155x adresinden erişilmiştir

Mind map (t.y.) 19 Nisan, 2020 tarihinde https://egitimsozlugu.com/oyt/zihin-haritasi-nedir/ adresinden erişilmiştir

Owen, C. (2007). Design Thinking: Notes on its nature and use. *Design Research Quarterly*, *2*(1), 16-27

Öztürk, A. (2020). *Co-developing STEM activities through design thinking approach for 5th graders* [Doktora tezi, Ortadoğu Teknik Üniversitesi, Türkiye]

Stakeholder Analysis toolkit, (t.y.). 21 Ekim, 2019 tarihinde https://www2.mmu.ac.uk/media /mmuacuk/content/documents/bit/Stakeholder-analysis-toolkit-v3.pdf adresinden erişilmiştir

Stakeholder Mapping Guide: For Conservation International Country Programs & Partners. (2014). 21 Ekim, 2019 tarihinde https://iwlearn.net/resolveuid/d20fc335-aa29-440b-ae14-f94f37321427 adresinden erişilmiştir

Taking Design Thinking to Schools (t.y.). 6 Eylül, 2018 tarihinde https://stanford.edu/dept/SUSE/taking-design/presentations/Taking-design-to-school.pdf adresinden erişilmiştir

The Field Guide to Human-Centered Design. (2015). 01 Kasım, 2019 tarihinde https://www.designkit. org/resources/1/ adresinden erişilmiştir

Thoring, K., & Müller, R.M. (2011, Eylül). *Understanding design thinking: a process model based on method engineering.* Engineering and Product Design Education Uluslararası Konferansı'nda sunulmuş bildiri, Londra, İngiltere

Tran, N. (2017). Design thinking playbook for change management in K12 schools. 25 Kasım, 2019 tarihinde https://dschool-old.stanford.edu/sandbox/groups/k12/wiki/ad2ce/attachments/3946e /DESIGN%20THINKING%20PLAYBOOK%20%281%29.pdf?sessionID=8cbdfc6129ceb041dbad2247ffc9d0112fd0ebce adresinden erişilmiştir

Uştu, H. (2019). *İlkokul düzeyinde bütünleşik STEM/STEAM etkinliklerinin uygulanması: sınıf öğretmenleriyle bir eylem araştırması*. (Publication No. 589311) [Doktora tezi, Necmettin Erbakan Üniversitesi, Türkiye]. CoHE Thesis Center

Van Boeijen, A., & Daalhuizen, J. (Eds.) (2010). *Delft design guide*. 20 Temmuz, 2017 tarihinde https://arl.human.cornell.edu/PAGES_Delft/Delft_Design_Guide.pdf adresinden erişilmiştir

V. STEM activity design guide (English Translation)

STEM ACTIVITY DESIGN
THROUGH A DESIGN THINKING APPROACH:
A GUIDE FOR SECONDARY SCHOOL TEACHERS

AHSEN ÖZTÜRK
2020

TABLE OF CONTENTS

1. PREFACE

I would like to express my deepest gratitude to Assoc. Prof. Dr. Fatma Korkut for her valuable support in the creation of this guide. I am also grateful to Prof. Dr. Gülay Hasdoğan, Prof. Dr. Kürşat Çağıltay and Assoc. Prof. Dr. Pınar Kaygan for assisting me with their suggestions in creating this guide. Besides, I am very thankful to the participants who contributed to my study tremendously by giving their precious time.

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I would like to remember the late Prof. Dr. Memduh Erkin, who was my teacher and co-worker. Rest in peace, my teacher; I am grateful for your support, your faith in me, and for always thinking about my welfare.

Ahsen ÖZTÜRK
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2. STEM EDUCATION AND DESIGN THINKING APPROACH

STEM (Science, Technology, Engineering and Math) education or in Turkish FeTeMM (**Fe**n/Science, **Te**knoloji/Technology, **M**ühendislik / Engineering, and **M**atematik/Math) education aims to integrate diverse disciplines by making interdisciplinary collaboration in K-12 education. As it is understood from its definition, STEM education only consists of 4 disciplines, and the other disciplines are excluded. When we review the STEM training and course materials given to teachers in Turkey, it is observed that they mainly focus on science and mathematics, and remain insufficient for disciplines such as social sciences, Turkish, English or visual arts. This situation implies that teachers from diverse disciplines need to work collaboratively among themselves. Creative processes that prioritize the effective participation of students and the design methods that support these processes have been increasingly used for different purposes in education. From this perspective, design is one of the most significant areas that would contribute to interdisciplinary education.

This guide includes the necessary stages and their explanations for the teachers from different disciplines to design a STEM activity intended for the secondary school students by working in interdisciplinary collaboration and applying design thinking approach. This guide about the STEM activity design has been designed for educators who have knowledge about STEM education. For applying this guide, it is significant to have interdisciplinary knowledge and to provide a continuous collaboration among the teachers. This guide is also recommended to be accompanied by a professional industrial designer who is knowledgeable about STEM education.

3. STEM ACTIVITY DESIGN

This guide has been created for the teachers from different disciplines to design a STEM activity intended for the secondary school students by studying in interdisciplinary collaboration and applying design thinking approach. According to this fact, considering your need, you can remove some of the stages or carry out all of them from the STEM activity design guide.

It is suggested for the stages in this guide to be carried out with a two-day study, which will be done one week apart (Table 1) since, it is recommended to pause for a week to gather information for the "Observe" stage. Except for this stage, in line with your workload, you can carry out the stages of the STEM activity design as you wish.

Table 1. *STEM activity design program*

STEM activity design	
First day	**Second day**
• What is design thinking? • Define the subjects (50 min.) • Define the stakeholders (60 min.) • Observe (50 min.) **PS:** It is recommended to pause for a week to gather information for the "Observe" stage.	• Develop a point of view (85 min.) • Ideate (120 min.) • Prototype (35 min.) • Test

In accordance with this plan, the preparations mentioned below have been offered to be made before and during the study:[6]

- Read the guide necessarily before starting the STEM activity design.
- Try to include only the experienced teachers from different disciplines in the STEM activity design process but also inexperienced or trainee teachers to teach STEM education.
- Create a study environment where you will be able to study comfortably and collaboratively (e.g., meeting room, library, etc.).
- Prepare the necessary materials and documents.
- Assign someone as your facilitator for directing you in the STEM activity design process.
- Before starting a meeting, determine the time you are going to spare for it and define your objectives that you are going to realize during this time.
- If possible, assign one of the team members to keep time at the activity design stages.
- Adjust a stopwatch for the time and make it visible for everyone.
  For every stage, you are given an ideal study time. To be compatible with this time, please pay attention to the details demanded from you for the preparation.
- During the study, seat yourself face to face with others for teamwork productivity.
- Encourage the whole team to participate in the design process.
- Pay attention to receiving and giving feedback from one another.

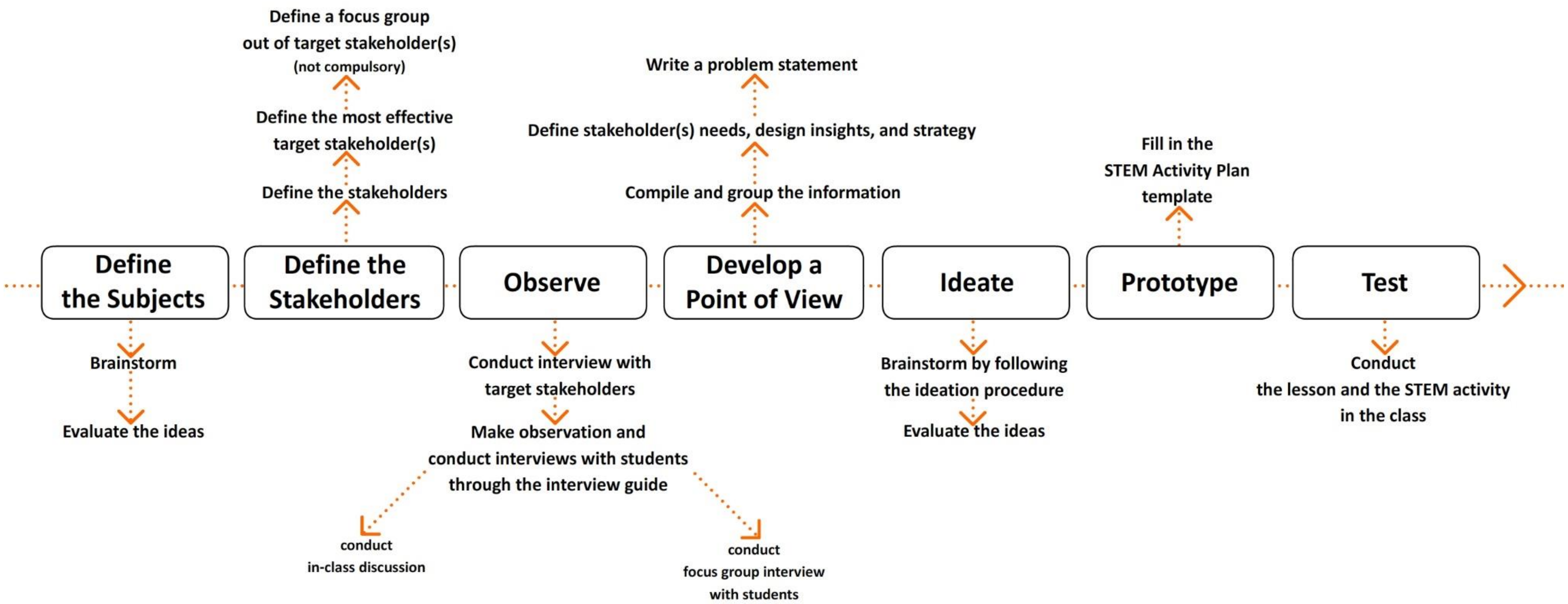
According to these, you are going to design a STEM activity by applying the seven-step design thinking approach offered to you in Table 2.

[6]Some of the preparations recommended before and during the study were prepared by considering HPI (t.y.).

Table 2. *Design thinking approach for designing a STEM activity*

The stages of a STEM activity design	Define the subjects (50 minutes)	Define the stakeholders (60 minutes)	Observe (50 minutes)	Develop a point of view (85 minutes)	Ideate (120 minutes)	Prototype (35 minutes)	Test
What is it?	Identify the subjects to be included in the activity/lesson in accordance with the curriculum	Identify the stakeholders, choose the most effective target stakeholder(s) and define a focus group among the target stakeholders, if needed	Make an observation and conduct interviews to get to know the stakeholders	Identify the needs and conduct an analysis for the STEM activity design/ lessons according to the information gathered in the former stages, and define the problem statement	Ideate for STEM activity design/ lessons	Write down the STEM activities/lessons designed at the "Ideate" stage in the "STEM activity plan" template by applying different prototyping methods	Receive feedback from the students by carrying out the designed STEM activity/lesson in the classroom and review the activity plan by making corrections, if necessary
Methods	Brainstorming	Brainstorming	Interview, observation, brainstorming	N.I.S. map (Need/Insight/Strategy map), brainstorming	Brainstorming	Planning, journey map, diagram, model making, web-based prototyping tools	Peer review

PS: In section 4.6, you have been told ten mindsets belonging to the design thinking approach, which should be adopted for realizing a STEM activity design and some of which occupy an important place in STEM education. It is suggested that you read these mindsets before the STEM activity design. Adopting a mindset is a long-time process; therefore, it will be helpful for you to work with an industrial designer during the activity design period as well.



Define a focus group
out of target stakeholder(s)
(not compulsory)
Define the most effective
target stakeholder(s)
Define the stakeholders
Write a problem statement
Define stakeholder(s) needs, design insights, and strategy
Compile and group the information
Fill in the
STEM Activity Plan
template
Define
the Subjects
Define the
Stakeholders
Observe
Develop a
Point of View
Ideate
Prototype
Test
Brainstorm
Evaluate the ideas
Conduct interview with
target stakeholders
Make observation and
conduct interviews with students
through the interview guide
conduct
in-class discussion
conduct
focus group interview
with students
Brainstorm by following
the ideation procedure
Evaluate the ideas
Conduct
the lesson and the STEM activity
in the class

Define the subjects	Define the stakeholders	Observe	Develop a point of view	Ideate	Prototype	Test

3.1 Stage 1: Define the subjects (50 minutes)

Materials: A colored pen, a ball pen, colorful sticky notes, a 50x70 cm sized paper, A4 paper
Method: Brainstorming

During this stage, we ask you to identify the subjects which will be included in the activity in accordance with the curriculum. This stage has two parts:

- Brainstorming
- Evaluate the ideas

We recommend you to pay attention to the points mentioned below during this stage:

- The subjects defined may change during the STEM activity design process.
- Please try to choose the subjects which make you feel comfortable and which you can spare time for preparation.
- Be sure that all the defined subjects have been taught before the STEM activity and pay attention in which order and when the subjects will be taught in the curriculum.
- To make this stage easier, please share your weekly lesson plans, curricula, and spare times with each other before you get together.
- If the STEM activity is carried out for the first time in the school, try to choose academically easy and funny subjects to ease the adaptation of both the students and the teachers.

1 – Brainstorming (40 minutes):
You will brainstorm about which subjects you will teach or have taught will be included in the STEM activity. To do this, prepare the necessary materials and spare 40 minutes to yourself. To make brainstorming easier, please consider the methods and rules offered to you about brainstorming (Look at 4.1).

- Write down which lessons you have in your group, side by side on a large sheet of paper (Figure 1).
- Brainstorm about which subjects to include in the STEM activity.
- While you are choosing subjects and sharing them with your teammates, search in the group, at which point you can make a connection with other lessons. So, focus on **what kind of questions can be asked to the students in the activity by handling all the subjects together or how these subjects can help the students to solve a problem**.
- Under the lessons written on the paper, stick the subjects which have come out during the brainstorming with sticky notes, and share them verbally with each other.
- Try to produce many ideas and do not qualify them.

History	Math	Science	Art
Conquest of istanbul	Fractions (Expressing the outflow of the sea water with fractions)	Transporting of the ships with the help of frictional force over land	Drawing an illustration of the conquest so making it more understandable

Social Science	Math	Science	English
Natural disasters (e.g. flood, avalanche…)	Fractions (Expressing the outflow of water with fractions)	Changes in the state of matter (Melting snow and flood)	The English meanings of natural disasters

Figure 1. A sample for brainstorming at the “Define the subjects” stage

2 - Evaluate the ideas (10 minutes):

- Ask everyone to vote for his/her favorite subject.
- With your team, write the subjects chosen by a large majority on an A4 paper.

Define the subjects	Define the stakeholders	Observe	Develop a point of view	Ideate	Prototype	Test

3.2 Stage 2: Define the stakeholders (60 minutes)

Materials: A colored pen, a ball pen, colorful sticky notes, a 50x70 cm sized paper, A4 paper
Methods: Brainstorming

At this stage, the stakeholders who have importance for the activity will be identified in accordance with the defined subjects. If the facilitator of this study is someone out of the school or who has newly started to work in the school, this stage will help him/her to get to know the organization he/she works for and the people he/she works with. This stage has three parts:

- Define the stakeholders.
- Define the most effective target stakeholder(s) for the STEM activity.
- Define 8 people at most as a focus group among target stakeholder(s) to make the following "Observe" stage easier.

1- Define the stakeholders (20 minutes):

In this section, you are expected to define the stakeholders who will affect the STEM activity design and practice in the school and who will be affected by these. The rules to obey during brainstorming and some methods about brainstorming have been told you in section 4.1. According to this;

- Draw the table in section 4.3 horizontally on a 50x70 cm sized paper.
- By taking the illustration in Figure 2 as an example, brainstorm about the stakeholders who will be actively incorporated in the STEM activity and who will help the activity to be carried out, then tell your group friends about the stakeholders you have chosen during this time with the reasons.
- Write down the names of the stakeholders on the sticky notes and stick them to a 50x70 cm sized paper and then share them with each other verbally.
- Ask everyone to vote for his/her favorite stakeholder.
- Fill a table (as in Table 4) by writing the stakeholders defined and the reasons for defining them by the information you have. At this point, the role of the stakeholders in the project, their attitudes towards the project if known, their anxiety about the project, the expectations from them about the project and the needs about them for the practice of the STEM activity will be determined. You can fill the certain sections in the table as below:
  1- His/her attitude towards the project: Supportive, Neutral, Moderately Supportive, Moderately Against, Strongly Against
  2- His/her role in the project: Active participant, Moderate Participant, Strongly Supportive (Providing place, material, etc. for practicing the STEM activity), Neutral

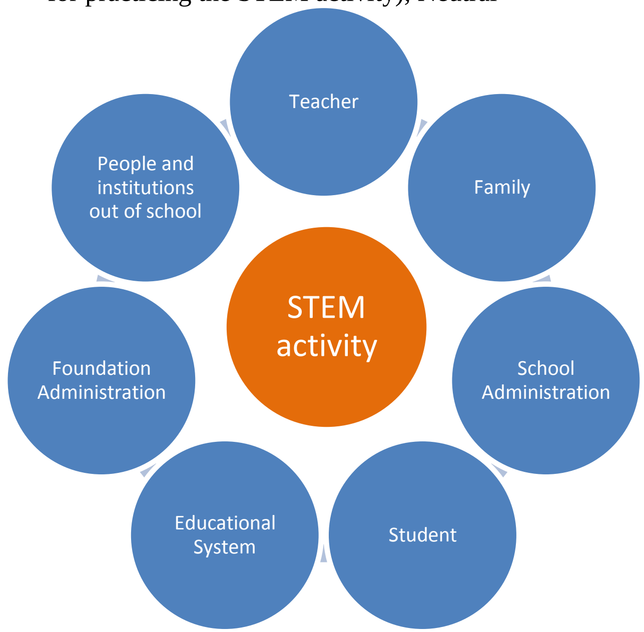


Figure 2. Possible stakeholders in STEM activity design and practice

2- Define the most effective target stakeholder/stakeholders for the practice of the STEM activity (20 minutes):

You are expected to define the most effective target stakeholder/stakeholders for the practice of the STEM activity in the second section. In this section, an impact level will be estimated upon the stakeholders about their effects on the STEM activity design and practice. In this way, the most and the least affected stakeholder/stakeholders from the STEM activity practice in the school will show up.

- Determine the level of the effect of the stakeholders you have defined (High, Medium, Low). At this point, the students are expected to be a part of the stakeholders to be most highly affected by the STEM activity practice. To define the others, the example below can give you an opinion (Table 3).

Table 3. *A sample of defining the level of the effect of the stakeholders*

One of the stakeholders who will affect the STEM activity practice is a family. Some of the families may think that a STEM activity practice can have a negative effect on their children's success since they give very much importance to their children's academic success in the lessons. In this situation, they are expected to be against STEM activity practices. Therefore, they may have a **high** effect on the practice of the STEM activity in the schools.

- According to the table, define the most effective target stakeholder/stakeholders among the ones who have a high effect level.

3- Define a focus group among the target stakeholder/stakeholders (20 minutes): (This stage is not compulsory)

In the following "Observe" stage, an interview and observation will be conducted to gather information about the stakeholders at a level of high effectiveness. If the number of the target stakeholders is too many (30-person-class) or the time for information gathering is constrained, a focus group of maximum 8 people can be (optionally) determined to represent all the stakeholders.

In this section, it should be decided first for which stakeholders the information will be gathered. After that, two separate ways are followed while defining the focus group for the students and other stakeholders.

3a- For the students:

- By brainstorming, determine the students who have different manners/success level or who are new in the classroom.
- Then, take notes of their names and the reasons why they have been chosen on a paper with sticky notes and share these with your teammates explaining the reasons to reach the final decision.
- During this stage, everyone can start to define a focus group regarding his/her own lesson, and after that, they can reach a final/common decision.
- If the focus group is selected, write who will be contacted during the "Observe" stage, on the required column as shown in Table 4.

3b- For the other stakeholders:

- Please determine whom you wish to get in contact with among the target stakeholders by brainstorming.
- Then, take notes of their names and the reasons why they have been chosen on a paper with sticky notes and share these with your teammates explaining the reasons to reach the final decision.
- If the focus group is selected, write who will be contacted during the "Observe" stage, on the required column as shown in Table 4.

PS: Potential strategies about the stakeholders in the table will be determined together with the "Observe" and "Ideate" stages. Moreover, some information (his/her role in the project, his/her effectiveness level on the project, needs, etc.) may show an alteration since some of the information will be gathered or clarified during the "Observe" stage. This situation may cause your rearrangement of the table.

Table 4. *A sample stakeholders analysis table*

The Stakeholder	The role in the project	Expectations	The attitudes towards the project	Anxiety about the project	The needs	The effectiveness level in the project	The focus group	The potential strategies
The Students	Active participant	To participate in the STEM activity.	Unknown	Unknown	To be included in the STEM activity practice.	High	Some information will be gathered about Ayşe, Fatma, Ali, and Ahmet.	
The Teachers	Active participant	To design and practice the STEM activity.	Strongly Supportive	Unknown	To spare time for the STEM activity design and practice.	High	<u>There is no need to gather information.</u>	
The School Administration	Strongly Supportive	To permit the practice of STEM education in the school.	Strongly Supportive		To give the required support to the teachers for STEM education. To help teachers for parents' approval.	High	<u>There is no need to gather information.</u>	
The Families	Strongly Supportive	To support the practice of STEM education in the school.	Unknown	Do the children fall behind the lessons? (there is lack of information)	To get permission from the families for practicing the STEM activity.	High	To contact the classroom parent, the selected student's parent, and if necessary, with the director of the parent-teacher association.	
The Educational System (national/school exams, system changes)	Neutral	To conduct study group lessons for national and school exams.			To provide the time spared for the STEM activity not to steal time from preparing for exams.	Moderate		
The external institutions included in the STEM activity: Museum	Active participant	To permit making use of the museum as an environment during the STEM activity practice.			To get permission from the parents, the school administration, and the museum authority for going to the museum. To arrange how to transport the students from school to the museum.	Low	According to the activity to be designed, if it is required, the museum will be contacted.	

3.3 Stage 3: Observe (50 minutes)

Materials: A form prepared for doing an interview, a form prepared for making an observation, a colored pen, a ball pen, colorful sticky notes, a 50x70 cm sized paper, A4 paper
Methods: Interview, observation, brainstorming

During this stage, it is aimed to gather information about the stakeholders by making observation and interviews with them. This method will help you to design a STEM activity appealing to all the stakeholders in particularly interdisciplinary STEM activity design and in the schools where STEM education is carried out for the first time. It is recommended that you spare one week time to gather information about the stakeholders. In this part, it should be decided first for which stakeholders the information will be gathered. After that, two different ways will be followed for the students and the stakeholders.

- Conduct an observation and interview with the students (pre-prepared questions for the interview will be given)
- Interview with the other target stakeholders (you will prepare questions for the interview)

Conduct an observation and interview with the students (20 minutes)

1- Conduct an interview:

In this part, you are expected to conduct interviews with the students by asking the questions given in section 4.4. Accordingly, we demand you to make an interview considering the points below:

- Check the available questions given to you for asking the students and revise them by adding or removing questions if you deem necessary. As the scope of the questions is broad, do not forget to consider the students' age range while choosing the questions.
- If you have constrained time, searching an answer for the last two questions under the title of "Defining a problem/theme for the STEM activity" can help you with designing an activity. If you want to get information from all students, these questions can be distributed to the class as a questionnaire. Besides, some themes can be added or removed according to the subjects chosen for the activity.
- Choose one of the teachers from your team to ask the questions (if available, he/she can be the classroom teacher or the counselor teacher).
- For doing an interview, choose one of the methods which have been told in detail below.

1a- Conduct in-class discussion:

To be informed about the whole class, the questions can be collectively directed to the students by creating a discussion environment in the classroom. At this point, the points below should be paid attention:

- During the discussion in the class, pay attention to the facial expressions, tone of voice, and body language of the student to check the accuracy of the information he/she is giving (MIT MOOCs course, n.d.).
- Take notes during and after the discussion, and then do not forget to write your opinions down about the notes you have taken (MIT MOOCs course, n.d.).
- To help you in the data analysis, which will be done in the following stage, write down the information you have gathered under the questions you have asked on the prepared form for the interview (Look at 4.9).

1b- Conduct a focus group interview with students:

If the class size is large or the time for gathering information is constrained, instead of the whole class, an interview can be done with **the focus group students** who have been chosen at the "Define the stakeholders" stage and who are considered to represent the whole class. The rules in the section 'Conduct in-class discussion' are also valid here. Because the data collected from these interviews will be less than the previous method, this situation will provide you save time in the following stage's data analysis.

2- Make an observation:

In this part, we demand that you make an observation by following up how your students behave in the classroom and how they get in contact with each other. Here, the aim is to verify the answers obtained from the interviews. Accordingly;

1. All the teachers included in the STEM activity design are expected to make an observation. So, the questions in Table 5 can guide you.
2. Please write down the information you have gathered at the “Observe” stage on the prepared form for observation (Look at 4.10) by grouping the information under specific titles (social relations, attendance to the lesson, etc.)

Table 5. *Sample questions to be answered while making an observation*

-What kind of activities do your students like, and what are their interests?
-In which way do your students like to learn?
Example: By listening, by reading, by watching, with games, with computers, by studying individually, by a group working, by peer learning, etc.
-How do your students express what they have learned most comfortably?
Example: By writing a report/story, by studying project-oriented, by doing artistic works, with drama, with media (video, presentation), by talking, by preparing posters, etc.
-What are some of the complaints/problems of the students that they mention their experiences in the classroom and their lives?
-What do your students think about your teaching approach?
-What is the level of your students’ attendance in classwork and lessons?
-How is your students’ interaction/communication with each other?

Conduct an interview with the other target stakeholders (30 minutes)

In this part, it is expected from you to conduct an interview with the other stakeholders to get to know them. Accordingly, we demand that you will make an interview considering the points mentioned below:

- Prepare your interview questions by brainstorming with your group.
- Choose one of the teachers from your group to ask the questions (if available, he/she can be the classroom teacher or the counselor teacher).
- Please write down the information you have gathered under the questions you have asked on the prepared form for the interview (Look at 4.9).

PS: At this stage, you are not expected to make an observation, but you are asked to take notes about your previous experiences on the prepared form for observation. For instance, if the stakeholders are the families, the information gathered from the parent-teacher meeting or one on one interviews can be noted down on the form; or in case of the fact that the stakeholders are the school administration members, their attitudes towards the education can be written on the form.

1- Prepare the questions

Materials: A form for doing an interview, a colored pen, a ball pen, colorful sticky notes, 50x70 cm sized paper, A4 paper

In this section, the aim is to prepare questions for the target stakeholders to help you with designing STEM activity (there may be 8 questions). Accordingly;

- Brainstorm with your group friends to prepare the interview questions and share the questions crossing your mind with your friends, meanwhile stating the reasons for them. The rules to pay attention to brainstorming and the methods that can be used have been told to you in section 4.1. At this point, the questions below (Table 6) can guide you;

Table 6. *Sample questions about the other stakeholders*

-If your stakeholder is the family, what are the expectations of the parents about their child? (To be a more successful/social/happier child, to have a particular occupation) -What do the stakeholders think about the education conducted in the school? -What are the opinions of the stakeholders about carrying out a STEM activity in the school? -What kind of attitudes do the stakeholders have about their children being transported outside the school for the activity (going to the museum for the activity?)

- Write down the questions formed within brainstorming on the sticky notes and stick them on a 50x70 cm sized paper, then share what is written on them with each other verbally.
- Ask everyone to vote for his/her favorite question.
- Write down the questions you have chosen on the prepared form for the interview (Look at 4.9) with your group. Do not forget to write your answers across the questions in accordance with the data you have received after the interview.

3.4 Stage 4: Develop a point of view (85 minutes)

Materials: 50x70 cm sized paper, a colored pen, a ball pen, colorful sticky notes, A4 paper, and paper tape
Methods: N.I.S. (Need/Insight/Strategy) map, brainstorming

At this stage, the participants are expected to identify the needs and insights for the STEM activity design considering the information gathered in the former stages, and to form a problem statement accordingly. To do these, it is necessary to create a N.I.S. (Need/Insight/Strategy) map at three stages.

1- The information gathered at the "Observe" and "Define the stakeholders" stages are brought together and classified.
2- In accordance with this information, for the STEM activity practice, needs are identified, analysis are conducted, and so the strategies are developed.
3- A problem statement is written in line with revealed needs and analysis.

1- Compile and group the information (35 minutes)

Before creating the N.I.S. map, the information will be classified in regard to the stakeholders.

- On a 50x70 cm sized paper, write the questions you have asked the stakeholders in the interview.
- If you have any other information apart from these questions, which you have collected by the help of your observations/experiences (such as social relations of the students with each other, the level of attendance to lessons, etc.), add the main titles about them on the same paper.
- Under these titles, attach the sticky notes on which you summarize the information you have collected and share this information with each other.
- Considering the defined subjects at the "Define the subjects" stage, remove the unnecessary information.

- If there are similar answers, bring them together with your teammates and eliminate the useless points.

As in Figure 3, three main titles have been formed about the students (defining the content of the STEM activity, the relation between the subjects or lessons, defining a problem/theme for the STEM activity) considering the interview questions (Look at 4.4). After that, the answers to the questions belonging to those titles have been attached under these titles by the help of sticky notes. Then, for the other two stakeholders defined apart from the students (families and the school administration), the information gathered has been again classified and attached on the paper with the help of sticky notes, so all the information has been brought together as classified.

2- Identify the needs/analysis/strategy (35 minutes)

In this stage, what your determinations are will be argued with your teammates according to the information gathered. After that, the needs will be identified, analysis will be conducted for the STEM activity, and so potential strategies will be developed. The meaning of defining the need/analysis/strategy has been summarized in Table 7. Furthermore, needs and analysis have been explained in detail in section 4.6. At this point, you can ask yourself these questions:

“What is the need (requirement) for stakeholders to support / actively participate in the implementation of STEM activity? In accordance with these needs, what kind of way/strategy should be followed?”

Table 7. *The definition of needs/analysis/strategy*

Need: At this stage, it is required that you identify the needs for the STEM activity according to the data you have by considering the STEM activity design, the students, the families, the school’s facilities, and administration. The needs you have defined are expected to give clues for helping you in the STEM activity design.
Analysis: An analysis is a concise statement of what you have learned from your research, and it always offers you a new perspective. At this point, please consider the needs and information you have gathered about your students, the other stakeholders, and the STEM activity. Examine this information for identifying your analysis and choose the information which is the most striking, interesting, and valuable to follow. Try to conduct your analysis as a synthesis of the information you have gathered (IDEO, 2012).
Strategy: A strategy means the steps and the methods for the STEM activity design and practice. Accordingly, you are expected to define strategies after identifying needs and analysis.

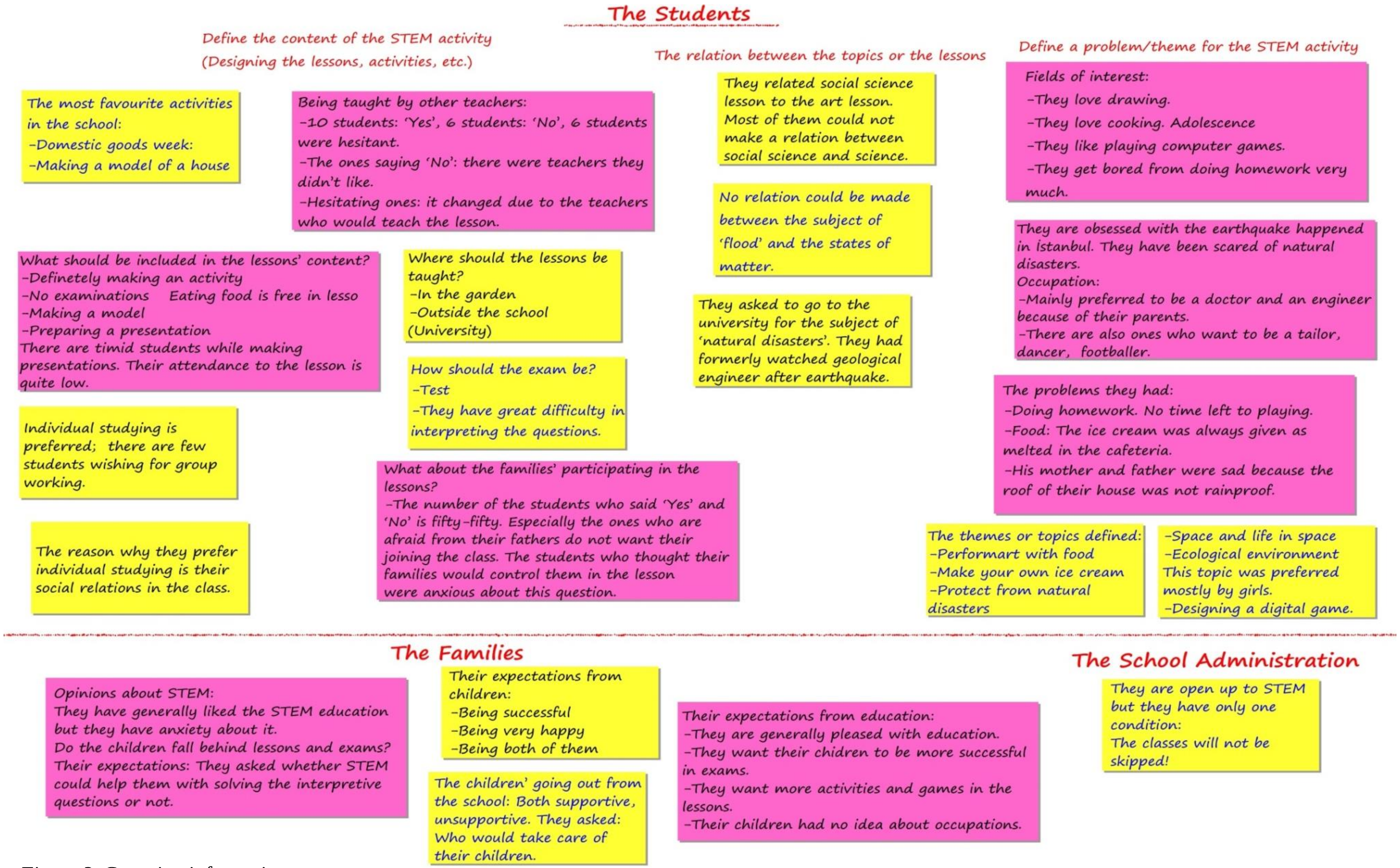


Figure 3. Grouping information

To identify the needs/analysis/strategies, the process below should be followed:

- First of all, attach the subjects decided at the "Define the subject" stage on a 50x70 cm sized paper with the sticky notes. What your subjects are will draw a frame for your defining the needs and analysis.
- Write three main titles on the paper to apply the STEM education in the school; these are *the regular lessons covering a common theme*, *interdisciplinary lessons* (*the interdisciplinary lessons conducted through team teaching and/or individual teaching*), and *the STEM activity* (Figure 4). Please do not forget that **it is not obliged to conduct a lesson before the STEM activity to apply STEM education in the school.**
- Primarily define your needs and conduct analysis by brainstorming under three main titles in accordance with the data on hand; after form your potential strategies considering your needs/analysis. At this stage, please primarily read the information given in section 4.5.
- Make deductions about what kind of way should be followed related to the other stakeholders for practicing the STEM activity in the school. So, you have been given an example in Table 8 to show how needs/analysis/strategy has been formed in Figure 4.

Table 8. *A sample for identifying need/analysis/strategy*

The children are not pleased with their parents' attendance to the lessons; moreover, they are anxious about this (**Analysis**). On the other hand, the parents do not want their children's success to be affected negatively because of STEM. So, it has been decided that the parents will be included in the STEM activity instead of the lessons (**Strategy**). Thus, the parents may have the chance to spend time with their children, and this can help to nurture the need for love rather than fear in children (**Need**).
According to the data collected, it has been revealed that both *the regular lessons covering a common theme* and the *interdisciplinary lessons* should be taught (**Strategy**). Interdisciplinary lessons are necessary because a connection cannot be made between the social science and science **(Need)**. The visual arts lesson has been added to the interdisciplinary lessons which will be conducted (**Strategy**) because the students have made a connection between social science and visual arts **(Analysis).**
Due to the subjects defined, it has been decided to teach the natural disasters subject both in social science and in English lessons (**Strategy**). At the same time, both two lessons will mention the changes in the states of matter. For the exhibition, which will be held at the end of the STEM activity, the posters and the invitation cards have been determined to be made in the visual arts and English lessons **(Strategy)** due to the subjects they have included **(Analysis)**.

3- Write the problem statement (15 minutes)

After identifying the needs/analysis/strategies, the problem statement will be formed to help us at the "Ideate" stage. At this point, you are expected to create a problem statement and write this on a sticky note by summarizing the needs/analysis/strategies about the activity and including the STEM activity, the lessons to be designed, the subjects of the lessons, the students and the other stakeholders. If you are not able to express yourself in one sentence, you can make multiple sentences or bullet points.

Table 9. *A sample for writing the statement of the problem*

For carrying out the STEM activities in the school, it is aimed: • To design one *interdisciplinary lesson* (science, social science, and visual arts) which will show the connection between melting-freezing and natural disasters and to design two *regular lessons covering a common theme* (English and social science) due to the theme of natural disasters, • To do the planning for making room for the interdisciplinary lesson in the weekly plan, • To make the students work in groups both for their individual and social development and to include the parents in the STEM activities, • To demand 2D or 3D products from the students as a solution considering the time spared to the activities, • To make these activities in the social activity lessons for not spoiling the school's functioning, • To hold an exhibition after the activity, the posters and invitation cards of which will be made by the students in visual arts and English lessons and to which all the families and the school members will be invited.

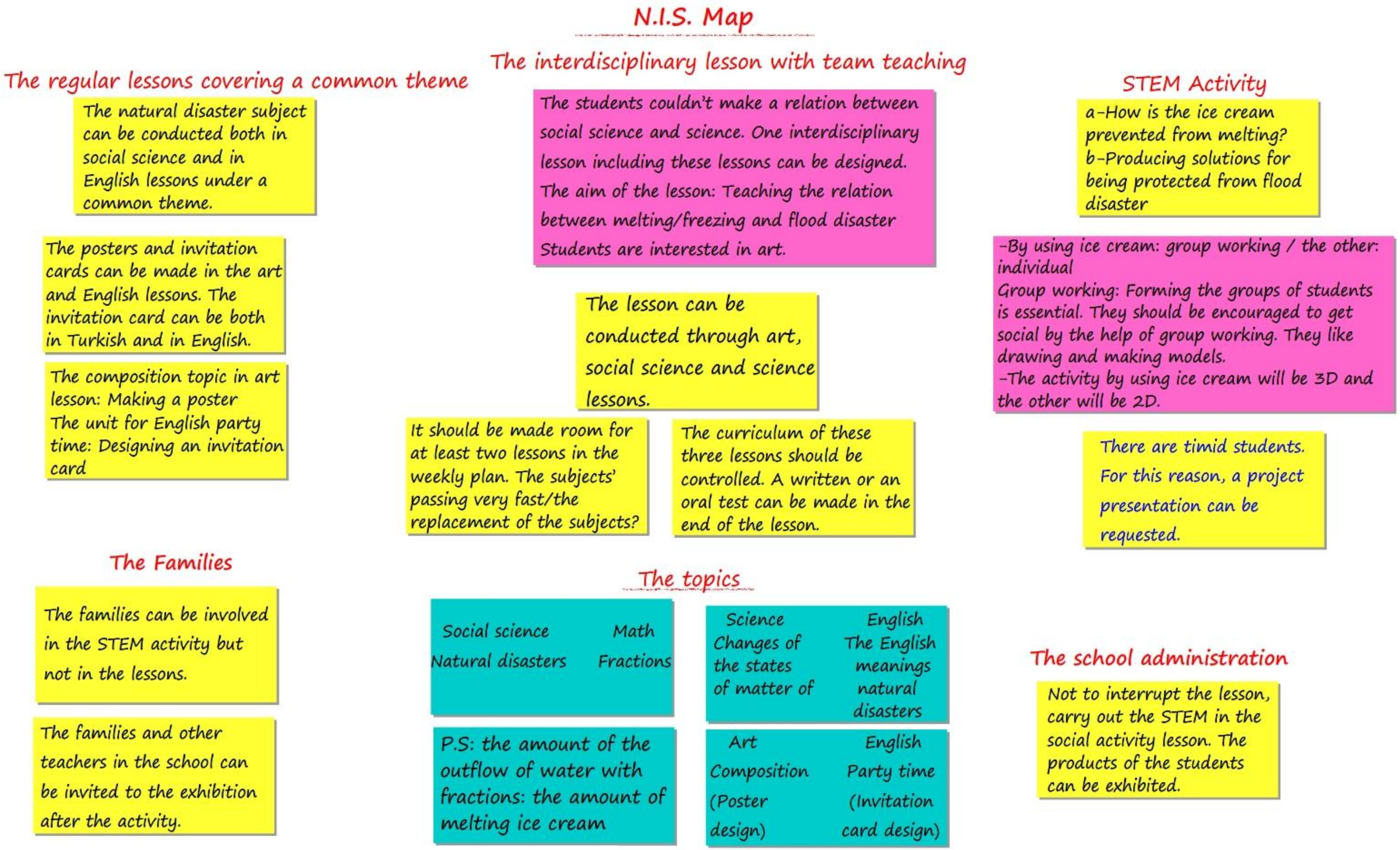


Figure 4. The map of identifying needs/analysis/strategy (N.I.S. map)

Define the subjects	Define the stakeholders	Observe	Develop a point of view	Ideate	Prototype	Test

3.5 Stage 5: Ideate (120 minutes)

Materials: A colored pen, a ball pen, colorful sticky notes, A4 paper, paper tape
Method: Brainstorming

At this stage, it is aimed to produce ideas for the STEM activity design/lessons. Accordingly, brainstorming will be conducted considering the N.I.S. map, defined subjects, and the STEM activity plan template. These two ways will be followed;

- Brainstorming
- Evaluating the ideas

1a- Brainstorming (60 minutes)

In this part, we ask you to ideate for the STEM activity/lessons design by brainstorming with your teammates. The rules to pay attention during brainstorming and some related methods have been told you in section 4.1. You have been presented a procedure (Table 10) (**if necessary, additions can be made to this procedure**) to ease and direct your brainstorming process. Here, the aim is to think about the details one by one considering the procedure instead of focusing on the whole activity/lesson design, then to ideate on them, and reach a final conclusion by combining the different ideas.

Table 10. *The procedure for ideation*

STEM ACTIVITY PLAN
• How will be the relations of the disciplines with each other in the STEM activity?
• What will be the theme or the problem statement of the activity?
• Which of the teachers will participate in the activity?
• When will the activity be held, and how long will it take?
• How will the activity progress?
1. How will the theme/problem be presented?
2. Which questions will be asked? At which stages will the questions take place?
3. How will the questions be tested in the lessons before?
4. If there is a group working in the activity, how will the groups be formed?
5. How many points will the stages be scored in the activity?
6. How will the students be motivated for the STEM activity?
THE PREPARATION STAGE FOR THE STEM ACTIVITY (THE LESSON PLANS OF THE REGULAR LESSONS COVERING A COMMON THEME/INTERDISCIPLINARY LESSONS)
• Which of the teachers will participate in the interdisciplinary lesson conducted through team teaching?
• In which lesson will the interdisciplinary lesson through individual teaching or team teaching be conducted?
• When will the lesson be conducted, and how long will they last?
• How will the lesson plan be?
PREPARING A REQUIREMENT LIST FOR THE STEM ACTIVITY/LESSONS

PS 1: Please primarily read the information given in section 4.5.
PS 2: At this stage, you can provide the participation of some of the students (or selected as a focus group) to whom you will apply the STEM activity, if you feel.

1b- Evaluate the ideas (20 minutes)

- Combine similar answers with your team and eliminate the useless parts.
- Ask everyone to vote for his/her favorite idea.
- In the following “Prototype” stage, summarize your ideas on the STEM Activity Plan template with your team.

Example: Two activity suggestions have been revealed in the N.I.S. map. According to the ideation procedure, with following samples and visual materials, you are presented the STEM activity plan (Figure 5 and 6) for Activity 1 (melting of the ice cream), the plans of *the regular lessons covering a common theme/interdisciplinary lesson* (Figure 7) for Activity 2 (flood disaster) and how the list of requirements for both of them has been developed (Figure 7). In these visuals, which are presented as examples for the “Ideate” stage, the summary of the information has been written on the sticky notes.

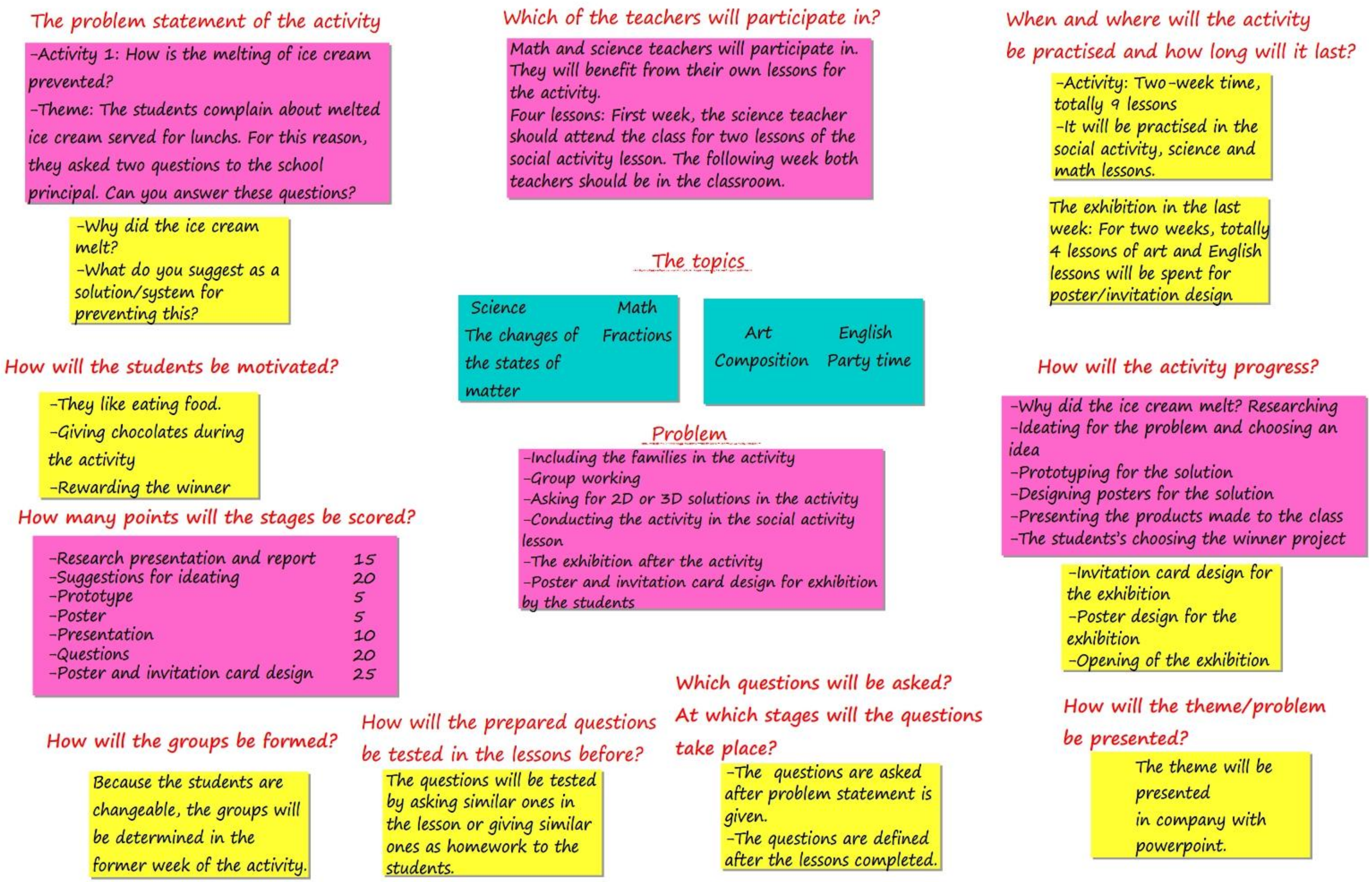


Figure 5. An example for “How to brainstorm about the content of the Activity 1” according to the ideation procedure

A SAMPLE
STEM ACTIVITY PLAN:
Activity 1

A sample STEM activity plan created according to the ideation procedure is presented below.

- **How will be the relations of the disciplines with each other in the STEM activity?**

In this part, which subjects will be included in the content of the activity according to the N.I.S. map is written in detail and attached on a 50x70 cm sized paper to be used in brainstorming.

Activity 1: How is the melting of the ice cream prevented?
Science: Changes in the states of matter (Melting of ice cream)
Math: Fractions (The amount of melting ice cream))
The exhibition to be held after the activity:
Visual arts: Composition (Poster design)
English: Party time (Invitation card design in English and Turkish)

- **What will be the theme or problem statement of the activity?**

In this part, it is aimed to form the problem/theme statement of the activity defined in general terms. At this point, it should be paid attention to the fact that the theme/problem statement includes the information belonging to all the lessons which are intended to be involved in the activity content. In case the students will be asked to create a product at the end of the activity, the product demanded and the materials needed should be considered formerly while forming the theme/problem statement. At this point, please do not go into brainstorming without reading the difference between the problem/theme statements in Table 11.

Table 11. *The difference between the theme and problem statements*

Theme: The students have difficulty in taking books from the shelves in the library, and they are not able to reach the books they want to take. What do they need to reach the books?
In this kind of theme-focus question, there is not only one direction to the answer, and the students try to reach a conclusion according to the problem they have defined by researching the theme. Here, the problem may result from the library's lacking of ergonomics or other reasons. Consequently, the needed solution may be either a ladder, low-shelf design, or entirely another one.
Problem: Design a ladder for students for their being able to reach the shelves in the library.
Because the problem has been given here directly in contrast to the theme-focus questions, the question only directs the student to design a ladder.

Accordingly, in the question belonging to Activity 1, a product has not been requested directly, and the students have been expected to find a solution by themselves. Here, the students can offer a freezer, upgrade a new refrigerator/freezer model, make a portable freezer/thermos bag, or suggest a solution for the refrigeration system of the vehicle transporting ice cream. As it is searched much more, the suggestions for the solution may show a further change due to the problems causing ice cream melting.

Activity 1: How to prevent ice cream from melting: **Theme:** Our students have been recently complaining about the melted ice cream they are having at lunch. At this point, they asked two questions to the school principal. Can you help us with answering these questions? -What are the reasons for the melting of ice cream? -What type of solution/system do you suggest for preventing ice cream from melting?

- **Which of the teachers will participate in the activity?**

Interdisciplinary STEM activities are designed with the help of collaborative working of the teachers from different disciplines. The designed activity can be conducted by only one teacher on the one hand, while more teachers can be assigned in the practice of the activity on the other hand. If two or more teachers participate in the activity, the teachers' weekly plans and their progress in the curriculum should be considered while planning when and how the activity will be held.

It has been decided that math and science teachers would be involved in **Activity 1,** and they would take advantage of their lessons for the activity. As they are in the future part of the curriculum, they have been asked to spare one week for the activity.

- **When will the activity be held, and how long will it last?**

In this part, it will be decided when, where (lesson, school garden, places out of school), and how long the activity will be. While defining the date of the STEM activity, the following should be taken into consideration: To prevent the activity from occurring at the same time as school or national examinations, to prevent the activity from being held at the end of the term, if possible not to conduct a difficult lesson/subject before the activity, to choose the most suitable and comfortable duration of time and lesson for the students and the teachers considering the weekly plan. Based on these, while the activity may be carried out on the same day, it can also be extended over a week, a month or a term. Moreover, the particular sections of the activity can be given as homework.

It has been approved that a two-week-time will be given for Activity 1, and four lesson hours of this activity will be conducted in the social activity lesson. Five hours of it will be conducted in the science and math lesson. Moreover, in the two lesson hours of the four-lesson of social activity lesson, the science teacher has been requested to attend the class; as for the following week's two lessons, both of the teachers have been asked to attend the class. A two-week-time and four lesson hours in total have been allocated for visual arts and English lessons after the activity to make the poster and invitation card designs of the exhibition where products made at the activity will be exhibited.

- **How will the activity progress?**

At this part, it will be defined how the content of the activity will be. First of all, the main titles of the activity should be determined; then, it should be thought in detail how these titles will be practiced.

- Which stages will be at the activity?
- Which of the teachers will be responsible for every stage?
- When will the activity be made?
- In which lesson/lessons will these stages be conducted?
- How much time will be given to every stage?
- What will be done during these stages? (Are there any individual or group studies?)
- What will be asked to the students to do? (To prototype, to write a research report, to create a presentation board of the system design, etc.)
- Will the students evaluate the projects of each other?
- Will an exhibition be held at the end of the activity? (How will the poster and invitation card of the exhibition be prepared?)

Generally, in any STEM activity, there are the stages of defining a problem, researching, ideating for a solution, prototyping of the activity, and testing. In this part, we have decided to benefit from the *HPI design thinking* approach (explained in section 4.6) to make the activity be designed more comfortably. While the six stages belonging to this approach (Understand, Observe, Point of view, Ideate, Prototype, and Test) can be used in the activity, it can also be preferred to use some of the stages by combining them or reducing them in number for the purpose of both saving time and providing convenience to the students. For **Activity 1**, we have approved to practice the six stages of the *HPI design thinking* approach in four stages by combining "Understand", "Observe" and "Point of view" stages together as below.

Conduct research to understand why ice cream melts (understand, observe and point of view)
Brainstorming to generate ideas, and choosing an idea (ideate)
Making a prototype of the solution and designing a poster to introduce the design solution (prototype)
Present the solutions to the class and evaluating the outcomes through peer review (test)
Design the invitation card and poster for the exhibition
Open the exhibition

1. How will the theme/problem be presented?

The presentation of the theme/problem is important for arousing the students' interest in the activity. Therefore, a presentation in a company with a PowerPoint/animation/film can be made instead of a speech.

2. Which questions will be asked? At which stages will the questions take place?

The questions prepared for the activity should be both within the scope of the theme/problem and show the relationships among the disciplines. It should be previously discussed what kind of questions will be asked, what kind of content the questions will have, at which stage of the activity the questions will be involved (Will the questions be asked before the problem/theme statement has been given, or after that in the particular stages of the activity?). If the lessons have not been conducted yet, considering the students' conditions, they can be prepared after the lessons have been conducted.

3. How will the prepared questions be tested in the lessons before?

STEM activity aims to test how the information learned is used. For this reason, according to the type of activity designed, in case of the fact that conducting the lesson and the activity will not be carried out together, it is significant to test the students' level of information before the activity through oral or written examinations.

4. If there is a group working in the activity, how will the groups be formed?

If there is a group working in the activity, the student groups should be organized considering their relationship with each other and their states of success. However, since they are changeable in their relationships, it is suggested to observe the students until the activity day and to review the groups if they have problems in their personal relations.

5. How many points will the stages be scored in the activity?

By getting together, the teachers should decide how and according to what kind of criteria they will evaluate the stages (Table 12). It has been determined in the previous STEM activities that the students give more importance to the prototyping than the benefit it provides for the problem's solution. Therefore, it is recommended not to give high scores to prototyping in grading the activity. On the other hand, peer review is one of the evaluation methods applied in the STEM activities. At this stage, an evaluation table directing the students can be given for making the students' choices correct (Table 13).

Table 12. *A sample evaluation table (Çorlu & Çallı, 2017)*

The stages of evaluation	The criteria for evaluation	The type of evaluation
Research and research report	It can be evaluated according to the information gathered, the quality of the information, and the resources used.	Giving marks or assigning a value between 1 and 4
Ideating	The intelligibility of the idea and the information it includes.	"
The fidelity of the solution to the problem	The accordance of the solution to the problem, the distinguishable features of the solution, its functionality and working principle.	"
Poster design	A composition formed on a paper (It should include the solution features and their contribution to the problem).	"
Making a relation among the disciplines	Have the information requested/expected and/or any other information been used in the solution?	"
The ability for presentation	Making a presentation in a clear and understandable way, mentioning what the problem is during the presentation.	"
The quality of the prototype	Making the prototype exactly and accurately in accordance with the solution, its aesthetic appearance	"
The use of materials	The correct use of the materials and the equipment, the amount of the materials used (whether there is excessive use of materials)	"
The originality of prototype	The product's including an original idea, a creative sense, a particular point of view, or it's a more developed version of the similar ones (not being an imitation of them).	"
Time-management	Performing the tasks requested in the prescribed time.	(Giving marks or rewarding with stickers)
Group working	Sharing the tasks, the compatibility of the teammates, sharing the ideas	(Giving marks or rewarding with stickers
Peer review		(Adding to the result as +1 point or rewarding)
PS: 1 is given as the lowest point, 4 is given as the highest point.		

Table 13. *A sample table for student evaluation*

Name/Surname:	1	2	3
How is the material usage? (less, medium, more)			
Does the product designed provide a solution to the problem?			
Is the prototype/product attractive aesthetically?			
Has an effective product presentation been made?			
Is the poster telling us about the product?			
Total score			
	1: Bad 2: Medium 3: Good		

6. How will the students be motivated for the STEM activity?

It should be aimed that the students enjoy the activity while learning. For this reason, some snacks like chocolate, etc. can be delivered to the students; the students winning the first place at the end of the activity can be rewarded (with a book, medal, or computer game, etc.).

Accordingly, activity content is prepared like in Figure 6 considering when the activity will be practiced, how it will progress, and who will participate in the activity (the whole activity has been given in section 4.8).

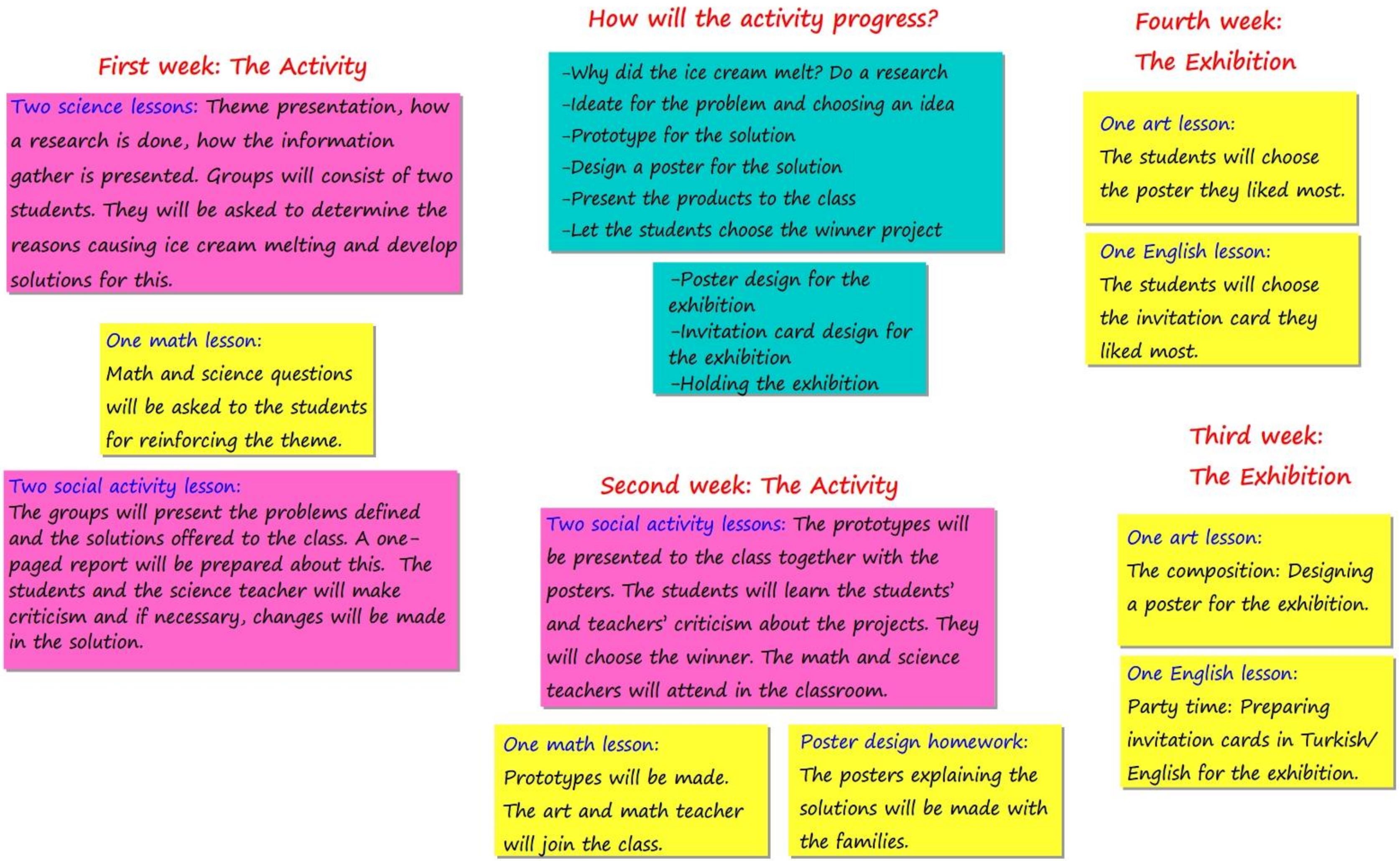


Figure 6. A sample for brainstorming about determining the content of the Activity 1

A SAMPLE
THE PREPARATION STAGE FOR THE STEM ACTIVITY
(THE LESSON PLANS OF THE REGULAR LESSONS COVERING A COMMON THEME/INTERDISCIPLINARY LESSONS):
Activity 2

In this part, it has been explained how the lessons have been planned according to the ideation procedure for Activity 2. Accordingly, two separate statements of the problem have been created for Activity 2 (Table 14), and by choosing the second one, the lessons have been designed according to it.

Table 14. *The statements of the problem created for Activity 2*

Activity 2: Finding solutions for being protected from the flood disaster
Science: The changes in the states of matter (Melting snow and flooding)
Math: The fractions (Expressing the amount of the outflow with fractions)
Social science: Natural disasters (Flood, avalanche)
English: The English expressions of natural disasters

Problem 1: During the seasonal change from winter to spring, in Erzurum city where it snows too much, it is observed that there is an excessive outflow in the amount of the water level of the dam, and there are plenty of floods.
• How does the seasonal change from winter to spring trigger floods?
• Explain the flood disaster after the seasonal change according to the states of matter.
• To prevent flood disasters from happening again, how many percent should the water level of the dam be increased considering the amount of the outflow?
• The research indicates that flood disasters cannot be prevented because of unplanned urbanization even the water level of the dam is increased. Considering this, what kind of city plan should be made to prevent Erzurum from flooding? Please, pay attention to locating the components, such as the residential areas, schools, highways, shopping malls, mountains, forestlands, stream beds in the inner city, and dams.

Problem 2: Every year, natural disasters such as floods, landslides, and avalanche happen in our country. But it has been observed that the number of people having consciousness about natural disaster is low.
• Spring rains and melting of snow can be ranked among the common reasons for floods and avalanches. Considering this, explain the reasons for floods and avalanches in accordance with the changes of the states of matter.
• How can we protect ourselves from flood and avalanche disasters?
• A museum of natural disasters will be built to draw attention to natural disasters and to make the public and especially the children be conscious about the precautions. While the museum is being planned as two floors as below, it has been understood that this area will not be enough, and an area of 100 m^2 is additionally needed. So, how many percent should the area of the museum be increased?
• In this museum, both the information about major natural disasters Turkey suffered from in the past, and the information about the reasons of natural disasters and the ways for being protected from them will be presented. At this point, the children's opinions have been asked. Because the Natural Disaster Museum, which will be built in Turkey, will have foreign visitors, you are asked to make a museum floor plan in English and Turkish. This plan should definitely include the following three factors; these are:

1. The information, films and visual materials about the major natural disasters Turkey suffered from in the past
2. The natural disasters and their reasons
3. The ways of being protected from natural disasters

In light of the information above, it should be paid attention to the facts when the lessons will be conducted, how long they will last, and how the lesson plans will be formed. In addition to these facts, for the *interdisciplinary lesson*, it should be considered which of the teachers will attend the class and in which of the class this lesson will be conducted (Figure 7).

- **Which of the teachers will participate in the interdisciplinary lesson conducted through team teaching?**

The teachers’ spare times coinciding with each other, and their progress in the curriculum are significant factors for conducting the *interdisciplinary lessons*.

- **In which lesson will the interdisciplinary lesson through individual teaching or team teaching be conducted?**

In *interdisciplinary lessons*, the lesson in which they will be conducted is a significant matter because of the fact that two or more teachers take charge both in design the lesson and in practicing the lesson in the case that *team teaching* is needed. At this point, in case the teachers' programs coincide with each other, one of the teachers can invite the other one to his/her class. If the teachers have difficulty in catching up with the curriculum, the interdisciplinary lesson can be conducted in an activity period, such as a social activity lesson, etc.

- **When will the lesson be conducted, and how long will it last?**

The number of lessons to reserve for *the regular lessons covering a common theme* and for the *interdisciplinary lessons* plays an important role in planning. Moreover, the lessons should be conducted before the STEM activity.

- **How will the lesson plan be?**

It has been approved for Activity 2 to design *regular lessons covering a common theme* and *the interdisciplinary lesson conducted through team teaching*. To teach these lessons, the subjects should be taught in advance.

The interdisciplinary lesson conducted through team teaching: Before the previous week from the activity, in one lesson hour of the social activity lesson, an *interdisciplinary lesson conducted through team teaching*, which included science, social science, and visual arts in its context, was designed. During the lesson, the visual arts teacher will be making a mountain model covered with snow, a forest on it, and a river. At this point, the science teacher will mention the changes of the states of matter referring to the formation process of snow and rain; the social science teacher will explain how flood happens, referring to the changes of the states of matter. At the same time, the visual arts teacher will demonstrate how the plaster used in the model making gives heat out while it is freezing in the course of the phase change of liquid to solid. So, these three lessons will have been connected with each other, and this interdisciplinary lesson will be conducted in the company with live model making. At the end of the lesson, an oral exam will be made. Besides, the visual arts teacher will ask the students to design a museum related to natural disasters as homework to be prepared for the STEM activity.

The regular lessons covering a common theme: Before two weeks from the activity, one lesson hour lasting *regular lessons covering a common theme* which taught natural disasters both in the lessons of social science and English were designed. While the social science teacher is teaching the subject of the natural disaster, he/she will refer to the science lesson because of its content (changes of the states of matter). So, some videos/animation movies demonstrating the melting of snow and floods resulting from this will be displayed in the lesson as related to the subject. At the end of the lesson, an oral examination will be made. The English teacher will teach the names and definitions of natural disasters in English. Moreover, while he/she is mentioning natural disasters, he/she will explain the words such as melting, freezing, etc. by referring to the changes of the states of matter and doing experiments in the classroom. For example, by melting a candle to show how a solis becomes a liquid by heating or by bringing iced water to the classroom to show how a solid becomes a liquid in the room temperature, he/she will teach the subject. In the lesson, the teacher will give question sheets, and the answers will be checked together with the students during the class.

PREPARING A REQUIREMENT LIST FOR THE STEM ACTIVITY/LESSONS: Activity 1 and Activity 2

After the STEM activity and the lessons are planned, it is useful to make a requirement list in terms of preparing the things needed. For example, it is essential to make a list of the materials of the prototype for Activity 1, to know how the poster and invitation card will be printed and the number of printing, and to prepare science and math questions. Furthermore, it is required to have an animation movie about natural disasters for the English lesson in Activity 2 and to bring candles and iced water to the classroom. The videos/animation movies demonstrating the melting of snow and the flood resulted from this are necessary for the social science lesson. Also, plaster, styrofoam, and paint should be provided for the interdisciplinary lesson (Figure 7).

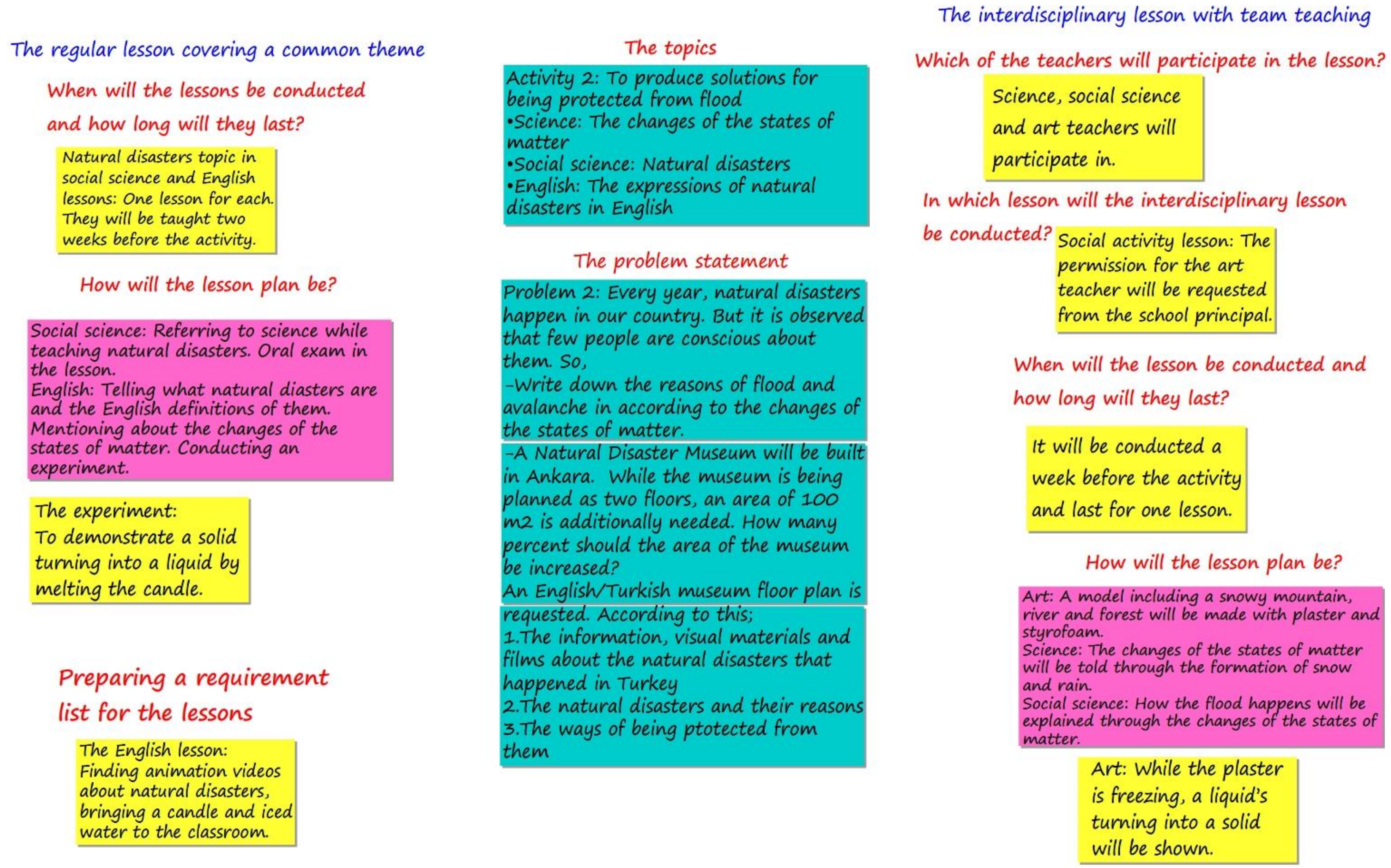


Figure 7. A sample of brainstorming about defining the lesson plans of the Activity 2

Define the subjects | Define the stakeholders | Observe | Develop a point of view | Ideate | Prototype | Test

3.6 Stage 6: Prototype (35 minutes)

Materials: STEM activity plan template, a colored pen, a ball pen
Method: Planning, diagram, model making, journey map, web-based prototyping tools

Designing a STEM activity, testing it by practicing, and modifying it if necessary after the practice is all learning processes. For this reason, it is possible not to reach a correct conclusion for the first time while designing a STEM activity or activity designs may change over time. For instance, the fact that the student group with whom you practice the activity changes every year even though the age range stays the same, and the changes in the school, in your working plan or the system of education may cause these changes. As a result, STEM activity designs become more successful as long as they interact with students and other stakeholders, and students and you -teachers- experience them.

At this stage, you are expected to write down the STEM activity and the lessons you have designed at the "Ideate" stage in the STEM Activity Plan template (Look at 4.7). At this point, you can benefit from various prototyping methods that have been introduced to you in section 4.2.

1- Fill in the STEM Activity Plan (35 minutes):

At this stage, you are expected to write down the STEM activity and the lessons you have designed at the "Ideate" stage in the STEM Activity Plan template. To do this, the necessary directions have been placed on the template, and you have been given an activity plan filled as an example in section 4.8. In this example, the STEM activity plan has been filled for Activity 1, and the section about the lessons to be organized for the preparation of STEM activity has been filled for Activity 2.

Define the subjects | Define the stakeholders | Observe | Develop a point of view | Ideate | Prototype | Test

3.7 Stage 7: Test

Method: Peer review

Testing is a part of an iterative process that provides feedback. At this stage, the activities/lessons you have designed will be implemented to the students, and if necessary, 'STEM activity plan' will be modified according to the results and feedback received.

At this stage, observing the process while practicing the STEM activities and lessons and considering how the activity can be developed will become more of an issue. Therefore, please take notes about the reactions of the students and your experiences. You can ask the questions below to other teachers and yourself while you are evaluating the STEM activities/lessons (MIT MOOCs course, n.d.):

- What did/did not you like about this activity? Why?
- What would you like to change in this activity?
- Were the explanations about the activity clear?
- Was there complexity in the content for the students? Do you have questions about the activity or the subject in your mind?

Moreover, you can learn the students' comments about how they have found the activity by asking questions to them or by preparing "A student comment card" (for expressions such as; the activity was interesting/useful. I had difficulty…, I have learnt new information, etc.) for the evaluation of the activity.

4. SUPPLEMENTARY MATERIALS

4.1 How to brainstorm

You will be requested to brainstorm at many stages while you are designing a STEM activity. Below, you have been given the rules you should obey during brainstorming and three methods that you can use for brainstorming.

1a- The rules you should obey during brainstorming (MIT MOOCs course, n.d.):

- Choose a person to facilitate brainstorming.
- Tell everyone the rules to obey during brainstorming.
  1. Not to be prejudiced.
  2. Not to question the quality/value of the ideas.
  3. To encourage for producing extreme and distinctive ideas.
  4. To develop one's own idea over others' ideas.
  5. Not to drift away from the subject.
  6. To share your ideas not only by writing but also by drawing.
  7. Instead of focusing on only one idea as a possible solution for the problem, to try to produce many ideas.
  8. To arrange the time given for brainstorming and to put the clock/timer somewhere seen by everyone.
  9. To provide producing more ideas under time pressure.
- While you are brainstorming, write at most two sentences with capital letters on every sticky note (not a word or a list!)
- Do not forget that there is not a bad idea at this stage!

Some methods to use in brainstorming:

1b- Scribble, say, slap

Materials: A colored pen, a ball pen, colorful sticky notes, 50x70 cm sized paper

One of the methods to use in brainstorming is "scribble, say and slap". To apply this method, quickly write down your ideas on sticky notes, then share them with other participants by shouting them out without waiting for your turn as you have to do in standard brainstorming, and finally stick your written ideas on a 50x70 cm sized paper. This method helps people to relax, lowers their inhibitions, and allows more timid group members to express their ideas (Ambrose & Harris; 2010, p. 67).

Figure 8. The stages of "Scribble, say, slap" method (Ambrose & Harris; 2010, p. 67)

1c- Hot Potato

Materials: An object which can be thrown, a colored pen, a ball pen, colorful sticky notes, a 50x70 cm sized paper, A4 paper, and paper tape

One of the methods to use in brainstorming is Hot Potato. This method can be applied in three different ways. Firstly, the subject/subjects is/are **written on an A4 paper** according to the brainstorming subjects (such as the titles in the ideation procedure at the "Ideate" stage), and everyone is asked to write down an idea in a minute on this paper by passing it from hand to hand between the group members. So, everyone sees the others' ideas and can improve different ideas over them. This process continues until the paper turns back to the starting point or a satisfying idea comes out. At this point, it is important to keep time for passing the paper. Finally, the ideas can be voted (Hot potato, n.d.).

In the second one, the subjects to brainstorm are written on a 50x70 cm sized paper, and this paper is hung on the wall. Then, every teacher is given his/her word and asked to express an idea about those subjects in one minute time. This process continues until getting to the first person to tell his/her idea or receiving a satisfying idea. After all, all the ideas can be voted (Hot potato, n.d.).

The third way is to brainstorm over the defined subjects one by one. To do this, the group members sit down in a circle and face to face with each other. A group member gives a start to brainstorming by shouting his/her idea out and then throwing the object in his/her hands (a ball, a toy, etc.) to the other group member. This member catches that object thrown and shouts his/her idea out, and brainstorming goes on like this during the time given. Here, it should be attached importance to the group members' acting fast to tell their ideas. Therefore, after the group members shout their ideas out and throw the object in their hands, they collect these ideas by writing them on sticky notes, and finally, everyone sticks the written notes on a 50x70 cm sized paper. Not to lose time, one person can be charged with writing the ideas on sticky notes and sticking them on the paper (Bleuel, Weinreich & Puget, 2017), or you can record the brainstorming process with a tape recorder.

1d- Mind Map

<u>Materials:</u> A colored pen, a ball pen, colorful sticky notes, a 50x70 cm sized paper, paper tape

A mind map is a graphical representation of the ideas and the point of view surrounding a central theme, and it shows how they are related to each other. With the help of a mind map, you can match all the related aspects and ideas of a subject and provide the problem with a structure, general view, and certainness.

Method:

- Write down the subjects for ideation in the middle of a 50x70 cm sized paper and draw circles around them.
- Place your written ideas connected with a line to the central idea and brainstorm about these ideas; then, write down the sub-ideas around them again. For example, if the brainstorming is being made for the "Ideate" stage, use this method for each title involved in the ideation procedure.
- Expand your map by adding new branches to the circles when necessary.
- Use sticky notes, words, and drawings.
- Examine the Mind Map to see which relations are existing and which solutions are suggested.
- If necessary, reshape the Mind Map or restructure it (Van Boeijen & Daalhuizen, 2010).

Figure 9. A sample of the mind map (Mind map, n.d.)

4.2 How to prototype

The prototyping methods below can help you with developing your STEM activity.

Model Making: A three-dimensional model can be made for the lesson/activity by using various materials (paperboard, styrofoam, paper, etc.). For example, in an STEM activity where space theme is processed, the following model was made for students to be used during the project presentation (Figure 10).

Figure 10. A model prepared for the STEM activity in which space theme is processed (Öztürk, A. 2020)

Journey map: A journey map helps you draw a route map to think systematically about the steps of a process. According to this, this method can be used for making the plans of content and timetables of the lessons and for determining how the activity plan will progress (Figure 11).

PS: You can make free digital journey maps by using the Drupal website (https://www.drupal.org/project/dipity).

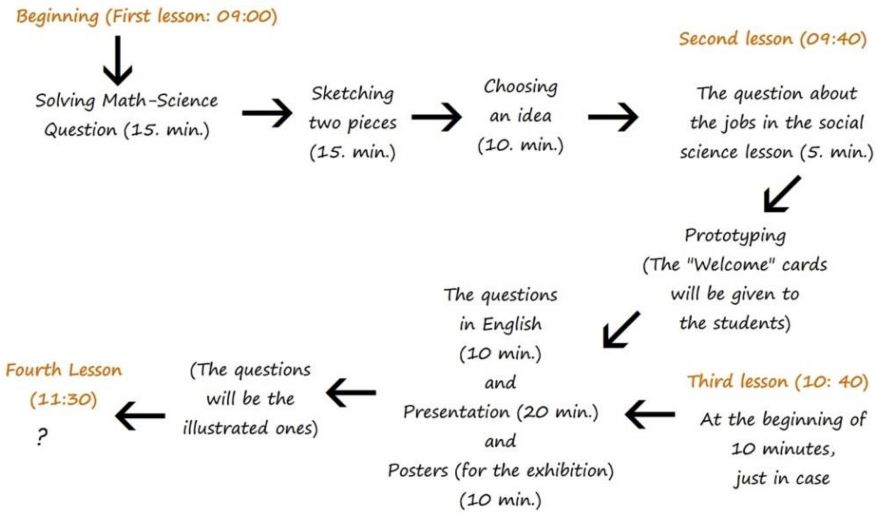


Figure 11. An English Translations of the journey map made for demonstrating how a STEM activity will progress (Öztürk, A. 2020)

Diagram: This brings out a process map related to the structure or the process of the idea. You can use this method while you are defining the stakeholders or designing the content of the STEM activity/lessons (Figure 12 and 13).

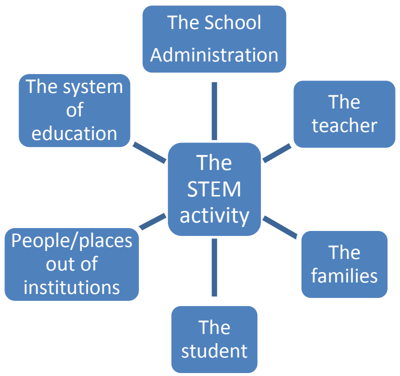


Figure 12. Defining stakeholders with diagram method at the "Define stakeholders" stage

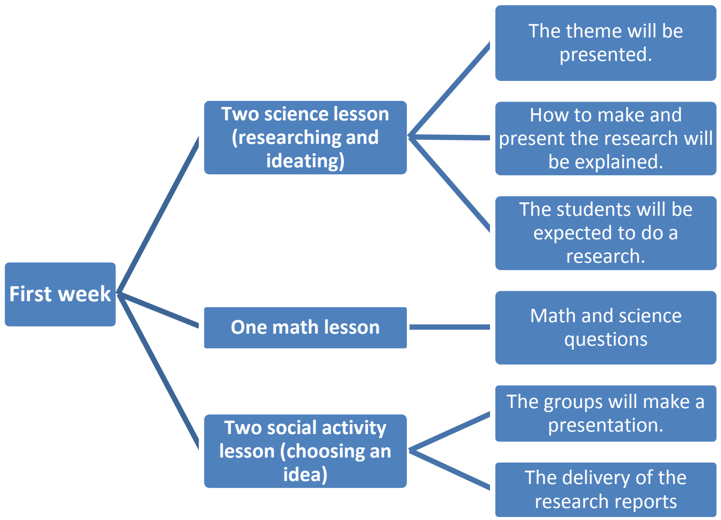


Figure 13. The demonstration of the lessons and their contents to be conducted in the first week in Activity 1 with the diagram method

Venn diagram: It can help you explain some important themes and their relations with each other. As seen in Figure 14, a Venn diagram can be used in various forms to express the connection between the relationships.

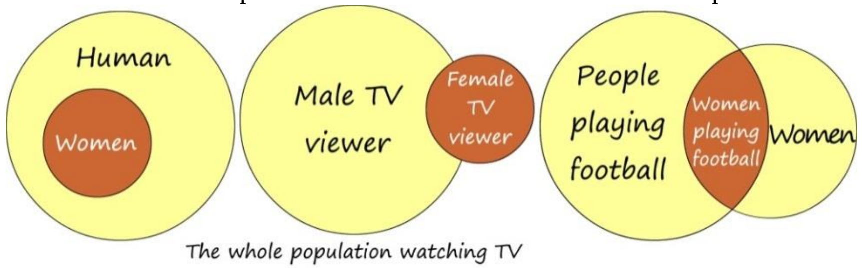


Figure 14. The types of Venn diagram (Ambrose & Harris; 2010, p.40)

This method can help you create the statement of the theme/problem at the "Ideate" stage or determining how the lessons will be related to each other at the "Define the subjects" stage (Figure 15 and 16).

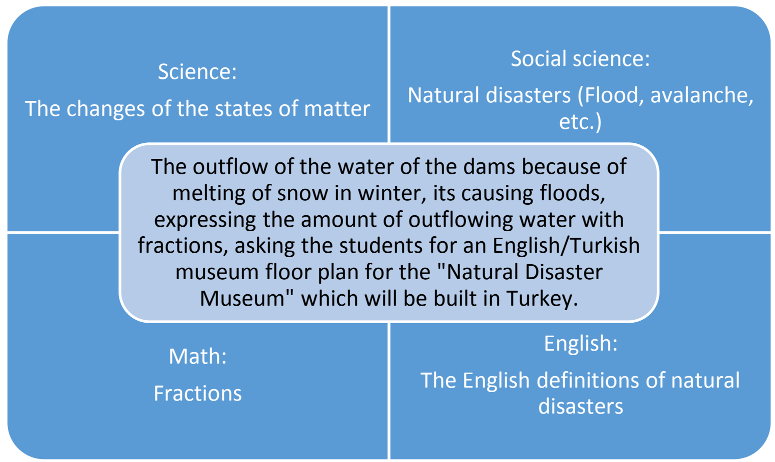


Figure 15. Using the Venn diagram for the "Ideate" stage in the Activity 2

At the “Define the subjects” stage for Activity 2, the subject of fractions has been expressed as a sub-set of math lesson in the left side. Then, it has been inferred that a connection can be made among the changes of the states of matter, natural disasters, and fractions by combining the science and math sets. Finally, the relation between natural disasters and the changes in the states of matter has been referred to as the intersection set of science and social science lessons. When we look at the whole, the subjects chosen for Activity 2 are stated under the disciplines with a Venn diagram.

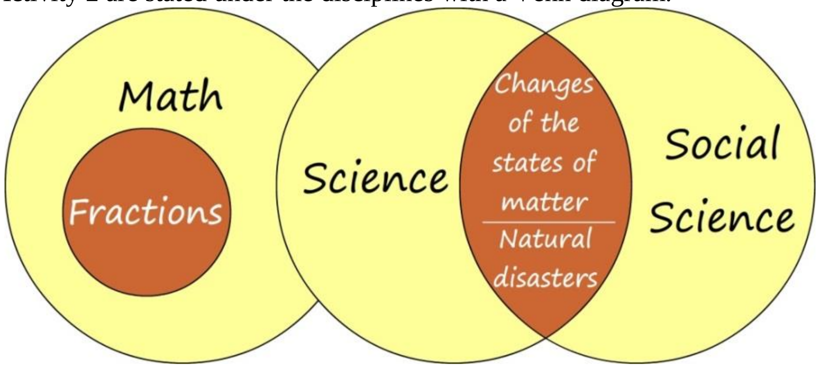


Figure 16. Using the Venn diagram for the “Define the subjects” stage in the Activity 2

Web-based diagram, table, map, graphic, and infographics drawing tools: Web-based interactive tools for drawing diagrams, Venn diagrams, graphics, tables, slides, mind maps, and infographics have been listed as the following. You can use them not only in the STEM activity design but also in developing materials for the lessons and activities.

- http://chartsbin.com/
- https://infogr.am/
- http://visual.ly/
- https://magic.piktochart.com/
- http://www.spicynodes.org/
- https://www.draw.io

Web-based student-answering systems: Interactive question preparing tools have been offered below. You can use these tools to make an interactive STEM activity/lesson content.

- **Addpoll**

It is an online tool for preparing questionnaires and forms (www.addpoll.com/).

- **Answergarden**

It is a web-based tool that provides viewers real-time participation, online brainstorming, and in-class feedback (answergarden.ch/).

- **Poll Everywhere**

It is a tool for preparing open-ended or multiple-choice questions for students in a real-time way (http://www.polleverywhere.com/).

- **Socrative**

It is a web-based evaluation tool for teachers to evaluate students about the lesson or activity of the day. Teachers can measure the comprehension level of the class with real-time questions and answers (www.socrative.com/).

- **Kahoot**

It is a game-based learning platform that makes learning enjoyable (https://kahoot.it/).

The other web-based tools: Some other tools which can be used in the STEM activity/lesson design or in developing materials for designed lessons and activities are below:

- **Story bird**

It helps you create web-based visual stories (https://storybird.com/).

- **Wordle**

It is a web-based tool used for generating “word clouds” (http://wordle.net/).

- **Pew Research Center**

Pew Research Center conducts demographic research, public opinion polling, content analysis, and other data-driven social science research which inform the public about the current issues, attitudes, and trends (http://www.pewinternet.org/).

- **Video Editor**

It is a video editing platform (www.nchsoftware.com/videopad/”).

4.3 Stakeholder analysis table (Stakeholder Analysis toolkit, n.d.)

The Stakeholder	The role in the project	Expectations	The attitudes towards the project	Anxiety about the project	The needs	The effectiveness level in the project	The focus group	The potential strategies

PS: You can fill in the particular sections in this table as below:

- The attitudes towards the project: Strongly Supportive, Neutral, Moderately Supportive, Moderately Against, Strongly Against (Stakeholder Mapping Guide: For Conservation International Country Programs & Partners, 2014)
- The role in the project: Active participant, Moderately Participant, Strongly Supportive (Place, materials, etc. for the practice of the STEM activity), Neutral
- The effectiveness level in the project: High, Moderate, or Low (Stakeholder Analysis toolkit, n.d.)

4.4 How to get to know students

While designing a STEM activity, we share some questions to help you get to know your students here. It can be added to these questions, or if you have information about the answers or if the problem is considered to be inappropriate, it can be decreased. Due to the wide scope of questions, please consider **the age range of students** when choosing them.

<u>Defining the content of the STEM activity (Lessons/activity design etc.)</u>

Lessons

1. What was your favorite activity that you joined in the school?
2. Where would you like lessons to be conducted most?
3. What should be in the lessons' content? (the choices can be multiplied)
   - Making an activity
   - Playing games
   - Doing an experiment
   - Watching an animation movie
   - Doing a project
   - Group working
   - Individual studying
   - Going on a school trip
   - Making a presentation
   - Making a model
   - Preparing a poster

4. While I am conducting this lesson, which of the teachers can help me, in your opinion?

PS: The opinions of the students about conducting a lesson through team teaching can be identified with this question.

5. Do you want your mother or father participates in the lesson/activity together with you?

<u>The relations between the subjects and lessons</u>

6. If you were the teacher, how would you conduct the subject of ……….?
7. In your opinion, are the subject of ………. and the subject of ………. related to each other? If yes, how? If no, why?

PS: You can write down the subjects you have chosen for the activity into the gaps in the 6. and 7. questions.

8. In your opinion, which lessons/subjects can the lesson/subject of ………. be related to? Why?

<u>Defining a problem/theme for the STEM activity</u>

Which job

1. Which job do you imagine that you will have in the future? Why?

Fields of interest

2. What is your favorite activity now?
3. Is there a subject that you wonder about or research nowadays? What is it?

PS: If demanded, 4. and 5. questions can be delivered to the students as a questionnaire.

4. What is the most significant problem that you, your family, or your friends have or encounter?
5. Which of the following subjects/themes draw your attention? (One or more options can be ticked off.)

   - **Designing a game (A digital game, a traditional game, etc.)**
   - **The ways to be protected from natural disasters**
   - **Camping in nature**
   - **Living alone in a deserted island**
   - **I am an engineer, and I want to design ………. on my own.**

   - **Art**
     - Let's make our own paints.
     - Let's make our own papers.

- Let’s make a piece of art by using fruits and vegetables.
- Let’s present our homemade food/sandwich/dessert in the most aesthetically way by plating it. (Making ice cream, a dessert, etc.)

- **Healthy living**
  - Sports
  - The diseases, treatments and protection ways from them today
  - Growing and consuming organic vegetables/fruits
  - Creating healthy living and working spaces

- **Ecological environment**
  - Animals (animals in danger of extinction)
  - Plants
  - Sustainable energy sources and protecting them
  - The ways for preserving the nature (ecosystem)
  - Sustainable architecture
  - The production and usage of renewable materials

- **The life, transportation, food, education, housing, health and art in the future**
  - Space and life in space
  - Designation of living spaces in the future
  - The jobs of the future
  - The education in the future
  - The diseases and treatments in the future
  - The art in the future
  - The agriculture in the future (growing vegetables/fruits)
  - The transportation, the means of transport and the fuels in the future
- **You can give themes about the narrations which are being read in Turkish or English lessons.**

4.5 How to conduct STEM activity and lessons for STEM education

The regular lessons covering a common theme or *interdisciplinary lessons* (individual teaching/team teaching) can be conducted before the activity, if necessary, for supporting the STEM activity (Table 15). *The regular lessons covering a common theme* are conducted like a regular lesson by the teacher mentioning about interdisciplinary relations around a single subject; however, *the interdisciplinary lessons* may include more than one teacher and subjects from different disciplines in their practices or lesson plans. For this reason, if there is a time constraint, it can be more practical to prepare and practice *the regular lessons covering a common theme* with regard to *the interdisciplinary lessons*, and this can be preferred because it is causing less workload for the teacher. Nevertheless, at the point of exploring the interdisciplinary relation, *the interdisciplinary lessons conducted through team teaching* can help both the students and the teachers who do not have experience with STEM education or interdisciplinary working because of the need for collaboration before and after the lesson. Moreover, the teachers can get to know the other teachers in the team vocationally because there will be information sharing during this collaboration. At this point, you can decide which type of lesson you will design considering the needs and analysis identified in the “Develop a point of view” stage and your weekly schedule.

Table 15. *The definitions about regular lesson covering a common theme and interdisciplinary lesson*

1- Conducting a regular lesson covering a common theme/subject: This means conducting lessons normally in different classes in the times close to each other by covering common theme/subject/subjects. On the one hand, individual activities can be made in these lessons, on the other hand, various products or a part of the activity can be generated in the content of the lesson to serve for the STEM activity (For example, to make the students design the invitation card for the exhibition, to make the students ideate primarily by giving homework including the problem of the STEM activity in the visual arts lesson).
2- Conducting an interdisciplinary lesson: The interdisciplinary lessons can be conducted in various ways. Here, we will emphasize the lessons conducted through team teaching and the ones given individually.
2a- Conducting an interdisciplinary lesson through individual teaching: It is a teaching method in which the teachers from different fields design lesson by working collaboratively on the subjects which they make interdisciplinary relations with each other but in the practice of which a single teacher conducts the lesson. While individual activities can be made in these lessons, various products, or a part of the activity can also be generated to serve for the STEM activity.
2b- Conducting an interdisciplinary lesson through team teaching: It is a teaching method in which the teachers from different fields design lesson by working collaboratively on the subjects which they make interdisciplinary relations with each other but in the practice of which the lesson is conducted by the teachers together who are involved in the lesson design. While individual activities can be made in these lessons, various products, or a part of the activity can also be generated to serve for the STEM activity.

In STEM education, the activities can be usually made in three different ways;

- Making an activity through individual teaching in a single lesson by relating a subject with various disciplines.
- Making an activity in more than one lesson by relating a subject with various disciplines on the same day/in the same week, month, or term.
- Solving a problem as an out-of-school STEM activity within the scope of a project.

The strategies below have been offered to help you with the design and practice of the interdisciplinary lessons and STEM activities (Table 16 and 17).

Table 16. *Strategies for interdisciplinary lessons*

Strategies for interdisciplinary lesson design	In planning the interdisciplinary lessons, the teaching order and timing of particular subjects and their interdisciplinary compatibility with each other should be taken into account.
	Integrating the visual arts and English disciplines along with the STEM disciplines into the interdisciplinary lessons would be advantageous due to their interdisciplinary curricula and activity based natures.
Strategies for implementing interdisciplinary lesson	When conducting a series of interdisciplinary lessons through individual teaching, making them consecutively would be more efficient for students' interdisciplinary learning.
	The interdisciplinary lessons can be concluded with short or introductory STEM activities for increasing students' familiarity with STEM activities.
Strategies for teachers	Conducting interdisciplinary lessons through individual teaching may be preferred when team teaching requirements concerning collaborating and scheduling cannot be met.
	In interdisciplinary lessons through team teaching, the workload of collaborating teachers should be equally distributed.

Table 17. *Strategies for STEM activity*

Strategies for STEM activity design	In the “observe” stage, make the students select the activity subject (s) from the proposed list.
	Identify an activity theme that attracts students’ attention to STEM activity.
	Integrate the DT approach into STEM activity with a special emphasis on prototyping and collaboration among students.
	Include team working and/or game-based learning in the STEM activity.
	If there is a time constraint (for example, one-lesson of practice), prepare worksheets containing problem solving using multiple disciplines for students (Figure 17).
	Impose restrictions on using the materials to prevent the unnecessary usage of the materials, and to trigger the creativity of the students in problem-solving.
	If appropriate, include a job introduction into the STEM activity design.
	Do not place any more questions after the prototyping part.
	Determine the date of the STEM activity in accordance with the collaborating teachers’ schedule and students’ exam schedule.
	Before executing the designed STEM activity on students, conduct a pilot implementation on another class with less number of participants (3 students, etc.) or implement the activities on yourselves/other teachers (Uştu, 2019). If there are problems detected in these implementations, revise the activity and then apply it in the class.
Strategies for implementing STEM activity	Introduce the design thinking process and STEM education to students before conducting the interdisciplinary lessons and the STEM activity.
	Test similar questions in class before implementing STEM activity.
	Review the relevant subjects in class before implementing STEM activity.
	Inform the students of the activity subjects before the STEM activity date.
	Separate the “answer the questions” part from the hands-on part spatially and cognitively in order to make students concentrate on both parts in a balanced way.
	Observe the students until the implementation of the STEM activity to understand the changes in students’ situations, and to develop and take the necessary actions.
	Create a comfortable working environment that is convenient for group working, encouraging students’ creativity, and allowing students to eat and drink.
	Inform collaborating teachers about the necessary points of the activity to enable successful guidance in the STEM activity.
	In the problem-definition stage, encourage students to read and re-interpret the STEM activity theme and write down their reflections in the form of a report.
	Emphasize the importance of the “ideate” stage during the STEM activity and encourage students to develop new and functional ideas rather than giving priority to building “appealing” prototypes.
	After completing the STEM activity, encourage students to present their outcomes to the class and provide them with a student evaluation table or a comment card for structuring the peer review process for evaluating the performance of student teams.
	Grade the STEM activity in order to make students take the activity seriously.
	In grading, give more points to the “answering the questions” part than the prototyping part.

Question: The students observe that the food jumbles in the storage box which they bring to put their remaining food at lunch because it does not have dividers in it. The demoralized students think that the storage box should have internal dividers. However, the food and the amount of it differs from person to person. Therefore, they realize that the design of the dividers can vary in itself. According to this, we want you to make a division for 4 kinds of food on the visual materials belonging to a storage box that have been given you. While doing this, please answer the following questions:

1- In how many percent of the storage box and which food do you want to keep in it? Please give an answer using fractional expressions and illustrate this on the visual material provided to you.

2- Paint the dividers using 3 primary colors and one of the secondary colors you like, that is to say, 4 colors in total.

For your answers, fill in the related fields on the worksheets.

The Menu: Soup, Meatballs and Potato, Pasta, Yoghurt, Ice cream, Bread

	1.The name of the food	2.The English name of the food	3. Which colour? (You can show painting here with the same colour)	4. In how many percent of the storage box is it kept?
1. Food				
2. Food				
3. Food				
4. Food				

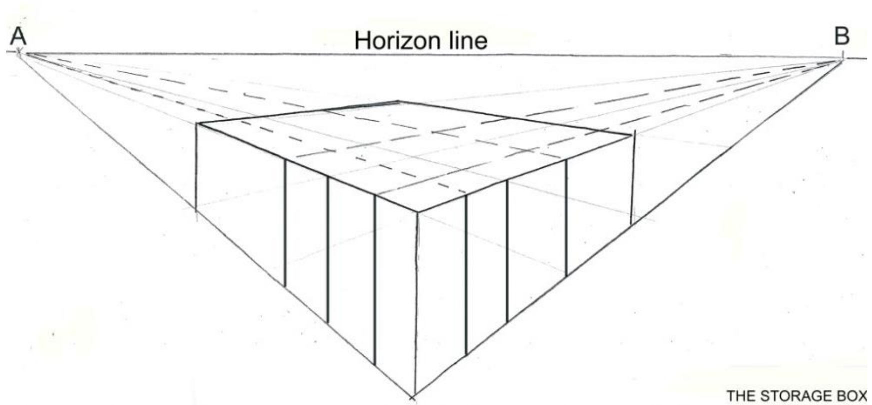


Figure 17. A STEM activity suggested for the fifth graders (Öztürk, A. 2020)

4.6 What is Design Thinking

Design thinking (DT) is defined as an interdisciplinary and human-centered approach (Brown, 2008) and is used as a tool for different aims, such as curriculum design in teaching and learning (IDEO, 2012), learning environment design (Design council, 2005), developing the skills of the students (d.loft STEM, n.d.). According to this, the teachers become able to develop a contemporary approach in their teaching by using their creativity by means of DT (Keane & Keane, 2014). *Design thinking* also involves the interdisciplinarity, learning by doing and experiential learning (Efeoğlu, Møller, Sérié, & Boer, 2013) and the 21st-century skills (Cooper-Hewitt, 2014); therefore, it has common features with STEM education. Moreover, it is used as an effective problem-solving method in STEM activities.

In order to carry out a STEM activity design through DT, there are ten mindsets, the adoption of which becomes more of an issue. Because of the fact that some of these are common with the features of STEM education (collaborating, learning from failure, iterating the process), they can be introduced to the students as well before the practice.

Table 18. *The mindsets of design thinking*

Creative Confidence: This mindset is to approach the world like a designer believing in that everybody is able to make a design and to be self-confident about having the creative ideas and the power for realizing them (The Field Guide to Human-Centered Design, 2015). To build up confidence over the creativity is a time-consuming process, and the STEM activity design guide will lead you in this sense.

Make it: Design thinking is interested in making prototypes and trying them. The aim of making a prototype does not mean which materials you use or how aesthetically well you create a model, yet it means presenting and sharing your ideas, and receiving feedback to know how to innovate your prototypes much more (Field Guide to Human-Centered Design, 2015).

Learning from failure: This mindset means producing many ideas and testing them with the users and, in case of failure, improving your applications learning from this failure (Brenner, Uebernickel & Abrell, 2016). This mindset is important for teachers in terms of developing strategies for a new activity in case of a failing one, and also, it is essential for students in terms of developing new ideas by learning from their projects failed.

Empathy: Developing empathy is to solve one's problems according to his/her point of view by placing yourself in his/her position. Developing empathy helps you with leaving your bias behind. (Field Guide to Human-Centered Design, 2015).

Embrace ambiguity: Not to know the answer to the problem to be solved in the design thinking approach can annoy you at first (Field Guide to Human-Centered Design, 2015). For this reason, it is considered that you can be open to creative ideas by embracing ambiguities and relying on the STEM activity design guide.

Optimism: Optimism is to believe that a better solution to the problem is possible, and you can arrive at it (Field Guide to Human-Centered Design, 2015).

Iterate: It is possible that one cannot arrive at the correct solution in problem-solving process at the first or second time, but he/she can achieve an embraceable solution by iterating the process (Field Guide to Human-Centered Design, 2015). From this point of view, it is essential to receive frequent feedback from the stakeholders.

Collaboration: It means the collaboration of people from different disciplines to understand a problem, analyze it, and develop a solution for it (Tran, 2017).

Be open to risk-taking: This means questioning the current situation by leaving the comfort zone to research new ideas (Chesson, 2017) and accepting that we cannot be successful for the first time by taking risks (Kolk, 2012).

Have a holistic viewpoint: This means regarding the problems based on holistic thinking as the problems needing systemic solutions consisting of the integration of procedures, organizational concepts or software, etc. (Owen, 2007). Having a holistic viewpoint is essential for students because it includes the evaluation of many factors to understand what the problem is at the "problem definition" stage in the activities, and it provides arriving at multiple solutions in this sense.

What are the stages of the Design Thinking Approach?

When we review the literature, we see that various design thinking approaches are carried out. At this point, because of the fact that it handles the approach in the process in more details and it is the starting point of the method used in the STEM activity design process, we are going to underline the design thinking approach used by **HPI School of Design Thinking**. *HPI School of Design Thinking* (HPI, n.d.) is to apply an alternating six-stage method, respectively, consisting of **understand, observe, point of view, ideate, prototype, and test**. In this approach, there is an iteration, which means that you can turn back to previous steps or starting point if necessary (Thoring & Muller, 2011).

- **Understand:** To do research about the subjects and gather information.
- **Observe:** To make observations and interviews in order to understand the problem and the user.
- **Point of view:** To examine what is needed or required by grouping the information gathered at the former stages together and accordingly to analyze what can be done. By making sense of this information, to introduce a point of view for the problem and to create a problem statement.
- **Ideate:** To try to find various ideas, which can be a solution for your problem with the help of brainstorming and to choose the most voted one by the group for the application.
- **Prototype:** To make prototypes by applying many different methods in order to try the idea defined or the concepts created.
- **Test:** To receive feedback from the user by testing the prototype on him/her and to review the prototype or the whole process by making corrections if necessary.

For designing a more systematic STEM activity, *Design Thinking Approach* can be involved in STEM activities as a problem-solving method. From this point of view, every stage of *Design Thinking* and how to use these stages in a STEM activity design have been explained to you below in detail.

PS: To quickly have an idea about design thinking, you can carry out the *Wallet Design Exercise* belonging to d.school in 90 minutes with your partner. You can access the documents and videos belonging to this activity from the websites cited below:

Table 19. *The websites for Wallet Design Exercise*

• https://dschool-old.stanford.edu/groups/designresources/wiki/4dbb2/The_Wallet_Project.html
• https://vimeo.com/33690707
• https://www.youtube.com/watch?v=Z4gAugRGpeY

Understand and Observe:
In the design process, the "Understand and Observe" stages help the participants to develop their empathy. (Taking Design Thinking to Schools, n.d.). For a human-centered design, it is necessary to understand the users. You should feel empathy with them to learn who the users are and what is significant for them. Watching people and observing their interaction, communication with their environment will give you an idea about what they consider and need (d.school at Stanford University, n.d.). <u>By using "Understand and Observe" stages, the STEM activities built for improving the feeling of empathy in students can be designed.</u>

Point of view:
At this stage, the participants are expected to have an opinion about people's needs and develop a point of view according to this (Taking Design Thinking to Schools, n.d.). Accordingly, the information gathered at former stages is brought together to determine what is necessary or required and what can be done accordingly. Consequently, a point of view for the problem can be put forward by making sense out of this information. The aim at this stage is to form a detailed and directive statement of the problem focusing on the user, his/her needs, and your analyses.

For example, **according to my findings, there is a need for ………. , because it happens that ………. , for this reason, my problem statement is ………………..**

<u>Then, how are the needs defined and analyses conducted?</u>

What is a "need"?
"Needs" are a person's emotional or physical needs, and they help you with defining your design problem. The needs can be defined by looking at the notes based on the characteristics of the user or the contradictions (the dissimilarity between what the user says and does) between his/her characteristics (d.school at Stanford University, n.d.).

Example: What does this girl need in order to be able to reach the books?

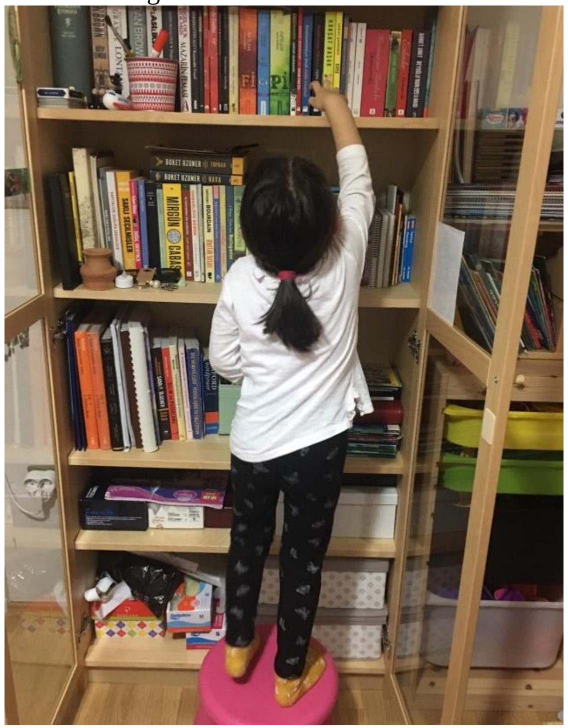


Figure 18. A picture of a girl who is trying to reach the books

Please think of the word “need” as an action, not as a noun. Because nouns mean solution suggestions (d.school at Stanford University, n.d.). For example, instead of saying, “The girl **needs a ladder or help of an adult**”, if you say “The little girl **needs to reach a book**”, the solution can be a ladder, a bionic arm, or anything else (Johnny Ryan, 2013). Therefore, options for the solution will have increased. <u>To identify the word “need” can help you with forming a theme statement instead of a problem statement, particularly in the STEM activity design.</u>

What is an analysis?

“The analyses are concise statements of what you have learned from your research” (IDEO, 2012) and syntheses of the information acquired. As a result, they offer you a new perspective. “Insights often grow from contradictions between two user attributes (either within a quadrant or from two different quadrants) or from asking yourself, “Why?” when you notice strange behavior” (d.school at Stanford University, n.d.). Let’s get back to our question; the answer we are searching about the previous picture maybe like this: “**This girl is reaching the shelves in this way to call her parents’ attention**”. So, the girl does not need a ladder or anything else; moreover, her hidden purpose is only to call her parents’ attention. This is already analysis, and in order to come to this conclusion, instead of only looking at the picture, an evaluation of the other data at hand (collecting information about the girl and her parents, observing them, etc.), that is to say, a detailed research should be made (Johnny Ryan, 2013).

<u>Consequently, defining the needs and analyses well can help you with defining the problem. At this point, the activities based on the “Understand and Observe” (gathering information) and the “Point of view” (defining the needs and analyses by the help of the information acquired) stages can help the students with defining the problem by looking from a broader perspective and with generating various solutions according to this. Besides, by combining the “Understand”, “Observe” and “Point of view” stages, a rearrangement can be made under the title of “Research” in the STEM activities.</u>

Ideate:

During this stage, it is aimed to produce ideas by brainstorming for solving the defined problem of the user. It is essential to ask open-ended questions during brainstorming. “How can we …?” questions are short questions giving a start to brainstorming, and they can provide us with reaching many options as the answers (MIT MOOCs course, n.d.). For instance, instead of asking a narrow question like **“How can we design a cornet for eating ice cream without dripping it?”** or a broad question like **“How can we design a dessert?”**, it is more appropriate to ask **”How can we design ice cream to be more holdable?”** (d.school at Stanford University, n.d.).

Example:

Problem: The user’s food starts getting cold when he/she takes his/her way to work.

The question-to-ask during brainstorming: How can you help the user with keeping his/her food hot while going to work?

<u>Asking this kind of question is important to help the students with coming to various solutions after the problem has been defined in STEM activities. For this reason, the students can be shown how brainstorming is done for the theme/problem statement with the STEM activities only based on “Ideate” in order to achieve distinctive and original solutions.</u>

Prototype:

Prototyping is a quick way to transfer an idea to the others and to “test the functionality”. To make a prototype, to test it and to renew the prototype by modifying it if necessary are all a learning process; therefore, it is not aimed to achieve a correct solution on the first try (d.school at Stanford University, n.d.). As a consequence, a prototype is a sketch belonging to your idea, and it can change over time (MIT MOOCs course, n.d.).

At the “Prototype” stage (d.school at Stanford University, n.d.):

- First of all, what to prototype should be determined.

- Then, what kind of prototype to make should be determined and which prototyping method to apply should be considered at this stage.
- Making a prototype should not take a long period of time, no fear should be felt for a failure, continually trying to make it should go on and which materials to use should be primarily defined.

Test:

Testing is a part of a repetitive process providing feedback. This stage may be inferred as getting back to your prototype and modifying it due to the feedbacks (Taking Design Thinking to Schools, n.d.). In this section, it is aimed to learn positive and negative aspects of your prototype in consideration of your target group's feedback after testing your prototype by sharing it with them, then to write down the questions you have on your mind and afterward to develop the prototype. <u>The "Test" stage can be involved in the STEM activities by consisting of the titles "Present a project, Receive feedback and Peer review".</u>

Sample STEM activities applying design thinking approach:

Some STEM activities in which design thinking approach is applied as a problem-solving method have been introduced to you below:

Social science education:

The students are requested to form a journey map showing the national days. They are also expected to illustrate the day they regard as the most significant to express what it means to them. While doing this, the students are actually expected to develop a point of view about why they regard the national days as significant and accordingly to use the information about that day on their journey maps. Here, instead of all the stages of the design thinking process, the "Point of view" and the "Prototype" stages have been included.

Science education:

Here, a STEM activity (Activity 1), which puts the science in the center but also consists of the disciplines of visual arts, math, and English, applies the design thinking approach as a problem-solving method. Instead of including the six stages, the "Understand", "Observe" and "Point of view" stages have been combined, and the activity has been conducted through 4 stages (Table 20).

Table 20. *The STEM activity design for Activity 1*

Question: Our students are nowadays complaining about being served melted ice cream at lunch. At this point, they asked two questions to the principal of the school; can you help us with answering these questions?

• What are the reasons for the melting of ice cream?

• What kind of solution/system do you suggest to prevent ice cream from melting?

For finding a solution, please follow the stages written on the worksheets given to you.

1- IDEA GENERATION: Please brainstorm with your teammates about how to prevent ice cream's melting and illustrate two of the ideas for the solution in the boxes below.

2- IDEA SELECTION: Please choose one of these ideas and explain your reason.

3- PROTOTYPING: Please make the prototype of the idea chosen with the materials given to you. Besides, please answer the questions below.

Materials: Aluminum foil, adhesive agent, a ruler, cardboard, wooden skewers, a sticky tape, scissors, pipettes, a colored paper, a white A4 paper, sticky notes, felt, a toilet paper or paper towel roll, colored pens, envelopes
PS: While you are at this stage, you can share tasks.

a- What is the way of working of this design (prototype)? How does it prevent ice cream melting?
b- Please answer the question below.
Question: Today, Ayşe bought three scoops of her favorite kinds of ice cream from the school cafeteria. But, she could not find time to have her ice cream at lunch, so she wanted to eat it when she came home. However, she noticed that 1/3 of the two scoops from three scoops of her ice cream and 1/2 of the other scoop melted. According to this, how many percent of Ayşe's ice cream remained?

c- Prepare an informative English poster regarding your design (prototype) on a 50x70 cm sized paper.
d- While solving the question asked to you, what information about which lessons did you need to use?

Math:
Science:
Visual Arts:
English:

e- Make a presentation:
Please make presentations of your projects to the class.

f- Peer review:
Please write down the project you liked most with its reasons and give the written note in a sealed envelope to your teacher.

4.7 Template for STEM activity plan[7]

Explain the activity in two or three sentences. Briefly summarize your activity plan and aim. What will your students learn at the end of this activity?

<u>The target stakeholder/stakeholders:</u> Who are the target stakeholder/stakeholders?

<u>Which of the disciplines will the activity consist? What will be the target learning outcomes?</u>

	Discipline 1	Discipline 2	Discipline 3	Discipline 4
Name of the lesson				
The subject/subjects to be involved in the activity				
The target learning outcome/outcomes				

<u>Which of the teachers will participate in the activity?</u>

<u>When and where will the activity be practiced (during the lesson/lessons, inside or outside the school, etc.), and how long will it last?</u>

<u>What is your statement of the problem/theme? What is your problem/theme statement/script which you will ask your students and which will provide them to use the information of all the lessons in the activity content?</u>

[7] Some parts of the STEM activity plan have been prepared by considering the MIT MOOCs course (n.d.).

What are your research questions? (if available)

What are your restrictions? (if existing)

How will the activity progress? How the activity's content will be is going to be written step by step. For this, please consider the points below:

- Which of the teachers will be responsible for every stage?
- When will the activity be made?
- In which lesson/lessons will these stages be conducted?
- How much time will be given to every stage?
- What will be done during these stages? (Are there any individual or group studies?)
- What will be asked to the students to do? (To prototype, to write a research report, to make a presentation, to design a poster, to create a presentation board of the system design, etc.)
- Will the students evaluate the projects of each other? (Peer review)
- Will an exhibition be held at the end of the activity? (How will the poster and invitation card of the exhibition be prepared?)

PS: You can benefit from the *HPI design thinking approach* (Understand, Observe, Point of view, Ideate, Prototype, Test) while you are creating the content of your activity.

- How will be the theme/problem be presented? (PowerPoint presentation, preparing animation, using film)

- Which questions will be asked? At which stages will the questions take place?

- How will the prepared questions be tested in the lessons before?

- If there is a group working in the activity, how will the groups be formed?

- How many points will the stages be scored? What will be the evaluation criteria?
  (The evaluation criteria of the outputs, such as answering questions, peer review, assignments, ideating, prototyping, preparing reports/presentations, designing posters, presentation boards of system design, etc.)

- Will you evaluate certain skills of the students during the activity? (to evaluate the points such as teamwork, time management, etc.) How will this evaluation be done?

- How will the students be motivated for the STEM activity? (Giving chocolates to the students in the course of the activity, giving a present to the winner, such as a book, medal or computer game, etc.)

- What will be the sources to put the activity into practice? (Books, YouTube videos, websites, etc.)

- What kind of materials will be required to be prepared? How will you prepare them?

- Will the students be required to bring materials for the activity? If yes, what are these materials?

- Will the students be given a detailed activity plan also consisting of the statement of the problem? Will you need to direct the students or give them instructions during the activity? If yes, in what way will you do this?

- What is the to-do list/requirement list for the STEM activity?

More information:

The preparation stage for the STEM activity
(Regular lesson covering a common theme / interdisciplinary lesson plans)

- ✓ Which of the teachers will participate in the interdisciplinary lesson conducted through team teaching?
- ✓ In which lesson will the interdisciplinary lesson through team teaching or individual teaching be conducted?
- ✓ When will the lessons be conducted, and how long will they last?
- ✓ Which of the hypothetical information will be given in the lessons, and in what way will the lessons be conducted?
- ✓ In which way do you intend to relate the subjects in the interdisciplinary lessons?
- ✓ How will the evaluation be made? (Assignments, examinations, peer review, etc.)
- ✓ What kind of materials will be required to be prepared for the lesson? How will you prepare them?
- ✓ Will the students be required to bring materials for the lesson? If yes, what are these materials?

Lesson 1
Type of the lesson:
Participants:
Subject/subjects:
Place/Date:
Evaluation:

Course plan

Lesson 2
Type of the lesson:
Participants:
Subject/subjects:
Place/Date:
Evaluation:

Course plan

Lesson 3
Type of the lesson:
Participants:
Subject/subjects:
Place/Date:
Evaluation:

Course plan

Lesson 4
Type of the lesson:
Participants:
Subject/subjects:
Place/Date:
Evaluation:

Course plan

- <u>What is the to-do list/requirement list for the lessons?</u>
- <u>More information:</u>

4.8 A Sample STEM activity plan: *Activity 1*

Explain the activity in two or three sentences. Briefly summarize your activity plan and aim. What will your students learn at the end of this activity?
It means the planning of an activity that consists of social science, science, and math lessons and aims at presenting the students the connection among the natural disasters, changes of the states of matter, and fractions.

<u>The target stakeholder/stakeholders:</u> Who are the target stakeholder/stakeholders?
The students, the teachers, the families, and the school administration

<u>Which of the disciplines will the activity consist of? What will be the target learning outcomes?</u>

	Discipline 1	Discipline 2	Discipline 3	Discipline 4
Name of the lesson	Science	Math	English	Visual Arts
The subject/ subjects to be involved in the activity	Matter and change	Fractions	Party time	Visual Communication and Forming
The target learning outcome/ outcomes	He/she makes an inference for the fact that matters can change because of heat energy.	He/she creates and solves problems requiring addition and subtraction of fractions.	He/she learns how to organize invitations and celebrations such as parties and how to invite people to these.	He/she makes choices to form a composition unity in the visual arts activity.

<u>Which of the teachers will participate in the activity?</u>

Math, science and visual arts teachers

<u>When and where will the activity be practiced (during the lesson/lessons, inside or outside the school, etc.), and how long will it last?</u>

The activity will be practiced for two weeks, totally in 9 lessons. It will be conducted in social activity, science, and math lessons. The design of the poster and invitation card of the exhibition which will be held in the last week of school for the activity will be made for two weeks, totally in 4 lessons of visual arts and English lessons.

<u>What is your statement of the problem/theme? What is your problem/theme statement/script which you will ask your students and which will provide them to use the information of all the lessons in the activity content?</u>

Theme: Our students are nowadays complaining about being served melted ice cream at lunch. At this point, they have asked two questions to the principal of the school; can you help us with answering these questions?

<u>What are your research questions?</u> (if available)

- What are the reasons for the melting of ice cream?
- What kind of solution/system do you suggest to prevent ice cream from melting?

<u>What are your restrictions?</u> (if existing)

There will be restrictions for materials-to-use in prototype making.

How will the activity progress? How the activity's content will be is going to be written step by step. For this, please consider the points below:

- Which of the teachers will be responsible for every stage?
- When will the activity be made?
- In which lesson/lessons will these stages be conducted?
- How much time will be given to every stage?
- What will be done during these stages? (Are there any individual or group studies?)
- What will be asked to the students to do? (To prototype, to write a research report, to make a presentation, to design a poster, to create a presentation board of the system design, etc.)
- Will the students evaluate the projects of each other? (Peer review)
- Will an exhibition be held at the end of the activity? (How will the poster and invitation card of the exhibition be prepared?)

PS: You can benefit from the *HPI design thinking approach* (Understand, Observe, Point of view, Ideate, Prototype, Test) while you are creating the content of your activity.

The stages will be conducted in Activity 1 as following;

- To research in order to understand why ice cream melts (Understand, Observe and Point of view)
- To ideate for the problem and choose an idea (Ideate)
- To prototype for the solution and design a poster (Prototype)
- To present the solutions to the class and peer review (Test)
- To design a poster and invitation card for the exhibition
- To open the exhibition

Activity 1:

The first week:

The two science lessons (to research and ideate): In this lesson, the theme will be introduced, and then it will be explained how to research and present the information acquired. After that, the students are expected to go to the school cafeteria in pairs and talk to the employees there, to define the problems causing ice cream to melt and accordingly to make suggestions for solutions. The students can take photographs or record videos if they wish.

The one math lesson: In this lesson, the math and science questions will be given to the students, and they will be asked to solve these questions during the class.

The two social activity lessons (to choose an idea): The groups will present the problems they have defined and the solutions they have suggested to the class by writing them on a 50x70 cm sized paper. Then, they will write at most one-page research report about the solution they have suggested. During the lesson, the students and the science teacher will criticize the presentations, and if necessary, the students will be requested to modify the solution.

The second week:

The two math lessons (to prototype): During this lesson, the students will create their two or three-dimensional prototypes by using the materials given. To support the stage of prototyping, the visual arts teacher will attend the class together with the math teacher.

Poster design as homework (to prototype): The students will be assigned homework to design a poster presenting the solutions for the problem. At this point, they will be told that they can ask for their families' help, and also the families will be formerly informed about this stage.

The two social activity lessons (to test): At this stage, the students will present their prototypes together with the posters designed to the class and then their teacher and friends will criticize their projects. Here the students will also be asked to choose the winner project by evaluating each other. During this stage, both the math and the science teachers will attend the class, and assess together the projects of the students.

The exhibition to hold after the activities

The third week:

The one visual arts lesson: To make a preparation for this lesson, the information about how to make a composition on a paper will have been primarily explained. According to this, in the lesson, the students will be asked to design a poster for the exhibition being held. They will start making their designs during the lesson, and they will come to the classroom with their designs fully completed in the following lesson.

The one English lesson: In order to be a preparation for this lesson, the subject about how to organize a party and how to invite people will have been conducted formerly in the Unit "Party time". So, in light of this information, the students will be asked to design an invitation card for the exhibition both in English and in Turkish. They will start making their designs during the lesson, and they will come to the classroom with their designs fully completed in the following lesson.

The fourth week:

The one visual arts lesson: The poster designs will be hung on the wall in the classroom, and the students will be requested to evaluate the poster they like most and put a written note about it in a sealed envelope.

The one English lesson: The invitation card designs will be exhibited on the teacher's table, and the students will be requested to evaluate the invitation card they like most and put a written note about it in a sealed envelope.

- How will be the theme/problem be presented? (PowerPoint presentation, preparing animation, using film)

The theme will be presented via PowerPoint presentation.

- Which questions will be asked? At which stages will the questions take place?

The questions will be asked for preparing the students for the activity after introducing the problem statement to the class. Which questions to ask will be determined after the lessons are conducted.

- How will the prepared questions be tested in the lessons before?

The questions of the activity will be tested by asking similar ones with them by oral examinations during the lesson or by giving homework.

- If there is a group working in the activity, how will the groups be formed?

Because the students are changeable in their relationships, the groups will be determined in the previous week of the activity.

- How many points will the stages be scored? What will be the evaluation criteria?
  (The evaluation criteria of the outputs such as answering questions, peer review, assignments, ideating, prototyping, preparing reports/presentations, designing posters, presentation boards of system design, etc.)

The presentation of the research, the report of the research: 15
Suggestions for ideas: 20
Prototype: 5
Poster: 5
Presentation: 10
Questions: 20
The poster and invitation card designs: 25
The group who takes most of the votes in peer review will be given +1 bonus point. The evaluation criteria for the prototype will be afterward determined together with the visual arts teacher. Moreover, an answer key will be prepared for the questions.

- Will you evaluate certain skills of the students during the activity? (to evaluate the points such as teamwork, time management, etc.) How will this evaluation be done?

The students' teamwork will be evaluated by the math and science teachers who are present during the activity, and the most compatible groups in the course of teamwork will be awarded +1 bonus point. As Activity 1 is the students' first STEM activity, the time management will not be included in the evaluation of it. However, an evaluation in Activity 2 can be made by looking at their former performances.

- How will the students be motivated for the STEM activity? (Giving chocolates to the students in the course of the activity, giving a present to the winner such as a book, medal or computer game, etc.)

In the course of the activity, it is considered to deliver chocolates to the students. At the end of the activity, it is planned to get the winner rewarded with a medal.

- What will be the sources to put the activity into practice? (Books, YouTube videos, websites, etc.)

Course books and question banks will be used. There will be a video or an animation movie explaining what an exhibition is for the English class, which will be conducted to design the invitation card for the exhibition.

- What kind of materials will be required to be prepared? How will you prepare them?

There is no need to prepare any materials primarily.

- Will the students be required to bring materials for the activity? If yes, what are these materials?

The students will bring along their basic materials (rulers, pencils, ball pens, colored pens, scissors, adhesive agents, sticky tapes, etc.) for the prototype stage and poster design.

- Will the students be given a detailed activity plan also consisting of the statement of the problem? Will you need to direct the students or give them instructions during the activity? If yes, in what way will you do this?

The students will not be given an activity plan. The teachers will come together before the activity, and they will discuss what will be done during the activity.

- What is the to-do list/requirement list for the STEM activity?

It is required to make a prototyping materials list for Activity 1 to give information about how to print posters and invitation cards and how many to print, and to prepare the science and math questions.

More information:

ACTIVITY 2

The preparation stage for the STEM activity (Regular lesson covering a common theme / interdisciplinary lesson plans)

- ✓ Which of the teachers will participate in the interdisciplinary lesson conducted through team teaching?
- ✓ In which lesson will the interdisciplinary lesson through team teaching or individual teaching be conducted?
- ✓ When will the lessons be conducted, and how long will they last?
- ✓ Which of the hypothetical information will be given in the lessons, and in what way will the lessons be conducted?
- ✓ In which way do you intend to relate the subjects in the interdisciplinary lessons?
- ✓ How will the evaluation be made? (Assignments, examinations, peer review, etc.)
- ✓ What kind of materials will be required to be prepared for the lesson? How will you prepare them?
- ✓ Will the students be required to bring materials for the lesson? If yes, what are these materials?

Lesson 1

Type of the lesson: A regular lesson covering a common theme

Participants: Social science teacher

Subject/subjects: Natural disasters

Place/Date: Social science class / Two weeks before the activity, 1 lesson

Evaluation: Oral examination

Course plan
While the social science teacher is teaching the natural disasters subject, he/she will refer to the science lesson (states of matter) because of its content. So, some videos/animation movies demonstrating the melting of snow and floods resulting from this will be displayed in the lesson as related to the subject. At the end of the lesson, an oral examination will be made.

Lesson 2

Type of the lesson: A regular lesson covering a common theme

Participants: The English teacher

Subject/subjects: Natural disasters

Place/Date: English class / Two weeks before the activity, 1 lesson

Evaluation: The question sheet related to the subject will be delivered in the classroom.

Course plan
The English teacher will teach the names and definitions of natural disasters in English. Moreover, while she is mentioning natural disasters, she will explain the words, such as melting, freezing, boiling, etc. by referring to the changes of the states of matter and doing experiments in the classroom. For example, by melting a candle to show how a solis becomes a liquid by heating or by bringing iced water to the classroom to show how a solid becomes a liquid in the room temperature, he/she will teach the subject. In the lesson, the teacher will give question sheets, and the answers will be checked together with the students during the class.

Lesson 3

Type of the lesson: An interdisciplinary lesson conducted through team teaching

Participants: Science, social science and visual arts teachers

Subject/subjects: Natural disasters, the changes of the states of matter

Place/Date: Social activity class / One week before the activity, 1 lesson

Evaluation: Oral examination

Course plan
During the lesson, the visual arts teacher will be making a mountain model covered with snow, a forest on it, and a river. At this point, the science teacher will mention the changes of the states of matter by referring to the formation process of snow and rain; the social science teacher will explain how flood happens by referring to the changes of the states of matter (flood resulting from the melting of snow). At the same time, the visual arts teacher will demonstrate how the plaster used in the model making gives heat out while it is freezing in the course of the phase change of liquid to solid. So, these three lessons will have been connected with each other, and this interdisciplinary lesson will be conducted in the company with live model making. Besides, the visual arts teacher will ask the students to design a museum-related to natural disasters as homework in order to be prepared for the STEM activity.

- What is the to-do list/requirement list for the lessons?

It is required to have an animation movie about natural disasters and to bring a candle and iced water to the classroom for the English lesson in Activity 2. There will be some videos/animation movies displaying snow's melting and floods resulting from this for the social science lesson. It should be bought styrofoam, plaster, and paint for the interdisciplinary lesson.

- More information:

4.9. Interview form

An Interview Form

Name / Surname:

Target Group:

Write down the interview questions you have defined below.

Record the notes of your interview below.

4.10. Observation form

An Observation Form

Name / Surname:

Target Group:

5. REFERENCES

Ambrose, G., & Harris, P. (2010). *Design Thinking (The Basics Design series 08)*. Switzerland: AVA Publishing SA

Bleuel, F., Weinreich, U., & Puget, A. (2017). *CoObeya Design Thinking Toolkit*. Retrieved November 01, 2019, from coobeya.net/download/dtcards_basic_en.pdf

Brenner, W., Uebernickel, F., & Abrell, T. (2016). *Design thinking as mindset, process, and toolbox.* In W. Brenner & F. Uebernickel, (Eds.). *Design thinking for innovation: research and practice* (pp. 3-21). Switzerland: Springer International Publishing

Brown, T. (2008). Design thinking. *Harvard Business Review, 86*(6), 84-92

Chesson, D. (2017). *Design thinker profile: Creating and validating a scale for measuring design thinking capabilities* [Master dissertation, Antioch University, USA]. AURA: Antioch University Repository and Archive. https://aura.antioch.edu/cgi/viewcontent.cgi?article =1398&context=etds

Cooper-Hewitt. (2014). *What is design? Teacher resource packet*. Retrieved September 08, 2016 from http://uh8yh30l48rpize52xh0q1o6i.wpengine.netdna-cdn.com/wp-content/uploads /2014/05/DITC-Teacher-Resource-Packet.pdf

Çorlu, S., & Çallı, E. (2017). *STEM kuram ve Uygulamaları*. Istanbul: Pusula Yayıncılık

Design Council. (2005). *Learning Environments Campaign Prospectus: From the Inside Looking Out*. Retrieved April 17, 2017, from archive.teachfind.com/ttv/static.teachers.tv/shared /files/2424.pdf

d.loft STEM. (n.d.). Retrieved September 06, 2016 from https://dloft.stanford.edu/

d.school at Stanford University (n.d.). Retrieved August 18, 2017, from https://dschool.stanford.edu /resources/the-bootcamp-bootleg

Efeoglu, A., Møller, C., Sérié, M., & Boer, H. (2013). Design thinking: characteristics and promises. In *Business Development and Co-creation: Proceedings of the 14th International CINet Conference* (pp. 241-256). Nijmegen, Netherlands

Hot potato (n.d.). Retrieved March 02, 2020, from https://teaching-strategies.wikispaces.com/Hot+Potato

HPI (Hasso Plattner Institut) (n.d.). Retrieved May 18, 2020, from https://hpi-academy.de/en/design-thinking/what-is-design-thinking.html

IDEO (Design Thinking for Educators) (2012). Retrieved September 06, 2016, from http://www.designthinkingforeducators.com/toolkit/

Johnny Ryan. (2013, December 13). *Design Thinking workshop with Justin Ferrell from Stanford d. school at The Irish Times* [Video]. YouTube. Retrieved https://www.youtube.com /watch?v=Z4gAugRGpeY

Keane, L., & Keane, M. (2014). Design is our nature disseminating design practices in K12 education. In *Proceedings of the International Teacher Education Conference 2014 (ITEC 2014)* (pp. 253-262). Dubai, UAE

Kolk, M. (2012). *Build 21st century skills with design thinking*. Retrieved September 07, 2016, from http://creativeeducator.tech4learning.com/2012/articles/InterviewDr_Maureen_ Carroll

MIT MOOCs course (n.d.). Retrieved August 06, 2017, from https://www.edx.org/course/design-thinking-leading-learning-mitx-microsoft-education-11-155x

Mind map (n.d.) Retrieved March 02, 2020, from https://www.mindtools.com/pages/article /newISS_01.htm

Owen, C. (2007). Design Thinking: Notes on its nature and use. *Design Research Quarterly*, *2*(1), 16-27

Öztürk, A. (2020). *Co-developing STEM activities through design thinking approach for 5th graders* [Doctoral dissertation, Middle East Technical University, Turkey]

Stakeholder Analysis toolkit, (n.d.). Retrieved October 21, 2019, from https://www2.mmu.ac.uk/media/mmuacuk/content/documents/bit/Stakeholder-analysis-toolkit-v3.pdf

Stakeholder Mapping Guide: For Conservation International Country Programs & Partners. (2014). Retrieved October 21, 2019, from https://iwlearn.net/resolveuid/d20fc335-aa29-440b-ae14-f94f37321427

Taking Design Thinking to Schools (n.d.). Retrieved September 06, 2016, from https://stanford.edu/dept/SUSE/taking-design/presentations/Taking-design-to-school.pdf

The Field Guide to Human-Centered Design. (2015). Retrieved November 01, 2019, from https://www.designkit. org/resources/1/

Thoring, K., & Müller, R.M. (2011, September). Understanding design thinking: a process model based on method engineering. *International Conference on Engineering and Product Design Education*. London, UK

Tran, N. (2017). Design thinking playbook for change management in K12 schools. Retrieved November 25, 2019, from https://dschool-old.stanford.edu/sandbox/groups/k12/wiki /ad2ce/attachments/3946e/DESIGN%20THINKING%20PLAYBOOK%20%281%29.pdf? sessionID=8cbdfc6129ceb041dbad2247ffc9d0112fd0ebce

Uştu, H. (2019). *İlkokul düzeyinde bütünleşik STEM/STEAM etkinliklerinin uygulanması: sınıf öğretmenleriyle bir eylem araştırması*. (Publication No. 589311) [Doctoral dissertation, Necmettin Erbakan University, Turkey]. CoHE Thesis Center

Van Boeijen, A., & Daalhuizen, J. (Eds.) (2010). *Delft design guide*. Retrieved July 20, 2017, from https://arl.human.cornell.edu/PAGES_ Delft/Delft_Design_Guide.pdf

W. Quotations and Conversations (Turkish)

[1] **İngilizce öğretmeni:** Normalde öğrenci bir dersi seviyorsa, o derste başarılı oluyor. Bu şekilde, bütün derslerde başarılı olması sağlanabilir.
[2] **Resim öğretmeni:** Bütün öğrencilerin öğrenme şekli farklıdır. Kimisi sayısaldan anlıyor, kimisi sözelden, kimisi görselden. Bu, bütün öğrencilere öğrenme olanağı sağlıyor.
[3] **Fen bilgisi öğretmeni:** Bir de şey var, disiplinlerarası ya. Normalde resim dersi iyiyse bir çocuğun, o çocuk resimde iyi denmez, ama fen bilgisi iyiyse, "o çok iyi fen yapıyor" denir. Ama resmi de iyi olabilir, ama hiç bir zaman bir anne, baba benim çocuğumun resmi iyi demez. Ama burada iyi olmasının bir önemi var. Her ders eşit yani.
[4] **Fen bilgisi öğretmeni:** Biz önceden dersleri sözel ve sayısal diye ayırıyorduk. Aslında her dersin birbiriyle ilişkisi olduğunu görmüş olduk.
[5] **Tarih öğretmeni:** Daha önce tarihi resim ve müzikle bağdaştırabiliyordum. Ama bir fen bilimiyle bağdaştırmayı herhalde düşünmezdim.
[6] **S1-P1-English-23 Ekim-(7-8)**
[**Araştırmacı:** "Daha önce hiç disiplinlerarası ders işlediniz mi?" sorusuna yanıt]
Elbette duydum. Zaten İngilizce derslerimiz az çok disiplinlerarası olmak zorunda. Çünkü ders kitaplarındaki konular az çok ilişkili olabiliyor. Matematik ve fen derslerinden konularla mutlaka ilişkili olabiliyor. Ama direkt olarak bu şekilde işlemedim.
[7] **S1-P1-English1-23 Ekim-(29-30)**
Biz bir de üçe ayrılıyoruz. X hoca biraz daha temel konular ve gramer veriyor. Ben beceri öğretmeniyim mesela; biraz daha yetenek ve okuma. Writing ve Speaking'e Y hoca giriyor. Ben Reading, Writing ya da Listening veriyorum. Bunları pekiştirerek ya da etkinlik, materyal hazırlayarak veriyorum.
[8] **S1-P1-Art-23 Ekim-(15-16)**
[**Araştırmacı:** "Hocam daha önce hiç disiplinlerarası ders işlediniz mi?" sorusuna yanıt]
Zaten ben bu mesleğe başladığımdan beri, planlarımızda disiplinlerarası bir bölüm vardı. Diğer zümre öğretmenleriyle işbirliği bölümü. Diğer zümre öğretmenleri derken, burada bir tarih öğretmeninin, bir matematik öğretmeninin, bir fen bilgisi öğretmeninin karşılıklı ilişkisi… Zaten müfettişler geldiğinde o zümre öğretmenleri ile ne derece işbirliği yapıyorsun diye bakıyorlar. Ben alanımla ilgili öyle bir şey yapıyordum.
[9] **S1-P1-Art-23 Ekim-(31 ve 33)**
STEM eğitimi hakkında ne düşünüyoruz, eskiden olan şeyler. İlk tanıştığımızda dediğim gibi, köy enstitülerinde uygulanan şeyler veya günümüzdeki adıyla toplam kalite. Benim branşım olmayabilir ama her öğretmen her disiplinden az veya çok anlamalı. Bunu karşısındaki ile tartışmalı, konuşmalı.
[10] **S1-P1-English-23 Ekim-(13)**
Dediğim gibi yeni bir şeyler öğrenmek, kalıcı bir şeyler öğrenmek. Yani süreklilik, devamlılık olsun istiyorum. Derslerde uygulanabilirlik bir defaya mahsus olmasın, daha uzun olsun istiyorum. Açıkçası bir sertifika beklentim de vardı.
[11] **S1-P1-English1-23 Ekim-(19-20, 23-24)**
Şu anda ben de merak ediyorum açıkçası nasıl bir şey olacağını. Anladığım kadarıyla, dersler birbiriyle uyumlu olarak verilecek. […] Örneğin, ben İngilizce alanında bir dersi verirken, matematik öğretmeni, resim öğretmeni ya da Türkçe öğretmeniyle konuşarak paralel olarak gideceğiz.
[12] **S1-P1-Art-23 Ekim-(31-32)**
[**Araştırmacı:** "Hocam peki, STEM yaklaşımı hakkında ne düşünüyorsunuz?" sorusuna yanıt]
Sizinle ilk tanıştığımda bana şu cümleyi söylemiştiniz, o benim dikkatimi çekti. Köy enstitülerinin şeyi? Aslında benziyor. Köylerde, bu okullarda, bu ders planı işlenmeyecek mi? Elbet işlenecek. Burada bütün mesele öğretmenin yapıcılığı ve yaratıcılığında. Hadi tuttuk, tasarımla ilgili bir şey

yapmaya çalıştık, bunun adı da takı oldu diyelim. Yorgan ipliği var, hiçbir şey bulamazsan. Doğada öyle bitkiler var ki, mesela kuş yemleri. Bunları bir ipliğe bile dizsen, tasarım oluşturuyorsun. Ya da kuşburnu, onlar daha sert. Diz bunları bir ipliğe. Yaptığın bir kâğıdı arasına koy. Eskiden şeyler vardı, ne kâğıdı diyorlar? Kadınlar oya yapardı, alüminyum folyolu kâğıt. Onları yuvarlak yuvarlak buruşturup iğneden geçirirlerdi. Çemberlerinin kenarlarına tasarım yaparlardı. Çok da şık olurdu, işte sallanırdı bunlar küçük küçük, topuz. Hepsi bir arada olduğu zaman daha farklı bir görüntü oluştururdu. Yani atık malzeme.

[13] **S1-P1-SocialS-23 Ekim-(17-18)**

İlk etapta, konu belirlemeden konuşuldu. Ben işte, yıllık plana baktım ve bir konu şekillendirdim kafamda. Hani bunu da önceden bildiğim yöntemler ile şekillendirmeyi planlıyorum. Hani bir materyal tasarlatacaksam çocuklara, kimle çalışabilirim diye düşünürüm. Görsel hocamız olabilir veya işte müzik dersini katabiliriz diye düşündüm. Öğrencilere biraz da dersi sevdirmek adına. Sözel bir dersi, sıkıcı bir dersi eğlenceli anlatabilirsek, çocukların dikkatini çekebilirsek, ders o kadar verimli geçecektir diye düşünüyorum.

[14] **S1-P1-SocialS-23 Ekim-(32)**

Fen'i katabileceğimi hiç düşünmüyorum ama. Hele matematiği.

[15] **S1-P1-English1-23 Ekim-(62)**

[**Araştırmacı: "**Kendinizi hangi alana yakın görüyorsunuz hocam. Resim galiba bir tanesi, başka?" sorusuna yanıt]

Ben fikir üretmede çok iyi değilimdir, ama üretilen fikri yürürlüğe koymada çok iyiyimdir. Pratiğimdir o konuda, her türlü kesip biçmeye hazırımdır. Çizme işlerinde iyiyimdir.

[16] **S1-P1-English-23 Ekim-(30)**

5X sınıfı iyi bir sınıf, akademik olarak da iyi bir sınıf ve sınıf ortamı ders işlemeye çok müsait. Çocukların algısı açık. Birçok yeteneğe de hitap edebilirsiniz orada. Görsel, işitsel ve hareket ederek öğrenmeyi daha çok seviyorlar. Kalkmayı, yapmayı, dokunmayı. Her türlü şey uygulanabilir o sınıfta.

[17] **S1-P1-Science-31 Ekim-(45)**

Nasıllar? Şimdi şöyle, diğer hocalarıma da sorduysanız, şimdi üç tane 5. sınıfımız var ve en rahat ders işlenen, en uslu sınıfımız diyebilirim. Evet, mesela, 5. sınıfların hepsinde öyle, bir soru sorduğunuz zaman parmak kaldırmaları yetmiyor, artık sıranın üzerine tırmanıyorlar "öğretmenim, öğretmenim, öğretmenim", şeklinde. Sadece akademik anlamda karşılaştırmak doğru olur mu bilmiyorum ama verileni alıyorlar. Çok daha rahat ders işlenebilen bir sınıf. Sorgulayıcı bir sınıf. Mesela, ödev için can atıyorlar. Enteresan.

[18] **S1-P1-Art-23 Ekim-(57-58)**

Ama genelde seviyorlar yani, seviyorlar ki, benden tuval istiyorlar mesela. Öğle tatilinde, boş zamanlarda matematik çalışmaktan yorulduklarında veya matematik, fen, sosyal konularından sıkıldıkları zamanlarda, "gelin atölyeme ben oradayım" diyorum.

[19] **S1- Observe -18 kasım-(39)**

Özellikle hedef kitlenin ve onları anlamanın önemini "wallet design exercise" ile anlamış oldular. Çünkü ilk başta partnerlerini tanıdıklarını zannederek onlara tasarladıkları cüzdan ile görüşme yaptıktan sonra tasarladıkları cüzdan farklı oldu. Aslında kişiler hakkında ön yargıları ya da kesin fikirleri olabildiği ortaya çıktı.

[20] **S1-P2-25 kasım-(124-126)**

Fen bilgisi öğretmeni: Ben hedef kitle seçilmesi taraftarıyım.

Araştırmacı: Ben gruplandırma yaparken çok işinize yaradığını düşünüyorum.

Fen bilgisi öğretmeni: Evet, çünkü cüzdan tasarlarken partnerimizi tanımaya çalıştık. Ondan sonra onun isteklerine yönelik bir şey yapmaya çalıştık. Burada da güzel bir sonuç almak istiyorsak çocukları tanımalıyız. Yani genel hatlarıyla tanımalıyız ki ona göre çalışmamızın sonucunda da verim alabilelim ve %100 tasarlayabilelim.

[21] **S1-P2-25 kasım-(70-75)**

Fen bilgisi öğretmeni: Ben bir şey eklemek istiyorum. Tasarım odaklı düşünme. Verdiğiniz örnekte de bir fotoğraf göstermiştiniz. Biz direkt çözüme odaklanıyoruz.
Araştırmacı: Evet, basamak, basamak ilerledik.
Fen bilgisi öğretmeni: Aynen.
Araştırmacı: Mesela, ne düşünüyorsunuz bununla ilgili? Hani ihtiyaç analizi yaparak başladık aslında.
Fen bilgisi öğretmeni: Aynen. Biz farklı açılardan bakabilirmişiz aslında. Bizim yaptığımız genel anlamda, hayatımız için de düşünecek olursak, hep böyle sonuca odaklanmak.
Matematik öğretmeni: Hep bir noktaya bakıyoruz.
[22] **S1-P2-25 kasım-(135-140)**
[**Araştırmacı: "**Peki, sizce tasarım odaklı düşünme metodunun STEM'i öğretmeye katkısı oldu mu, sizin bu çalıştayı tamamlamanıza?" sorusuna yanıt]
Fen bilgisi öğretmeni: Evet.
Matematik öğretmeni: Evet, evet.
Herkes: Evet, evet.
Matematik öğretmeni: Yani en başta cüzdan tasarlanmasaydı, bence bu kadar da hızlı ilerleyemeyebilirdik.
Fen bilgisi öğretmeni: Aynen sonuçta.
[23] **S1-P2-25 kasım-(76-78)**
[**Araştırmacı:** "Peki, şey tasarım odaklı düşünme metodu diye bir şey öğrendiniz. Hatta aktivite tasarlarken bunun basamaklarını teker teker takip ettiniz. Bununla ilgili düşünceleriniz neler?" sorusuna yanıt]
Fen bilgisi öğretmeni: Burada, mesela, ne yaptık? İşte bir şey tasarlarken, cüzdan tasarlarken, basamaklarının olduğunu, bu basamakların bir sırasının olduğunu ve buna göre gidildiğinde, karşı tarafın da istediği ürünü çıkarabileceğimizi gördük. Bu çok da faydalı oldu. Tasarım odaklı düşünme bana bunu kazandırdı mesela. Yani bir şeyi düşünürken onun basamaklarını düşünmek.
Araştırmacı: Sistematik olarak…
Fen bilgisi öğretmeni: Evet, aynen, düşünmemiz gerektiğini kazandırdı.
[24] **S1-P2-25 kasım-(199-201)**
[**Araştırmacı: "**Peki bu ilkti gördünüz, ikinci aşamada yine bu şekilde mi ilerlerdiniz? Yoksa daha farklı mı olurdu? Aktivite tasarlama anlamında ilerlemeniz nasıl olurdu?" sorusuna yanıt]
Matematik öğretmeni: Aşama, aşama takip ederdik (herkes başıyla onayladı).
Fen bilgisi öğretmeni: Çünkü bu yol gösteriyor ve kolaylık sağlıyor.
Matematik öğretmeni: Bu yol bizi problem cümlesine daha kolay ulaştırdı. Bu yolu izlemesek belki daha düzgün bir problem cümlesi kuramazdık.
[25] **S1-P2-25 kasım-(84)**
Fen bilgisi öğretmeni: Ama hocalarımın da dediği gibi ezberci bir sistem olunca, birde zaman kısıtlı olunca, maalesef bunu yapamıyoruz. Bu anlamda sistematik bir şey olduğunu öğrendik. Gerçekten iyi oldu bizim için.
[26] **S1-P2-25 kasım-(87-94)**
[**Araştırmacı: "**Sunulan yöntemin sıralaması sizce nasıldı? Fazlalık ya da eksiklik var mıydı?" sorusuna yanıt]
Sosyal bilgiler öğretmeni: İlk başta çalıştaya başlamadan önce "cüzdan tasarlayacağız" dediniz. Ben hani dedim "Cin Ali" bile zor çizerim.
Araştırmacı: Ama gayet iyi iş çıkardınız.
Sosyal bilgiler öğretmeni: Sonra kendi tasarladığım cüzdanı görünce şaşırdım.
Araştırmacı: Çünkü direkt verileri aldınız ve verilere göre hareket ettiniz.
Sosyal bilgiler öğretmeni: Evet. Bu da aynı şekilde. Basamak, basamak ilerledi şu anda çalıştayımız.
Peki, doğru muydu bu şekilde ilerlemesi?
Herkes: Evet, evet.

[27] **S1-P2-25 kasım-(210, 213)**
Fen bilgisi öğretmeni: Yani şöyle, tasarımı sadece tasarımcıların yapmadığını burada uygulamalı olarak görmüş olduk.
[28] **S1-P2-25 kasım-(14, 16)**
Resim öğretmeni: Takım çalışmasının önemli olduğunu anladım. Yani disiplinlerarası takım çalışmasının önemli olduğunu anladım. Hatta ve hatta derse mümkün olduğunca fazla öğretmenin ve disiplinin bir arada girme gerekliliğini anladım. Hani, eskiden derse tek öğretmen girer iki öğretmen girmez gibi katı kurallar vardı. Bu program, bunun gerçekleşebilme ihtimalini arttırdı.
[29] **S1-P2-25 kasım-(180-186)**
[**Araştırmacı**: "Çalıştay sonrasında bir takım şeyleri daha farklı yapacağınızı düşünüyor musunuz? Kendi mesleğiniz açısından olabilir ya da başka açılardan olabilir." sorusuna yanıt]
Resim öğretmeni: Evet.
Fen bilgisi öğretmeni: Yani, tabii ki farklı bir bakış açısı oluştu bizde. Ders anlatım konusunda ne bileyim. Biz de disiplinlerarası şeyi öğrendik yani az çok.
Matematik öğretmeni: Mutlaka kazandık. Yani, sözlü olan bir şeyi uygulamaya geçirdik.
Sosyal bilgiler öğretmeni: Bu kadar birbirimizle hani koordineli olmasak bile sonuçta ortaokul seviyesindeki konulara hâkimiz, kendimiz de katabiliriz, diye düşünüyorum.
İngilizce öğretmeni: Ya da en azından gidip birbirimizden bu anlamda yardım isteyebiliriz. (**Fen bilgisi öğretmeni**: Aynen) Bende bu konu var ama hatırladığım kadarıyla sende de bu konu vardı ya da işte konuları nasıl entegre edebiliriz? Nasıl küçük te olsa bir aktivite tasarlarız? (herkes bu düşünceye onay verdi).
[30] **S1-P2-25 kasım-(79-81)**
Resim öğretmeni: Direkt malzemeyi uygulamadan önce, çizimler, karalamalar, eskizler yani beyin fırtınası yapmak. Zaten bu eğitimin temel şeyi, yani temeli bu, ama bunu keşke yapabilsek. Yeri geliyor yapıyoruz, yeri geliyor, en kestirme yoldan yapıyoruz, zamanı şey kullanma açısından, bana verilen bir süre var. Bu sürede, ben en seri şekilde şunu öğretirim. Orada da işte, öğretmenliğin cambazlıkları başlıyor.
Matematik öğretmeni: Aynen.
Resim öğretmeni: Öyle zaman, bütün mesele zaman.
[31] **S1-P2-25 kasım-(59-60)**
[**Araştırmacı:** "Peki şey, tasarım odaklı düşünme metodu diye bir şey öğrendiniz. Hatta aktivite tasarlarken bunun basamaklarını teker teker takip ettiniz. Bununla ilgili düşünceleriniz neler?" sorusuna yanıt]
Resim öğretmeni: Eğitimci olarak zaten tasarım […] Bence her eğitimcinin her şekilde tasarıma ihtiyacı var. Bu temel bir kere. Gerek düşünce olarak, gerek çizim olarak, gerek üç boyut olarak, gerek iki boyut olarak, hepsinde hemen hemen bütün öğretmen arkadaşlar bunu düşünür. Sizin tasarımcı olmanız bana artı değer kattı. Benim adıma, bana artı değer getirdi.
[32] **S1-P2-25 kasım-(83)**
Matematik öğretmeni: En büyük sıkıntımız, bir müfredatı kâtip gibi uygulamaya çalışmamız. Müfredat olmasa, tasarım odaklı daha çok düşünülebilir.
[33] **S1-P2-25 kasım-(82)**
İngilizce öğretmeni: Sistemden de biraz kaynaklı hani. Şimdi tasarım deyince yaratıcılık geliyor aklınıza. Biz biraz tabi eğitim sistemindeki bu hızdan dolayı, ezberci sistem olabiliyor. Ama keşke tasarım üzerine ders yapsak.
[34] **S1-P2-25 kasım-(45-48)**
Matematik öğretmeni: Benim vardı. Yani şöyle, siz şahsi olarak değil de. Hep eğitimci olarak, eğitim eğitimciler tarafından verilmiyor diye düşünürüm. Özellikle sürekli eğitim sistemlerimiz değişiyor ya. En başında bir eğitimci olması gerektiği taraftarıydım. Yani kafamda soru işareti vardı "Bir tasarımcı eğitim modelini nasıl uygulayabilir?" diye. Hani bir eğitim olmadan ya da böyle mi olması gerekiyor? Onları bilmeden şey yaptım, düşündüm.

Fen bilgisi öğretmeni: Tasarlamayı geçip bir de karşıdaki insanlara bunu vereceksiniz ve onlardan da bunu tasarlamasını isteyeceksiniz. Bu zor bir durum.
Matematik öğretmeni: Çünkü karşınızdaki tasarımcı değil. Evet, siz tasarımcısınız, eğitimci değilsiniz, ama biz de tasarımcı değiliz, eğitimciyiz. Hani sizin açınızdan da zorluk vardı.
[35] **S1-P2-25 kasım-(49-55)**
[Araştırmacı: Peki, sonuç olarak tasarımcı ile çalışmak hakkında ne düşünüyorsunuz?] diye soruldu.
Fen bilgisi öğretmeni: Ama gerekli olan bütün kaynakları da bize sağladığınız için.
Matematik öğretmeni: Yani siz bize her türlü kaynağı sağladığınız için gayet uyumlu ve verimli geçti.
İngilizce öğretmeni: Evet hazırdı her şey. Bir de, bize yeni bir şey öğrettiniz. Bir bakış açısı kazandırdınız.
Fen bilgisi öğretmeni: Aynen.
İngilizce öğretmeni: Bunun için illa öğretmen ya da yönetici olmaya da gerek olmadığını düşünüyorum ama.
Matematik öğretmeni: Yok, yok, evet.
[36] **S1-P2-25 kasım-(62-69)**
Resim öğretmeni: Artı bir değer getirdi. Ben hiç şeyi hissetmedim. Yani, işte, eğitim fakültesi çıkışlı falan.
Matematik öğretmeni: Yok, yok.
Resim öğretmeni: Ben normal bir öğretmen olarak görüyorum. Hala da öyle görüyorum.
Matematik öğretmeni: Yani sorduğumuz her sorunun cevabını çok kapsamlı aldık.
Resim öğretmeni: Çok rahat aldık.
Matematik öğretmeni: Belki karşımızda bir eğitimci olsa bunu alamazdık.
Resim öğretmeni: Bu kadar alamazdık. Evet, evet.
Matematik öğretmeni: Bu kadar alamazdık. Yani, hani, kıyaslamak için değil. Yapılış sisteminden bahsetmek istemiştim. Belki, eğitimci olsa, böyle net olmazdı.
[37] **S1-P2-25 kasım-(25-30)**
[**Araştırmacı:** "Peki bugüne kadar yaptığımız şeylerden farklı mıydı? Hem çalıştayın kendisi, hem de bu şekilde ders anlatmaya çalışacaksınız sonuçta." sorusuna yanıt]
Fen bilgisi öğretmeni: Tabii ki çok farklı. Yani mesela, hal değişimini ben geçen yıl da anlatıyordum çocuklara. Muhakkak ki hayattan örnekler veriyorsunuz ama.
Sosyal bilgiler öğretmeni: Uygulamakta…
Fen bilgisi öğretmeni: Hani mesela, hocamız müsait oldu, dersimize girdi. Birlikte örneklendirerek bu konuyu pekiştirmeye çalışmak, vs. Bunlar daha farklı şeyler.
Sosyal bilgiler öğretmeni: Bu kadar detaylı.
Fen bilgisi öğretmeni: Evet bu kadar detaylı yapmadım, ben şahsen yapmadım.
İngilizce öğretmeni: Bir de mesela şey, İngilizce derslerinde genelde kitaplarda hani farklı farklı konular var. Direkt ders olarak değil ama en azından, o konunun matematik ya da fen ile alakalı olduğu belli oluyor. Yalnız, yüzeysel geçiliyor. Yani, asıl anlatılmak istenen, öğretilmek istenen İngilizce konusuyken, konuyu yüzeysel geçiyorduk. Ama şimdi öğrenciler gibi biraz daha ne yaptığımızın farkında olacağız.
[38] **S1-P2-25 kasım-(84)**
Fen bilgisi öğretmeni: Bu yaptığımız çocukları düşünmeye, fikir üretmeye, bir şeyler üretmeye yönlendirecek.
[39] **S1-P2-25 kasım-(5)**
Fen bilgisi öğretmeni: Ama hocam aslında ben başta da söylemiştim, çocuğun sevdiği ders var ve sevmediği ders var. Sevmediği dersi bile bu şekilde verebiliriz. Ya da anladığı konu var, anlamadığı konu var. Anlamadığı bir konuyu bile başka sevdiği bir dersle geçirerek, anlamasına yardımcı olabileceğimizi düşünüyorum. Bu anlamda bence iyi olacak.
[40] **S1-P2-25 kasım-(31)**

Matematik öğretmeni: Soyut olarak diğer derslere uyguluyoruz, tabii ki etkileşimli anlatıyoruz. Matematik her derse uygulanıyor. Matematik problemlerini de günlük hayata uyguluyoruz, ama sadece soruda kalıyor. Ama böyle yaşayarak öğrenmeleri ile daha çok pekişiyor.

[41] **S1-P2-25 kasım-12, (18-19)**

[**Araştırmacı: "**Genel olarak ders bazında tasarladığınızda, bir de 5 disiplin birden tasarladığınız da neleri dikkate aldınız tasarımlarınızı yaparken, aktiviteleri tasarlarken?" sorusuna yanıt]

İngilizce öğretmeni: Uyumu dikkate aldık.

[42] **S1-P2-25 kasım-(20)**

İngilizce öğretmeni: Konulara hâkim olmak gerektiğini anladık. Diğer disiplinlerdeki konulara da en azından hâkim olmak. Bir şeyler bilmemiz gerekiyor diye düşünüyorum (**Resim öğretmeni:** Evet). Yani en azından konuya giriş yapmak adına.

[43] **S1-P3-ST-4 aralık-(5-8)**

Araştırmacı: Arkadaşlar bugün resimde matematik yaptınız. Bunun hakkında ne düşünüyorsunuz?

Çok sıkıcı.

Araştırmacı: Neden çok sıkıcı? Matematiği sevmiyor musunuz?

Öğretmenim sabahta 2 ders matematik yaptık.

[44] **S1-P3-ST-4 aralık-(12-17)**

Öğrenci G: Öğretmenim bence gayet güzeldi.

Araştırmacı: Neden güzeldi? Peki, resmin içinde matematik yok mu sizce?

Var (bazı öğrenciler).

Yok (bazı öğrenciler).

Ya şekiller var şekiller.

Hocam bizim sınıfta matematik öğretmeni 1 dakika da 10 soru çözdüğü için bütün sınıf matematikten bıktı.

[45] **S1-P3-ST-4 aralık-(21-23)**

Öğrenci G: Biz Türkçe dersinde matematik işliyorduk.

Araştırmacı: Nasıl işliyordunuz?

Öğrenci G: Yani bizimki tam olarak Türkçe dersinde matematik işleme değil, nasıl biliyor musunuz? Türkçeyi matematik öğretmeni kaldırıyordu, yerine direkt matematiği getiriyordu. Yani bildiğiniz matematik öğretmeni ders programını değiştiriyordu.

[46] **S1-P3- Math -11 aralık-(48)**

Matematik öğretmeni: Mesela, bugün Aydın öğretmen dedi ya turuncu ile boyayın. Turuncu yerine alternatif düşünemiyorlar. Mesela, hangi iki rengin karışımı turuncu olur, biliyorlar. Ama bunu pratiğe dökemiyorlar.

[47] **S1-P3- Math -11 aralık-(18-21)**

Matematik öğretmeni: Anlatamıyoruz. Son 15 gündür çocuklara, bütün 5. sınıflara, hayatın her alanında matematik olduğunu, her mesleğin içinde olduğunu anlatmaya çalışıyorum. Bazıları "Aaa, evet" diyor. Mesela, "Fibonachi Dizisi"nin ayçiçeğinin içinde olduğunu anlattım. Kimisi de bilmiyor, şaşkınlıkla bakıyor, ama hayatın her yerinde matematik olduğunu kavrayamıyorlar.

Araştırmacı: Meslekleri anlatmamız lazım. STEM de meslekleri anlatma var. Mesleklerde ne olduğunu bilmedikleri için, seçtikleri mesleklerde matematik olmayacağını sanıyorlar.

Matematik öğretmeni: Mesela, matematik olmayan bir meslek seçmek istiyor, ama her yerde var, balede bile var. Aslında meslekler bu dönem planlarımızda yetişmedi, ama 2. dönem mutlaka yapalım.

[48] **S1-P3-Art-11 aralık-(52-54)**

Resim öğretmeni: Yani, bak, hiç matematikle uzaktan yakından ilgisi olmayan çocuk bile orada üçte biri hissetti, tamı hissetti.

Araştırmacı: Yani bir farklılık yapamayan da gördünüz mü?

Resim öğretmeni: Tabii, ben farkındayım.

[49] **S1-P3- Math -11 aralık-(32-34)**

Matematik öğretmeni: Hani Öğrenci N başarılı ama çok çok başarılı değil. Öğrenci D ya da Öğrenci C ile aynı düzeyde değil. Ama onun kâğıdı da başarılıydı. Ya da çok daha başarılı olan öğrenciler resimde biraz dağınık ve daha farklı çalışmışlar. Ben onu gözlemledim.
Araştırmacı: Yani şaşırdıklarınız da oldu ama daha başarılı bulduklarınız da oldu.
Matematik öğretmeni: Evet, yani zaten başarılı olanlar beni şaşırtmadı, ama şaşırtanlar da oldu.
[50] **S1-P3- Art -11 aralık-(101)**
Valla sayın hocam, bunu kullanmak gerektiğini şey yaptım. Sadece "siz bugün buradasınız", işte "yarın yoksunuz", "siz yarın olmayacaksınız" diye şey yapmıyorum. Biz dedik ya başta, eskiden gelen bir eğitim sürecinde diğer zümre öğretmenleriyle işbirliği ister istemez oluyor hocam. Cumhuriyet Bayramı'nda sosyal bilgiler öğretmeniyle muhatap oluyorum, gerek sınıfta muhatap oluyorum, gerek koridorda, gerek atölyede. Veya 23 Nisan'da ilkokul öğretmenleriyle sahne düzenlemesinde, sahne tasarımlarının yapılmasında, konuların verilmesinde, özgün konuların çıkarılmasında muhatap oluyorum. Bu zaten var olan bir şey, eğitimin içinde var olan bir şey. Atmak yerine geliştirmek gerekir diye düşünüyorum.
[51] **S1-P3- English -21 aralık-(68)**
Yani farkındalar mı bilmiyorum ama belki bakış açısını değiştirmiş olabilir. Yani çocuklar mesela. Ben o derste onlara sadece "objeleri" verseydim -ki öyleydi konu- sadece o kitapla sınırlı kalsaydı mesela, sadece oradakileri öğrenip geçeceklerdi. Hani bunun nasıl başka dersle ya da nasıl başka bir kavramla bağlanabildiğini gördüler. Mesela, kesirler için, "ne alaka" oldu çocuklar. "Niye matematik öğretmeni geldi?". Sonra konunun sonunda bu ilişkiyi anladıkları için belki bakış açılarına değinmiş olabiliriz. "Evet, bu böyle oluyormuş, ne kadar da güzel oluyormuş" gibi düşünüyor olabilirler.
[52] **S1-P3- Math -21 aralık-(5)**
Benim açımdan çok güzel geçti. Hani Speaking ile. Hani matematik her şeye uyum sağlayan bir branş, ama İngilizce öğretmeninin yaptığı kek aktivitesi onlar için çok eğlenceli oldu. Güzel oldu, hani içinde kesirleri de verdi. Çocuklar artık her şeyin içinde matematik olmasına aşikârlar. Anladılar. Bugün ben ders işlerken, böyle normal konuşurken "Aaa dedi, matematiğin içine Türkçe girdi". Derslerin içinde onlar da artık ne yapıldığının farkındalar. Hani, ben gayri ihtiyari bir söz söyledim, biri "Aaa neden-sonuç ilişkisi, Türkçe' ye girdik" dedi.
[53] **S1-P3-Art-21 aralık-(43)**
Matematik, Matematik. Yani algılarında farklılık vardı. Yani hissedebildi çocuk şundaki, en köşedeki derinliği, sağ yüzü, sol yüzü, üstü. Direkt orada şeyi, şekli bizzat gördü, taşırmadan o bölümü boyadığında. Bunların da devamının olduğunu, orada kübik bir şeklin derinliği olduğunu hissetti. En azından hissettiler ki diğer parçaları -İngilizce dersi için şey yapıyorum- diğer parçaları da hiçbir zaman çoğu öğrencilerimiz orada yan yana asker bavulu gibi dizmediler. Arkasına koydular, önüne getirdiler. Bir daireyle bütünleştirilebilen bir kompozisyon oluşturdular. Orada ondan hareketle, ben onu yeri geldi bir çatı dekorasyonuna benzettim.
[54] **S1-P3- English -21 aralık-(29)**
Mesela, şekilleri kendileri istedikleri gibi yaptılar. En azından bir ölçü falan vermedik ya da "şöyle yapacaksınız" demedik. Ellerinde farklı tiplerde kekler vardı, o yüzden.
[55] **S1-P3- English -21 aralık-(9)**
Güzeldi, ders bayağı verimliydi ve dolu, dolu geçti. Şöyle söyleyeyim, planladığım gibi güzeldi, ben de zevk aldım. Çocukların da, sonradan işte dönüşlerini duydum. "Hocam başka yapmıyor muyuz, yine yapsak ya" falan dediler, sevdiler yani onlar da sevdiler.
[56] **S1-P3-Art-21 aralık-(86-91)**
Resim öğretmeni: Bu sefer daha isteklilerdi. Özellikle kek kesimlerinde ki o şekillerin yapılmasında ve şeylerin boyanmasında falan zaten ben onlara ton değerlerini veriyordum, şey yapıyordum. Bir resimde olmazsa olmaz, çizgi, leke, renktir. 3 tane üçgen düşünün: çizgi, leke, renk. Resim nedir? Eşittir çocuklar, "çizgidir, lekedir, renktir" derdim. Ve bunu hep vurgulamaya çalışırdım, şimdi daha kolay şey yaptılar. Bunu en azından ders içinde değil de koridorlarda

“öğretmen tonlama istiyor.” diye duydum. (**Araştırmacı:** Çocuklar kendi aralarında konuşurken), birbiriyle konuşurken bile böyle şeylere şahit oluyorum. Bu beni mutlu ediyor.
Araştırmacı: Bu derslerden sonra olan bir şey mi, yoksa daha mı önceden?
Resim öğretmeni: Bu dersten sonra o sınıfta duyduğum şeyler, evet, “öğretmen tonlama istiyor”.
Araştırmacı: Yani sizin daha önceki öğrettiğiniz bilgiler iyice hem o derste hem de o dersten sonra oturmuş durumda.
Resim öğretmeni: Evet, oturmuş durumda.
Araştırmacı: Buna o aktivitenin mi katkısı var?
Resim öğretmeni: O aktivitenin katkısı var. Bizzat matematik öğretmeninin, benim ve işte bir takım arkadaşlarla beraber, birlik içinde olmamızın şey yaptığı bir durum bu.
[57] **S1-P3- Math -21 aralık-(34-36)**
Matematik öğretmeni: Yani şöyle, yaptığımız işlere olan farkındalığımız arttı. Yaptığımız işleri daha anlamlandırdık. Yani şöyle, zaten hani yapıyorduk ama daha bilinçli yapıyoruz. Hani herkes dersini anlatırken zaten günlük olaylara iniyor ya da farklı branşlara değiniyordu. Şimdi yaparken farkına vararak yapıyoruz, yaparken konu seçimine dikkat ediyoruz. Biraz yaptığımız işin farkına vardık. Yani ben kendi adıma farkına vardım diyebilirim, hani anlamlaştırdım biraz.
Araştırmacı: Yani şey, konuları zaten bağlıyorduk, bu sefer daha bilinçli bir şekilde oldu.
Matematik öğretmeni: Daha bilinçli ya da ne yaptığımı bilerek. Bunu zaten fen’ e bağlıyorum ama artık yaparken fen’ e bağladığımın farkındayım. O an belki farkında olmadan bağlıyordum.
[58] **S1-P3-Art-07 ocak-(22-25, 26)**
Resim öğretmeni: Milli eğitim müfredatında diğer zümre öğretmenleriyle işbirliği…
Araştırmacı: İş birliği kısmı beraber derse girmeyi de kapsıyor muydu?
Resim öğretmeni: Kapsıyordu, yeri geliyordu kapsıyordu, tabii, tabii. He, bir sınıfa öğretmenler beraber girer mi? Girmemesi gerekir pratik de deniliyor, öğretmen sınıfta tektir. Niye efendim? Yani, biz bir takım şeyleri hep birlikte öğreneceğiz, herkes bir şeyi, her şeyi bilemez.
[59] **S1-P3- Math -21 aralık-(19)**
Matematik öğretmeni: Onun dışında, Speaking, Skills, Main course dersleri, bunlar öğrencilerin sevdiği dersler. Eğlenceli geçiyor bir Matematiğe, bir Türkçeye, bir Fen’e göre. Yani diğer dersleri bilmem ama matematiğe göre eğlenceli geçiyor. Matematiğin sıkıcı gelmesinin sebebi benim müfredatta eksik kalma durumumdan ötürüydü.
[60] **S1-P3- English -29 aralık-(28)**
Yani ben çok eğlendim, keyif aldım. Yani bu konuyu mesela düz bir şekilde anlatsaydım, böyle olmasaydı, bu kadar eğlenip bu kadar belki etkilenmeyebilirlerdi. Ama bu şekilde olduğu zaman, farklı bir bakış açısıyla, çocuklar da öyle bakıyorlar olaya.
[61] **S1-P3- SocialS-26 aralık-(6-8, 11, 13)**
[**Araştırmacı:** “Nasıl gözlemlediniz sınıfı?” sorusuna yanıt]
Sosyal bilgiler öğretmeni: Heyecanlılardı. Derse katılmayan öğrenciler bile katıldı.
Araştırmacı: Örneğin kimlerdi?
Sosyal bilgiler öğretmeni: Öğrenci F mesela, çok katılmazdı. Öğrenci F i gözlemledim. Yine Öğrenci L aktif olarak parmak kaldırmıyordu, ben sorunca cevap veriyordu. O da kendiliğinden yine parmak kaldırdı, katıldı.
[62] **S1-P3-ST-26 aralık-(43, 49-56, 58-60)**
[**Araştırmacı:** “Peki derste ne anlatıldı?” sorusuna yanıt]
Öğrenci X: Öğretmenim, doğal afetlerin tanımını okuduk. Sonra doğal afet’ li animasyon izledik, öğretmenlerimiz de birkaç hatırlatma yaptı bize, sonra bu etkinliği yaptık.
Kız öğrenci: Bir şeyi unuttun.
Araştırmacı: Bir şeyi unuttun bence de.
Kız öğrenci: Maddenin hal değişimini.
Araştırmacı: Aynen öyle, maddenin hallerini gördün. Maddenin halleriyle doğal afetler birbiriyle alakalı mı?
Birçok öğrenci: Evet, evet.

Araştırmacı: Ne açıdan alakalıymış?
Öğrenci H: Öğretmenim, ben söz almadım.
Araştırmacı: Sen söyle.
Öğrenci H: Mesela, karların erimesi yüzünden sel oluşuyormuş.

[63] **S1-P3- English -29 aralık-(24)**

Yani güzeldi, ben sevdim açıkçası, diyorum ya her derste aslında isterim biraz. Biraz, ucundan köşesinden başka derslere dokunsun. Sanki daha kalıcı oluyor gibi geliyor bana çocuklar açısından da.

[64] **S1-P3- Science-29 aralık-(48)**

Tabii ki yeni yeni öğrendiğim için alıştıkça, zaman geçtikçe insan derse girdiğinde, bu dersi böyle monoton anlatmak yerine "şöyle mi yapsam, böyle mi yapsam" diye düşünüyor. Tabii ki farklılıklar oluyor, STEM'i de kullandıktan sonra, gördükten sonra, e tabii ki daha farklı anlatmaya çalışıyor insan. İster istemez oraya kayıyor yani insanın aklı. Diğer branşlardan fikir alıyor, yapıyoruz yani, bunu kesinlikle yapıyoruz. Bize katkısı olmadı mı? Benim için kesinlikle katkısı oldu, farklı bir açıdan bakmayı öğrendim.

[65] **S1-P3- Science-29 aralık-(132)**

Şu an için yok. Yani kesinlikle düşünüyorum, yani şöyle bir müfredatı kontrol edip, yani neden yapılmasın ki? Güzel oluyor bence. Müsait olan iki öğretmen, üç öğretmen sınıfa girse, önceden hazırlansa ve konuları birleştirerek anlatsa, çok güzel olur yani. Ve ben müsait olduğum müddetçe, ben yapmak isterim bunu kesinlikle. Çünkü hem ders sıkıcı geçmiyor, çocuklara "motamot" ders anlatmak çok sıkıyor. Onlara böyle yapmaktansa, böyle aktivitelerle dersi işlemek, birkaç öğretmenle birlikte işlemek, çocukların da ilgisini daha çok çekiyor. Çünkü derse de çekiyorsunuz çocukları ve daha güzel olur diye düşünüyorum. Bunu da uygulamayı planlıyorum, istiyorum yani.

[66] **S1-P3- Science-29 aralık-(30)**

Mesela, bende şu oluştu, dersi anlatıyorum, örneğin kuvvet konusunu anlatıyorum. Dinamometrede hesaplamalar var, çocuklar bunları bilmeli. Mesela, kuvvet konusu da yapılabilirdi. Anlatırken şunu düşündüm. Dinamometre sorusu var, çözmeye çalışıyoruz. Çocuklardan hemen "yine matematik, öğretmenim" diye bir tepki geldi, kesirler girdi işin içerisine. İşlemin sonucu, oran orantı istemiş. Çocuklar da böyle olunca tabi ki ben bu dersin de matematikle birlikte anlatılabileceğini gördüm. Yani Filiz Hoca da girse o derse çok da faydalı olacaktı diye düşündüm. Yani artık bu açıdan bakmaya başladım, anlatabiliyor muyum?

[67] **S1- Observe-8 ocak-(10)**

Öğrenci A: Ben resim yapmak istiyorum ama Ahmet teacher resim yapıyor.

[68] **S1-P3-Art-08 ocak-(37-38)**

Aktiviteyle ilgili aklımda soru işareti var mı? Şey, daha fazla görev alsaydı diye düşünüyorum (**Araştırmacı:** Kim hocam?) Sosyal bilgiler öğretmeni […] Mesela, soruyorum, bu menderes midir? "Evet, hocam, menderestir" diyor. İşte nehir kenarlarına yerleşim yerlerinin yapılmaması gerektiği, tarım arazilerinin olması gerektiği, yeryüzü şekillerinin bozulmaması gerektiği noktasında sosyal bilgiler öğretmeni olarak daha fazla devreye girebilirdi. Mesela Emine Hanım, fen bilgisi olayında girdi biraz, şey yaptı.

[69] **S1-P3- SocialS-11 ocak-(158-159)**

[**Araştırmacı:** "Peki aktiviteleri hazırlarken İngilizce ve resim öğretmenine sizin katkınız nasıl oldu?" sorusuna yanıt]

Sosyal bilgiler öğretmeni: Resim öğretmeniyle çok sık görüştük nasıl yapılacağını. İngilizce öğretmeniyle çok görüşme fırsatımız olmadı, sadece işte ayaküstü 1-2 dakika nasıl işleyeceğini konuştuk. Onda kontrol İngilizce öğretmeninin elindeydi. Ama resim öğretmeni ile bağlantılı çalıştık, haberim vardı ne yapacağından.

[70] **S1-P3- SocialS-11 ocak-(100)**

Derslerdeki çocukların katılımına göre, istekli bir şekilde katıldılar, eğlendiler. İlgilendikleri an öğreniyorlar zaten.

[71] **S1-P3-Art-08 ocak-(14)**

Bugünkü aktivitede sizin de dikkatinizi çekmiştir ki, sessizce, "Bu alçıdır, işte bu donar, suyla birleşirse şöyle olur" dedik. Alçılarla biz de burada küçük bir örneğini yaşatalım dedik ve can kulağıyla dinlediler. Gayet sessizce de takip ettiler onun hamur kıvamına gelmesini.

[72] **S1-P3-Art-08 ocak-(88, 70)**

İdari kesimde, teorik dersler önemli dersler grubuna ve bu resim, müzik, beden eğitimi dersleri de ikinci plana atılan dersler anlamına geliyor, ama tekrar başta söyledim. En azından, ben şunu da anlamış durumdayım. Benim dersim bir İngilizce kadar etkili, bir matematik kadar etkili. Bir sosyal bilgiler kadar etkili olduğunu da, daha önceden de ufak şeylerle anlamıştım zaten. Bu kadar az saatim olmasına rağmen bu kadar işin içinde olmak demek benim var olmam demektir. Benim dersimin esas ders olması demektir. (**Araştırmacı:** Yani, merkezi ders olması). Yani matematik gibi, Türkçe gibi, sosyal bilgiler gibi, fizik gibi, kimya gibi...

[73] **S1-P3-Art-08 ocak-(66)**

Aslında resim […] Görsel sanatlar […] Şu çalıştayın başından beri hemen hemen her derse girdim, her etkinliğe katıldım ve her şeyde sizinle röportaj verdim. Ve burada ben sanatın ne derece engin bir şey olduğunun farkına vardım. Sanatsız olmuyor, tasarımsız olmuyor sonucuna vardım. Ben resim öğretmeniyim. Haftada bir saattir resim. Aksesuar derstir. Orada sınav yapılır. (**Araştırmacı:** Evet dersleriniz hep alınıyor.) Ama yeri ve zamanı gelince de hep resimden bir şeyler istenir. Yani yarışma olur başarı istenir, sosyal gün veya özel gün olur, resim öğretmeninden sahne tasarımı istenir, düzenleme istenir, süsleme istenir. Ama ya resim işte boş ver, matematik gibi yazılı okumuyorsun ya…

[74] **S1-P3- SocialS-11 ocak-(181-182)**

Toplumumuzda o derslere karşı zaten bir önyargı var, hobi olarak da görenler var, sınavlarda çıkmadığı için, hayatları boyunca işte karşılaşmayacakları için.

[75] **S1-P3- Science-15 ocak-(129)**

Tabii ki çocukların bağdaştırması çok daha kolay. Mesela sosyalle alakalı, yani çocuk karın oluşumunu biliyor, ama görseliyle görüyor. O kar oluştu, ama sonrasında ne oluyor? Onu sosyalde öğreniyor. Yani birbiriyle bağdaştırabilmesi aslında daha kolay olacaktır.

[76] **S1-P3- Science-15 ocak-(122-125)**

[**Araştırmacı:** "Peki hocam, görsel sanatlar, İngilizce ve sosyal bilgilere karşı sizin çalıştay öncesinde bakış açınız nasıldı?" sorusuna yanıt]

Fen bilgisi öğretmeni: Nasıl bağdaştırırım ki bilmiyorum, diyordum.

Araştırmacı: Peki, şu anda ne düşünüyorsunuz?

Fen bilgisi öğretmeni: Şimdi, daha fazla tabii ilgiliyim, yani ben de eğlendim. Atıyorum, bir görsel dersine girdik. Evet, biz bir-iki teorik bilgiyi belki şey yaptık, ama hocam yeni bir ürün ortaya çıkardı. Her şeyi görmelerini sağladı, yani elinden geldiğince. Bu onlar için ne kadar eğlenceli olduysa, bizim için de iyi oldu. "Demek ki bu böyle de yapılabiliyormuş" dedim.

[77] **S1-P3- SocialS-11 ocak-(186)**

Bu noktada, birleştiği zaman daha anlamlı oluyor, çocuklara katkı açısından daha anlamlı oluyor. Bu ders sizin dediğiniz gibi bütün derslerle birleştirilebilir bir ders, işte müfredatlarını belki milli eğitim, sosyale göre, fen'e göre ayarlayabilir.

[78] **S1-P3- English -21 aralık-(74)**

Şöyle ki, bir eğitimci olmakla beraber, bu işi de bilmek lazım, yani tasarımı da bilmek lazım. Her ne kadar, biz bir şeyleri, bildiğimizi aktarmaya çalışsak da, tasarım çok farklı bir durummuş. En azından işin içine girince biraz daha anlamış olduk.

[79] **S1-P3-Art-21 aralık-(148, 50)**

Hem de ne güzel oldu diyorum ya, bakın. Çok farklı şey üretmem gerektiğini, öğrenciye de verirken çok farklı şeyler üretmesi gerektiğini deklare etmeyi öğrendim. Tasarımın resim kadar, matematik kadar, İngilizce kadar önemli olduğunu, şey yaptım, orada hissettim. Tasarım, özellikle eğitimin son zamanlarda gelişen en önemli unsuru bence. Tasarım yıllar önce de vardı. Bir yüzeyde formu geliştirirken ya da uzayda formu yukarı doğru geliştirirken, şu binaları düşünün. Onların oluşumu bile bir tasarım ürünü. Yani bir binanın şekli bile bir tasarım ürünü. Yani tasarım olmadan, asla.

Yani son zamanlarda çok daha fazla kullanılması gereken bir öğe olarak şey yapıyorum. Çünkü tasarım estetik değerlerin ortaya çıkmasını, estetik değerlerin herkes tarafından hissedilmesini ve bir takım şekilsizlikleri ortadan kaldırır.

[80] **S1-P3-Art-21 aralık-(106)**
İlk tanıştığımızda, işte sizler birtakım malzemelerle şey yaptınız, keçeler verdiniz. Orada zaten adapte olmaya başladım olaya. Bunun bir üretim olabileceği, bununla işte çocuğa eğitim verilebileceği sonucuna vardım.

[81] **S1-P3-Art-21 aralık-(136)**
Evet, ben bir eğitimciyim ama burada kendimi bir öğrenci olarak düşündüm. Farklı ne yaparım? Yani farklı ne üretebilirim? Hücreden hareketle bir cüzdan tasarlamaya çalıştım.

[82] **S1-P3- Science-29 aralık-(64, 80)**
Tabii ki, öyle bir beyin fırtınası yaptım ki, yani şimdi her şeyi düşünüyor insan. Karşı tarafa nasıl sormalıyım, onu nasıl tanımalıyım? Yani nasıl soru sormam gerektiğini bile irdeledim. Anlatabiliyor muyum? Çok ince düşündüm, bu biraz beni zorladı ama gerçekten insanın zorlanması gerekiyor bence. Öyle yaptığınızda, hiçbir şey sormadan, karşıdaki insanı tanıyamıyorsunuz, zevklerini bilmiyorsunuz, hiçbir şeyini bilmiyorsunuz. Doğal olarak, kendinizce bir şey yapıyorsunuz. Ama tabii ki karşıdaki insanla konuştuktan sonra, tabii ki çok fazla eklemeler oldu, tasarım değişti.

[83] **S1-P3- SocialS-21 aralık-(11)**
Bunu o zaman da belirtmiştim zaten, cüzdan tasarlama bölümü ilginç gelmişti bana, karşımızdakinin isteklerine önem verme konusunda. Burada hani çocukların da ilgi alanlarını bir yerde tespit ettik.

[84] **S1-P3- English -21 aralık-(100)**
Diğer branşları da anlamaya çalıştım. Empati kurmaya çalıştık. En azından diğer branşları irdeledik yani hani işte arkadaş nasıl anlatıyor veya derste ne olması gerekiyor. Birbirimize fikir de verdik, "Bak bunu böyle yapsan daha iyi olur" gibi. Kimse alınganlık göstermedi bu anlamda. Yani bunları görmüş olduk.

[85] **S1-P3- Science-29 aralık-(54)**
Mesela, sosyalde. Yani özellikle konulara ilk baktığımızda bunu nasıl bağdaştırabiliriz ki diye çok düşündüm. Müfredatı, defteri çok karıştırdım ama daha sonrasında beş kişiyiz, siz de varsınız, gösteriyorsunuz, fikir veriyorsunuz, yol gösteriyorsunuz. Doğal olarak hangi açıdan bakmak gerektiğini fark ettim. O yüzden, şimdi bir ders anlatırken, burayı burayla da bağdaştırabiliriz diyebiliyorum artık.

[86] **S1-P3-Art-07 ocak-(52)**
Öğrenciye bir konu verirken ilk başta "tasarlayalım çocuklar, düşünelim çocuklar" ile giriyorum konuya mesela. Basit bir konuyu verirken, "ne düşüneceğiz" e getiriyorum. "Neyi tasarlayacağız, hangi malzemeleri kullanacağız" diye soruyorum. Bunları şey yapıyorum ben.

[87] **S1-P3- English -21 aralık-(76)**
Şimdi şöyle mesela, tasarım deyince benim aklıma bir kere beyin fırtınası geliyor. Yani tek başına tasarlamak biraz daha zor olabiliyor ya da bir araya geldiğimizde beyin fırtınasıyla daha güzel şeyler çıkabiliyor ortaya. Dolayısıyla bunu yönlendiren kişi de aslında tasarımcı oluyor yani…

[88] **S1-P3- SocialS-21 aralık-(96)**
Hem bütün branş öğretmenleri de bir aradayken daha kolay oldu. Tek başıma olsaydım bu kadar düşünemezdim detaylı.

[89] **S1-P3- Science-29 aralık-(106)**
İki kişinin fikriyle bir ürün ortaya çıkarmak başka bir şey, beş kişinin fikriyle bir ürün ortaya çıkarmak çok başka bir şey. Siz çok farklı bir açıdan bakıyorsunuz konuya, ben çok farklı bir açıdan bakıyorum. Bunlar birleştiğinde, çok değişik ve çok farklı bir ürün de ortaya çıkabilir. O yüzden bence tek grup olması çok daha iyi oldu. Çünkü takıldığımız yerde özellikle, -ben kendi adıma bunu söylüyorum- ilk defa böyle bir şeye katıldığım için, yani mesela İngilizce hocası kadar aktif olamadım. Ben bunu kendim de biliyorum.

[90] **S1-P3- SocialS-21 aralık-(97)**
Eee, disiplinleri birleştirme açısından kolaylaştırdı. Daha detaylı düşündük.
[91] **S1-P3- Science-29 aralık-(112)**
Fen bilgisi öğretmeni: Bence kolaylaştırdı, çünkü dediğim gibi sistematik çalışmak, yani basamak, basamak gitmek benim için özellikle çok iyi. O yüzden kolaylaştırdı, zorlaştırmadı.
[92] **S1-P3- SocialS-21 aralık-(181, 183)**
Yok, olmazdı herhalde. Çünkü ihtiyaç analizinden, hedef kitle belirlemeden haberimiz yoktu.
[93] **S1-P3- Science-29 aralık-(121-122)**
Genel anlamda bu yolu izlemeliyiz diye düşünüyorum şimdi. Öğrencilerimiz de yeni, biz de. Onları çok uzun bir süredir tanımıyoruz, en fazla dört aydır tanıyoruz. Doğal olarak şimdi daha uzun bir süre geçti, çocukları daha fazla gözlemleme şansımız oldu. Bir çalışma yaptık ve bunun bir sonucu olacak. Yani bunu göreceğiz. Ona göre tabii ki yine bu yollar izlenir, belki çok uzun sürmez.
[94] **S1-P3- SocialS-21 aralık-(56-57)**
Herkes kendi branşı için değerlendirdi. Bende iyi olan bir öğrenci İngilizcede kötüydü. Diyorum ya, tamamen burada zorlandık…
[95] **S1-P3- Science-29 aralık-(86)**
Yani Ahsen Hanım, aslında bu değişken biraz. Çocuklar zaten en büyük etken. Yani şimdi şöyle, o kadar değişkenler ki doğal olarak siz de doğru kararı veremiyorsunuz bir türlü. Yani kesin karar veremiyorsunuz. Şu şudur, bu budur diyemiyorsunuz öğrenciler hakkında. Doğal olarak öğrenci, hepsi de birbirinden o kadar farklı ki. Yani bizim bu grup oluşturmada zorlandığımız, en çok bizi zorlayan şey aslında bu oldu. Çünkü bir günü bir gününü tutmuyor, çocuk bunlar bir, ikincisi çok değişkenler, gerçekten çok değişkenler. O yüzden zorlandık. Ama tabii ki onlar da böyle bir çalışmanın içine girince bunu gördüler. O yüzden bence, ikinci dönem için soruyorsanız eğer, tabi ki daha kolay olacaktır diye düşünüyorum.
[96] **S1-P3-Math-15 ocak-(73-75)**
Matematik öğretmeni: Kafaları karışmış. Ortak aktivite sorularında çok iyi olan çocuklar da yapamadılar. O 150 metre-250 metre sorusunu birçoğu yapamadı.
Araştırmacı: Soruyu anlamadıklarını mı söylediler size?
Matematik öğretmeni: Ne yapacağımızı bilemedik, kafamız karıştı dediler. Ama o gün defalarca tekrarladığımı ben de hatırlıyorum, siz de anlattınız. Yani belki kâğıtta görünce yapamadılar.
[97] **S1-P3-Art-15 ocak-(31-35, 37)**
Resim öğretmeni: Soru bence ağırdı.
Araştırmacı: Beşinci sınıf için mi?
Resim öğretmeni: Beşinci sınıf için ağırdı.
Araştırmacı: Ne açıdan hocam?
Resim öğretmeni: Yani akademik açıdan sayın hocam. Yani orada daha kesirler verilmiş. Eee, ben bile soruyu hemen ilk hamlede şey yapamadım, algılayamadım ki çocuğa kesirler verilmiş dönem, dönem, işte hemen akabinde 9 Ocağa gelinmiş. Eee, böyle bir şey […] Daha yenilik olabilirdi sanki. Yenilik olsaydı hiç sorun olmazdı.
[98] **S1-P3- SocialS-11 ocak-(125-131)**
Sosyal bilgiler öğretmeni: Yani şu soru çok basit bir soru, karşılarına 1/5, 2/5 gibi kesirli bir biçimde verseydik, hepsi sadeleştirip genişleteceklerdi.
Araştırmacı: Yani, yine yoruma mı gelmiş oluyoruz?
Sosyal bilgiler öğretmeni: Evet, yine yoruma geliyoruz.
Araştırmacı: O zaman bizim tasarımımızda mı sorun?
Sosyal bilgiler öğretmeni: Sorun Türkçe' de herhalde.
Araştırmacı: Anlama bilgileri mi eksik?
Sosyal bilgiler öğretmeni: Evet.
[99] **S1-P3- Math-15 ocak-(12)**

Öğrenci X bireysel de ıhıh. Öğrenci F de böyle sessiz durur ama akademik olarak iyidir. Ama ilk bireysel sorular da saydığım öğrenciler de başarı yok, hiçbir şey yapamamışlar. Mesela, Öğrenci L diyoruz ya biraz gerisindedir sınıfın, hani benim dersimde 80-90' lık öğrencidir. Mesela o yapmış.

[100] **S1-P3- Science-15 ocak-(71)**

Matematikte bireyseldeki cevaplandıramamaları üzdü beni yani, çünkü çok çabaladık. Bilmedikleri şeyler de değil gerçekten, yani yapabilecekleri şeyler. Ama gerçekten de ilk deneyim olduğu için -çocuklar da böyle bir ortama ilk defa giriyorlar-, o yüzden de olabilir herhalde. Net olarak ikinci dönem herhalde ne kattığını göreceğiz diye düşünüyorum.

[101] **S1-P3-Art-15 ocak-(9-11)**

Resim öğretmeni: Şimdi açıklama, eee, biz bu renkler konusunu zaten derslerin içinde de işliyoruz, örneğin bir boyama yaptırırken işte "iki ana renk ile bir ara renk kullan" şeklinde devamlı ikazlarımız olur. Oradan gelen şeydir bu. İki ana renk, bir ara renk. Bunları devamlı tekrar ediyoruz. Tekrar etmemiz de gerekir. İşte o zaman sanıyorum o bölümleri çizmemiştik.

Araştırmacı: Evet siz çizmemizi istediniz, sonradan çizdik biz onları.

Resim öğretmeni: Onları sonradan kap şeklinde şey yaptık. Oradan bir şaşırma olur yani, yoksa başka türlü aynı şekilde yine "sağ yüzdeki ve sol yüzdeki yüzeyleri ana renklerle boyayın" deseydik boyarlardı. Ama bu sefer o kap derinlikleri, işte perspektifteki o şey çocuğu şaşırtıyor. Ve bu bir ders saatinde değil de birkaç ders saatinde düzelebilecek şeyler.

[102] **S1-P3- SocialS-11 ocak-(59-62)**

[**Araştırmacı:** "Aktivite bitiminde neler hissettiniz? Hatta siz iki soruyu birden gördünüz galiba." sorusuna yanıt]

Sosyal bilgiler öğretmeni: Renklerle ilgili tasarım konusunda resim öğretmeni' nin bayağı etkili bir çalışması oldu.

Araştırmacı: İkinci soruda ne gözlemlediniz?

Sosyal bilgiler öğretmeni: Ana renk, ara renk ayrımı yapamadılar. Bir de çocuklara göz attığımda, istenilen oranı da boyayamamışlardı (**Araştırmacı:** Kesirli ifadeleri?) Hı hı, kesirli ifadeleri. Neden yapamadılar? Onun endişesini taşıdım aslında.

[103] **S1-P3-Art-15 ocak-(12-15)**

[**Araştırmacı:** "Eee, o zaman sorun mu yaşadılar çocuklar hocam aktivitede?" sorusuna yanıt]

Resim öğretmeni: Yok sorun yaşamadılar.

Araştırmacı: Nasıldılar sonuç olarak?

Resim öğretmeni: Tabii, tabii, bir göz gezdirdim, yani uygun şeyleri de uygun, ufak tefek eksiklikler de var ama o zamanla düzelecek şeyler, birden düzelmez. Mesela, kaynaştırmalar, karıştırmalar, iki rengin işte şeyi. Çocuğa orada diyorum ya her defasında kolaya kaçıyor. Kırmızıyı boyuyor, sarıyı boyuyor, bu sefer turuncu yapıyor, turuncu yeri boyuyor, ben hâlbuki istiyorum ki orada iki rengi karıştırsın.

[104] **S1-P3- SocialS-11 ocak-(106)**

Arkadaşlarıyla çalışma konusunda iyilerdi, orada bir sıkıntı çıkmadı 9 Ocak ta ki için (**Araştırmacı:** Bekliyor muydunuz böyle bir şey?) Evet bekliyordum. Ama onda bir sorun çıkmadı, en azından Öğrenci B çok muhalefet olmadı.

[105] **S1-P3- Science-15 ocak-(38-39)**

Yani, Öğrenci X biraz dediğimiz gibi, hiç beklemediğimiz bir tepki verdi. Onun dışında çok eğlendiklerini gördüm. Yani bir şeylere çabaladıklarını gördüm. Yani mesela çizdiler, yazdılar. Ardından, "şunu da şöyle mi yapsak? Bunu da böyle mi yapsak?" diye konuştular.

[106] **S1-P3- Science-15 ocak-(61)**

Mesela, Öğrenci X çok şaşırttı beni, Öğrenci B çok şaşırttı. Bir de Öğrenci F çok şaşırttı beni. Çünkü Öğrenci F çok şeydir, böyle yani, çok sessiz, sakin bir çocuk. Çok naif, çok kibar bir çocuk. Çok böyle aktif değildir ama başarısız bir öğrenci de değildir. Onun mesela çabalaması çok hoşuma gitti. Çok çabaladı, yani grup arkadaşı onu çok zorlamasına rağmen, bir şeyler çıkarmaya çalıştı. O anlamda, yani Öğrenci F açısından çok şaşırdım. Öğrenci X [...] Öğrenci X' den çok farklı şeyler bekliyorduk. Çok aktif bir öğrenci çünkü çok da iyidir, başarılıdır. Ondan hiçbir şey çıkmaması çok enteresandı. Öğrenci B'nin hiç uyumsuz bir davranışının olmaması ayrıca bir enteresandı yani. Demek ki yani çok farklı olabiliyorlar grup çalışmasında. Yani böyle bir aktivite içerisinde olunca, normaldeki arkadaşlık seviyelerinden farklı olabildiklerini görmüş olduk burada.

[107] **S1-P3- Science-15 ocak-(62-63)**

[**Araştırmacı:** "O zaman sunumlarını ve grup çalışmalarını genel olarak değerlendirirsek?" sorusuna yanıt]

Fen bilgisi öğretmeni: Pozitif, aynen pozitif. Çok çabaladılar çünkü. Mesela, Öğrenci Z'yi çıkardık şey yapsın diye, hiç konuşmayı beceremeyen çocuk yani. Ama o bile yani ifade edebildi, yani bu güzel bir şey bence. Çocuklara bir şeyler katmışızdır diye düşünüyorum.

[108] **S1-P3- English -18 ocak-(122)**

Aslında az çok kendi performanslarını sergilediler. Ama açıkçası yaptıklarını böyle güzel sunacaklarını çok beklemiyordum. Çünkü baktığınız zaman hani çok basit şekilde hazırlanmış mekanizmaları, hayal ederek de çok güzel bir şekilde sundular.

[109] **S1-P3-Art-15 ocak-(7)**

Çocuklar bu araç gereçleri, bir nevi hazır malzeme de olsa, atık malzeme de olsa, birlikte değerlendirme fırsatını buldular. Eee sizin de getirmiş olduğunuz şeyler de gayet güzel ki, atık malzemeler ve hiç kullanılmayan malzemeler vardı içlerinde. Özellikle çocuklar renkli malzemelere oldukça ilgi duydular. Onları kullanmaya çalıştılar. Ve umduğumdan, o zaman da demiştim, umduğumdan daha farklı, gerek çizimlerde, gerek üç boyutlu şeylerde sınıf seviyelerine göre şeyler çıkardılar diyebilirim.

[110] **S1-P3-Art-15 ocak-(19)**

"Eee şu uzun kenar, bu kısa kenar, örneğin 10 cm işte 20 cm. Bunu malzemeye çizelim. Makasla tık tık tık keselim, üzerine koyalım ve yapıştıralım." Çocuk hemen yapışsın istiyor. Zaten o sınıftaki çocuk bunu isteyebilir. İşte hangi yapışkanla hangi malzeme daha iyi yapışır? Orada bakın şeylere giriyoruz… İşte bir takım kimyasal yapıştırıcılar var orada, o kimyasal yapıştırıcılar; uhu, pritt, katı yapıştırıcılar, sıvı yapıştırıcılar. Baz yapıştırıcılar bazı malzemeleri yapıştırmaz. Bunu da veriyoruz bakın. Hangi malzeme, hangi malzemeyle nasıl yapışır? Veya hangi malzeme bunu tutar? Yani bunları da dolayısıyla verdik ve daha da bilgi sahibi oldular.

[111] **S1-P3- Science-15 ocak-(39, 59)**

Malzemelere gidince hani farklı fikirlere, farklı yerlere de yöneldiler, gördüm yani. Yani, onları sürekli böyle arı gibi çalışırlarken görmek […] Onları öyle görmekten çok mutlu oldum açıkçası.

[112] **S1-P3- Science-15 ocak-(55-57)**

Fen bilgisi öğretmeni: Yani aslında şey, dediğim gibi istediğim cevabı almışım. Mesela, kendilerince o probleme buldukları çözümler bence güzeldi. Yani farklı şeyler çıkarmak, işte aman dondurma dökülmesin diye şuradan bir tutacak yapayım. Aman şurada erimeyen bir buz olsun vesaire güzel fikirleri vardı. Ben onlara süblimleşmede kuru buzdan bahsettim. Mesela, diyor ya işte "erimeyen buz, erimeyen buz!"

Araştırmacı: Yani kullanmışlar mı bilgilerini bir şekilde?

Fen bilgisi öğretmeni: Aslında evet kullanmışlar, tabii ki kullanmışlar. Bu hoşuma gitti, yani bu anlamda iyi bir sonuç aldım. Ben kendi alanım için iyi aldığımı düşünüyorum.

[113] **S1-P3- Science-15 ocak-(115)**

Ama MİS' in ne zaman olacağını bilmiyorduk biz de. Tam tarihini bilmiyorduk. Öyle bir zamana geldi ki bizim sınavlarımız başladı, MİS araya girdi. Sınavlarda normalde bir gün de ara veriyoruz; mesela biz pazartesi yapıyorsak, salı yapmıyoruz, çarşamba yapıyoruz, perşembe yapmıyoruz, cuma yapıyoruz. Çocuklar bir hafta boyunca her gün sınava girdiler MİS' den dolayı. (**Araştırmacı:** Üzerlerine de gelmiş gibi olduk). O yüzden de çok bunaldılar, yani terslik oldu.

[114] **S1-P3- Science-15 ocak-(121)**

Aslında çok eğlenceli geçti, çocuklar açısından da çok eğlenceliydi. Hocalarımız çok gayret ettiler zaten. Hani onun karşılığında o branşların ürünlerini almaları gerekiyordu ama olmadı. Gerçekten deminden beri konuştuğumuz gibi hani birçok etken vardı, mesela sınavların üst üste gelmesi, belki hazırlıksız olmaları, ilk defa böyle bir aktivitenin içinde olmaları. Bir başka deyişle, çocuklar bir aktiviteye gidecekler ama ne olacağını bilmiyorlardı, hazırlıksızlardı.

[115] **S1-P3- Math -15 ocak-(25)**

Ama aktivite öncesindeki sorular hoşlarına gitmemiş. Onun bana dönütünü verdiler. Aktivitede bir şeyler yapmak hoşlarına gitmiş, ama öncesinde soru çözmek hoşlarına gitmemiş.

[116] **S1-P3- Science-15 ocak-(19-20)**

Araştırmacı: Ben şimdi videolara tekrar bakmak istedim. Zaten dikkat ettiğim, bilişim sınavında 15 dakika boyunca çıtları bile çıkmadı. Pür dikkat yaptıklarından, aklıma gelen tek şey şu oldu, bizi kaale almadılar.

Matematik öğretmeni: Çünkü neden? Bana şeyi sormuşlardı, hocam karneyi etkilemeyecek değil mi? Ben de karne işin içine girince bazen panikliyorlar, stres yapıyorlar, yapamıyorlar diye hayır karneyi etkilemeyecek dedim. En azından şöyle diyelim ikinci dönem, ikinci veya üçüncü sözlü notlarınız bu aktivitedeki durumunuza göre verilecek.

[117] **S1-P3- English -18 ocak-(60-62)**

İngilizce öğretmeni: Ben de merak ettim çocukların fikrini ne düşünüyorsunuz diye, yarısı çok sevdik, bayıldık dedi. İşte yarısı, hocam sevmedik, hiç hoşlanmadık dedi. "Neden?" diye sorduğumda, işte "Vakit çok kısaydı." diyen çocuklar da oldu, işte, "Biz daha güzel şeyler yapardık." diyen de, "Daha mükemmel olabilirdi, ama yapamadık" diyenler de oldu. Ondan sevmedik dediler. Aslında sevmemek değil bence onların söylediği.

Araştırmacı: İyi işler ortaya çıkartamamak?

İngilizce öğretmeni: Aynen, hani onları da tatmin mi etmedi bilmiyorum. Öyle düşünüyorlar ama bence güzeldi. Genel olarak güzeldi.

[118] **S1-P3- English -18 ocak-(92)**

Ama onlar benim dersimi nasıl görüyor ya da görsel sanatları nasıl görüyorlar? Görsel sanatlar dersi aslında, şöyle tabii ki olması gerektiğini düşünüyorlardır ama çok sıkıştıkları anlarda mesela etüttür, o tarz şeylerde görsel sanatlara yönelebiliyorlar. Yapmamamız gerekiyor aslında ama inanın bizim çok karışık bir veli potansiyelimiz var. O kadar karışık düşüncelere sahipler ki, yani kimisi diyor ki, işte çocuğum mutlu olsun, kimisi diyor ki çok başarılı olsun, en başarılısı benim çocuğum olsun. İşte kimisi diyor ki, meslek sahibi ya da öğretmen olsun ya da ne bileyim işte ortalama bir hayat standardına sahip olsun diyen de var. Ya böyle konuyla alakası hiç olmazken, gelip bize burada işimizi öğretmeye çalışanlar da var. Dolayısıyla hani hepsine hitap etmemiz gerekiyor, herkesi memnun etmemiz gerekiyor.

[119] **S1-P3- English -18 ocak-(48-50)**

İngilizce öğretmeni: Tabii bir de ailelerin de böyle bir durumu söz konusu. 5/B ve 5/C bu durumu kabul etmediler. Yani, veli bakış açısı genel olarak okulda şu, çocukların böyle sosyal faaliyetlerde bulunmasını istiyorlar fakat her zaman da akademik başarı odaklılar. Yani çocuk testten yüksek not alsın, denemelerden iyi şey çıkarsın, işte atıyorum yarın lise sınavlarında iyi bir yere yerleşsin, istedikleri aslında bu. Ama bir yandan çocuğun sosyalleşmesini de istiyorlar. Yalnız, o noktada eğer akademik başarısından çalıyorsak diye düşünüyorlar. Ama aslında öyle bir şey yok. Bence de yok, ama o şekilde düşünürlerse eğer, o zaman hiçbir anlamı yok onlar için sosyal faaliyetin, sportif faaliyetin.

Araştırmacı: Bu sosyal faaliyet gibi mi gözüktü sizce orada?

İngilizce öğretmeni: Hayır hayır, demek istediğim şu: yani diğerleri STEM aktivitesini böyle sosyal faaliyet olarak değil de hani dersin dışında bir etkinlik olarak algıladıkları için sadece 5/X sınıfında bir ortak kararı yakalamış olduk.

[120] **S1-P3- English -18 ocak-(46)**

Yani şöyle bir durum var, bence çocukların bu durum hoşlarına gitti. Ama hani bu bir algı meselesi. Hani çocuklar şöyle algılasalar, bizim derslerimiz böyle işleniyor, hani, okuldaki teknik bu diye düşünseler ya da öyle kabul etseler, eminim daha farklı yaklaşırlardı. Ama bunun geçici bir süreç olduğunun galiba farkındalardı. Ya da hani biz mi belki o mesajı verdik, bilmiyorum. Ondan dolayı…

[121] **S1-P3- English -18 ocak-(50)**
Şimdi 5/A sınıfında da bu aktivite, STEM aktivitesi dedik ya, bence böyle algıladı çocuklar. Yani bu bir aktivite, geçici bir durum da söz konusu. Bir de kesinlikle yanlış anlamayın, sizin olmanız, mesela dışarıdan bir öğretmenin olması da bu algıyı yaratmış olabilir. Dediğim gibi, okulda bu program uygulanıyor olsa, öğretmenler tarafından yapılıyor olsa, belki çocuklar bunu kabul edebilirlerdi. Onlar da geçici gözle bakıyorlar bence.

[122] **S1-P3- English -18 ocak-(24-26)**
İngilizce öğretmeni: Ya bence onu çocuklar biraz sunum diye dinlediler diye düşünüyorum. Hani ders ile ilgili ya da kitapta da bizim yoktu ya.
Araştırmacı: Yok muydu?
İngilizce öğretmeni: Hayır, ekstradan eklemeler yapacağım diye demiştim ya size. Ekstradan ekleme yapıp diğer derslere de uyarlamaya çalıştığım için çocuklar biraz bence böyle, eğlence açısından evet güzeldi ama ders olarak çok görmediler galiba. Ya da ders olarak görmediler mi demek lazım ya da çok daha fazla sunum olarak mı hissettiler?

[123] **S1-P3- English -18 ocak-(90)**
Kendi düşüncemi söyleyeyim, yani okulda ve çocuklar adına da İngilizce ve görsel sanatlar rahatlatıcı bir ders açıkçası. Onlara sorsanız eminim onlar da aynı şeyi söyleyecektir. Sadece kendim için söylemiyorum, Main Course dersi ve diğerleri de. Çocuklar seviyorlar, hani biz girdiğimiz zaman derse mutlu oluyorlar. Tabii sınav stresi elbette yaşıyorlar, bizde de var. Ama yine de her iki grupta da benim dersim ve görsel sanatlar sevdikleri bir ders ve rahatladıkları bir ders. Diğer branşlar daha tabii ki hani akademik başarı gerektiren ya da atıyorum her çocuğun gerçekten ortak olarak sevdiği dersler olmayabiliyor. Yani bir çocuk matematiğe ilgi duyarken diğer çocuk onu hiç sevmeyebiliyor ya da fen dersine daha fazla ilgi duyabiliyor. İngilizcede bunu genelde yaşamıyoruz. Çok tek tük, nadir durumlar, o da çocuk daha eksik bir alt yapıyla geldiyse…

[124] **S1-P3- English -18 ocak-(98)**
Mesela, bir gün derse girdiğimde çocuklar bana dersimiz gitti dediler. Hep bu cümleyi tekrar ettiler. Hani hep bir ikna etme peşindeydim. “Bizim ünitelerimiz bitti, şu an planladığımı yaptım, bitirdim. Bakın 12 tane ünitemiz var, 6 tanesi bitti. Atladığımız sayfa var mı? Yok. Atladığımız bir konu var mı? Yok. Ekstradan konu işledik mi? Hani o şekiller vardı ekstradan, ben size bilgi verdim mi? verdim. Başka bir şey işledik mi? Evet. Yani buna da zamanımız var!”

[125] **S1-P3- Science-15 ocak-(91, 93)**
Yani baktığımız zaman çocuklar aktivitenin içinde çok daha aktiflerdi. Çok daha mutlulardı. Çok daha iyi çalıştılar ve bir ürün çıkardılar. Eee soruya boğmaktan ziyade daha böyle aktivite odaklı ve bir ürün çıkarma odaklı gidersek bence daha iyi olacaktır diye düşünüyorum. Yani tamamen aktivite yaptırma daha şey geliyor, yani daha böyle aktif oluyorlar. Belki daha öncesinde bunun teoriğini de vermek lazım bu çocuklara, bir şeyleri bağdaştırabilmesi lazım ki bir ürün ortaya çıkarabilsin, bir problem verdiğimizde çözüme ulaştırabilsin. Şimdi şöyle genel olarak baktığımızda, derslere sürekli olarak girilmesinden çok sıkıldılar. Aynı şeyi tekrar yaparsak bu sefer ters tepecektir. Önüne de geçebileceğimizi zannetmiyorum çünkü çok fazla tepki veriyorlar.

[126] **S1-P3- Math -15 ocak-(51-55)**
Matematik öğretmeni: […] Soru hazırlarsak daha çok böyle bir şeyleri hazırlarken cevap verecekleri sorular tarzında olur.
Araştırmacı: Yani, hem kendi el becerilerini de kullansınlar, hem de aynı zamanda bir şeyler üretsinler.
Matematik öğretmeni: Üretsinler gibi olsun
Araştırmacı: Daha katılımcı olur.
Matematik öğretmeni: Daha katılımcı olur, daha hoşlarına gider. Sıkılmadan yaparlar.

[127] **S1-P3- Math -15 ocak-(31, 38-41, 43)**
Matematik öğretmeni: Belki 2. dönem aktiviteyi bu kadar dönem sonuna bırakmasak mı diye düşündüm.
Araştırmacı: O zaman önerilerinizi alayım ben.

Matematik öğretmeni: Bu kadar sona bırakmama taraftarıyım ben. Evet, ilk dönem benden kaynaklı çok büyük problem oldu.
Araştırmacı: Sadece sizden değil, genel olarak sonuçta herkesin yetiştirme…
Matematik öğretmeni: Genel olarak vardı ama en büyük problem benden kaynaklıydı. Çünkü ben yeni katıldım. Ben katıldım STEM başladı. Ve müfredatta bir buçuk aylık boşlukları vardı. Ben daha yeni, yeni başladım. Ve bir tek bu hafta ders işlemiyorum, hani test çözdürüyorum. Hani 2. dönem konu eksiğim yok. Hani 3. sınavlardan belki önce yaparsak, hani motivasyon açısından iyi olur.

[128] **S1-P3- Math -15 ocak-(139)**
Endüstri 4.0 devriminden bahsediyoruz ve unutulmaya yüz tutmuş bir çok meslek canlanacak ve yeni bilmediğimiz birçok meslek gelecek. Bizim öğretmenler olarak en büyük önerimiz çocukları mesleklere teşvik etmek; hani ilgi alanlarını ortaya çıkarmak. STEM' in de bir parçası ya, ben meslek tanıtımını 2. dönem yapmak istiyorum.

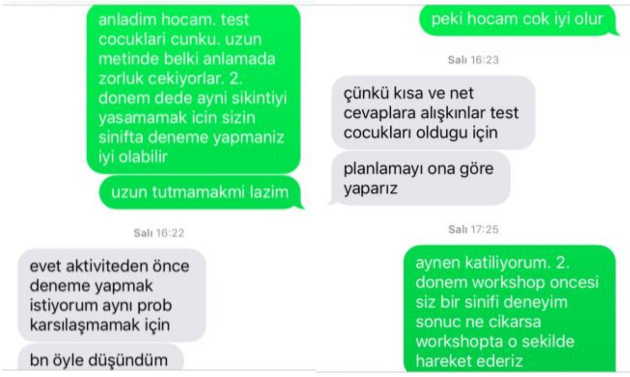
[129] **S1-P3- English -18 ocak-(82)**
Diğer branşlarla ilgili ne düşünüyorum, yani diğer branşlarda daha sadeleştirmek mantıklı bence de hocam. Siz de aynı şekilde düşünüyorsunuz ama daha düzenli, daha sade. Yani başından sonunu tahmin ederek, ya da çıkacak olan şeyi tahmin ederek daha sadeleştirerek yapmak önemli.

[130] **S1-P3- English -18 ocak-(51-52)**
Araştırmacı: Ben derslere girmesem sizce değişir miydi algıları?
İngilizce öğretmeni: Olabilirdi aslında, ama bunu bilemezdik yani başında. Elbette çalışma bittikten sonra bunu ancak algılayabiliriz. Ya belki olabilir, yani ama çocuklar şu an STEM olarak bildikleri için belki hiç adını anmamak lazım bir daha ki dönem. Çaktırmamak lazım.

[131] **S1-P3- Science-15 ocak-(97-101)**
Fen bilgisi öğretmeni: Siz yine derslere yine girecek misiniz?
Araştırmacı: Aktivite için gireceğim.
Fen bilgisi öğretmeni: Hayır, şey için. Mesela, derslerimize giriyordunuz, dinliyordunuz, fotoğraf çekiyordunuz, vesaire…
Araştırmacı: Disiplinlerarası bir ders planlayacaksanız gireceğim, planlamayacaksınız girmeyeceğim.
Fen bilgisi öğretmeni: Yani bence bunu böyle yapmayalım, çünkü dediğim gibi çocuklar bu anlamda çok tepki veriyorlar. Eee, aktivite için tabii ki de geleceksiniz, tabii ki de burada olacaksınız. Ama iki hoca, üç hoca bir araya gelerek ders yapmayalım. Çünkü ters tepiyor. Onun dışında tabii ki de biz derste hocalarımızla bir arada olalım, yani iletişim halinde olalım. Ama siz bulunduğunuz zaman çok daha farklı bir tepki alıyoruz biz sınıftan. O yüzden bence yapmamak daha mantıklı görünüyor.

[132] **S1-P3- Math -15 ocak-(106-109)**
[**Araştırmacı: "**Peki ne yapılabilir 2. dönem?" sorusuna yanıt]
Matematik öğretmeni: Mesela, çocukların not korkusu da çok fazla var.
Araştırmacı: Ne yapılabilir sizce?
Matematik öğretmeni: Sordular "Hocam karnemize geçecek mi?" diye. Ben panik olmasınlar diye karnenize geçmeyecek dedim. Belki 2. dönem sözlü notlarınızı etkileyecek diyebiliriz. "Bir sözlü notunuz bundan" diyebiliriz.

[133] **S1-P3- Math -15 ocak-(122-125)**
[**Araştırmacı: "**Bireysel mi hocam, grup mu yapalım 2. dönem." sorusuna yanıt]
Matematik öğretmeni: Bence grup yapalım. Bireysel yapmayalım. Çünkü bireysel de çok büyük başarısızlık ortaya çıkıyor. Ben bireysel soruları göze alarak söylüyorum. Ortak olunca hem akran anlaşması olur…
Araştırmacı: Öğrenmesi olur.
Matematik öğretmeni: Hem de ortak da olur. Hem de ortak bir şeyleri yapmak daha büyük erdem. Ben ortak taraftarıyım.

[134] 

[135] **S1-P3-Art-15 ocak-(79)**
Aktivite devam eder. İşte aynı sınıf, ikinci dönem de, başka bir konuda [...] Çünkü daha zamanla oturacak şey sayın hocam. Yani biz birtakım şeylerle girdik, hadi oturmadı deyip mücadeleyi bırakmak olmaz. Yani zaman meselesi bu. Resim de zaman, sosyal de zaman, İngilizce de zaman, müzik de zaman, hep bunlar zaman meselesi.

[136] **S1-P3- English -18 ocak-(44)**
Ben daha çok, bütün bu yaptıklarımızın değerlendirmesi gibi düşünüyorum. Öyledir herhalde diye düşünüyorum. Çünkü en başından beri öğrettiğimiz bütün konuları bir bütün halinde gördük. Soru sorduk çocuklara. İşte belli bir doküman istedik. Kendi öğrendiklerini de beyin fırtınası yaparak bir araya getirmelerini istedik tabii ki. Benim adıma hani başından beri güzel bir aktiviteydi. Yani nasıl diyeyim, uygulanabilirliği olabilen bir şey hani ama zaman. Ben bunun için özel bir departman olması gerektiğini düşünüyorum, mesela, bize bir oda verilse ve bu öğretmenler bir araya gelip belli saatler, belli boş saatlerde, ortak saatlerde, ortak çalışmalar yapsak, daha etkili bir performans sergileyebiliriz açıkçası. Ama böyle aralarda derelerde, işte sizinle iletişim kopukluğuyla, bence yine en iyisiydi. İmkânsızın en iyisiydi diye düşünüyorum. Hani kötü değil düşüncem, kesinlikle olumsuz düşünmüyorum.

[137] **S1-P3- Math -15 ocak-(211)**
Hani şöyle, hani sizin elinizde olan bilgiler elimde olursa “Evet”. Ama tek başıma her şeyi yeniden hazırlayamam, tek başıma olmaz, belki de şöyle, nasıl diyeyim? Hani sizin vardı ya, bize tanıttığınız bilgiler olursa, o bilgilerden yola çıkarak, belki birinin yardımıyla yapabilirim.

[138] **S1-P3- Science-15 ocak-(67-69)**
Fen bilgisi öğretmeni: Kesinlikle resim öğretmenine bu anlamda katılabileceğimi düşünmüyordum ama katılıyorum. Çok fevri bir adam kendisi. (Gülüşmeler…)
Araştırmacı: Sonuçta siz de birbirinizi tanımış oldunuz aslında.
Fen bilgisi öğretmeni: Evet, evet, öyle, çünkü mesela selamlaşıyoruz koridorda, belki yemekte selamlaşıyoruz. Onun dışında, böyle aynı aktivite içerisinde bulunma şansımız olmuyor hiç okulda. Herkesin kendine göre dersi var yani. Ders saatleri birbiriyle çakışmıyor, çakışsa, ben resim öğretmeniyle belki. Şimdi biraz da asabi bir adamcağız yani, ama çok da iyidir kendisi. En azından, bir arada nasıl çalışılabileceğini de görmüş olduk, onunla da. Yani bizde, öğretmenler açısından bir farklılık, bir değişiklik oldu yani.

[139] **S1-P3- Math -15 ocak-(143)**
Görsel sanatları matematikle ben çok bağlayamam diyordum. Hani görsel sanatlar için, tabii bana katkısı olmuş oldu. Hani en azından daha farklı düşünme, hani bir düşünce baloncuğu daha çıkmış oldu kafamda.

[140] **S1-P3- Science-15 ocak-(127)**
Tabii ki, mesela, biz bir kuvveti anlatırken, ben bunun içerisinde bir matematik olduğunu biliyordum, ama bunu matematikle birlikte anlatabileceğimizi hiç düşünmüyordum açıkçası. Şu anda öyle değil ama şu anda daha farklı. Şöyle bir örnek vereyim size, altıncı sınıflarda şey var sürat

konusu var. Sürat konusu tamamen matematik aslında ve öğrenciler anlamıyorlar. Kendi öğretmeni anlatıyor, anlamıyor. Matematik öğretmeninden gidip danışma istiyor bu çocuk. “Öğretmenim, yani bu matematik gibi bir şey değil mi zaten?” diyor. “Fen görüyoruz ama ne olur bana danışma verin de bunu anlatın” diyor. Anlatabiliyor muyum? Yani bu özellikle anlaşılması zor ağır konular için, özellikle birkaç branş mesela bu şekilde bağlanabilir. Konuyla ilgili bağlantılı branşlarla bir araya gelerek, daha verimli anlatılabileceğini düşünüyorum artık.

[141] **S1-P3- Math -15 ocak-(147)**

Yani şöyle, zaten farkında olmadan derslerde STEM yapıyorduk. Hani STEM olarak çok büyük bir farkındalığım artmadı. Sadece müfredatı uydurabilmede, hani müfredata göre gitmede bir farkındalık arttı. Zaten derslerimizi anlatırken, hani zaten hepsi iç içe giriyor. Hani en azından bu STEM aktivitesi, müfredatta şu konuları bağlayabiliriz aklımıza gelir. Onu bilmiş olduk.

[142] **S1-P3- SocialS-11 ocak-(146)**

İlk başta yapılabilirliğini çok düşünmüyordum ders birleştirmenin, ama yapılabilirliğini gördüm, olabileceğini gördüm. Kullanmayı düşünüyorum, kendi derslerimde de bağlantı kurmayı düşünüyorum, ama dediğim gibi İngilizce olmasa da en yakın fen ile…

[143] **S1-P3- Science-15 ocak-(117)**

Daha sonrasında ne gördüm biliyor musunuz? Herhangi bir konuyu anlatırken bile çocukların hemen dikkatini çekiyor. “Aaa burada matematik var.” “Aaa şunu sosyalde de görmüştük.” gibi mesela. Artık ilgilerini çekiyor, farkındalar.

[144] **S1-P3- Math -15 ocak-(161)**

Yani mesela, İngilizce dersine girip kek’ in üzerinden kesirleri öğretmem, onların aktivite yapması hani İngilizce ve matematiği birleştirmek açısından faydalı oldu. Zaten fen ve sosyalde çalışma kâğıdı dağıttık. Görsel sanatlarda da, hani kesirleri, perspektifle bağlamamız da güzel oldu. Hani, en azından çocuklar her yerde matematiğin olmuş olduğunu gördü. Aslında her dersin içinde de biraz matematiğin olmuş olduğunu görmüş oldu.

[145] **S1-P4-18 ocak-(315)**

Öğrenci E: Eee, ben STEM’i çok da sevmedim ama şu yönden de sevdim. […] Mesela, normal bir ders olsa ders işliyoruz ama burada böyle daha eğlenceli. (**Öğrenci D**: Kafasını sallar ve “Aktiviteler var” der). Yani şöyle, aktivite olunca böyle çok yoğun olmuyor dersler. Biraz daha eğlenceli.

[146] **S1-P4-18 ocak-(324)**

Öğrenci F: Biraz eğlenceliydi geçen hafta yaptığımız etkinlik. Ama ondan sonra ben bazı dersleri farklı yapınca, karıştırıyorum.

[147] **S1-P4-18 ocak-(34-36)**

Öğrenci A: Eee, İngilizce’ de değil de, daha çok hep Speaking dersinde yaptığımız için…

Araştırmacı: Speaking dersinde olması mı seni rahatsız etti?

Öğrenci A: Hmm, zaten haftada sadece iki dersimiz var. Onlar da gitti.

[148] **S1-P4-18 ocak-(45-46, 48-51)**

Öğrenci C: Güzel ama matematiğin her derste olması beni sıkıyor. Çok hoşlandığım bir ders değil ama işlemeyi de seviyorum. Matematik her derste olunca benim de canımı sıkıyor.

Araştırmacı: Bu durum bu sene mi oldu? Hani hocalarınız çok değişmiş sizin arka arkaya. Bir de sıkışmışsınız galiba müfredatta (**Öğrenci C:** Kafa sallar. **Öğrenci A:** “Evet” der). Bu sene mi böyle sıkıldınız?

Öğrenci A: Mesela, bu sene şöyle bir şey oldu. -Bir dakika!- Sadık Hoca gitti, Tuğba Hoca geldi. Tuğba Hoca gitti, öğretmenimiz geldi.

Araştırmacı: Öyle mi? Arada başka hocalar da geldi yani?

Öğrenci A: Zaten okulda 5 tane öğretmen var, 4 tanesini biz kullanıyoruz. O kadar yani.

[149] **S1-P4-18 ocak-(257-268)**

[Araştırmacı: “Yani şey, matematik her şeyin içinde var. Fen ve diğerleri için ne düşünüyordunuz? Örneğin, görsel sanatlarda, matematikte, fende, sosyal bilgilerde var mıydı?” sorusuna yanıt]

Öğrenci G: Bence vardı.

Öğrenci E: Aslında fende çok şey var.
Araştırmacı: Var derken bunu şimdi mi düşündün yoksa daha önceden de düşünüyor muydun?
Öğrenci E: Daha önceden düşünüyordum.
Öğrenci C: Fen ve matematiği düşünüyordum. Fen ve matematiğin öyle olduğunu düşünüyordum, ama öbür derslerin o kadar bağlantılı olduğunu düşünmemiştim.
Öğrenci E: Fen ve matematik sadece.
Öğrenci A: Ama bir şey var. Fen ve sosyal vardı. Yani sosyaldeki şeyler, dağlar, ovalar, işte deprem falan onlar fene gidiyor. Fende işlem yapıyoruz ve matematiğe gidiyoruz.
Araştırmacı: Tamam, bu şimdi anladığın bir şey mi?
Öğrenci A: Evet.
Araştırmacı: Daha önceden böyle düşünüyor muydun?
Öğrenci A: Yok.
[150] **S1-P4-18 ocak-(68-72)**
[**Araştırmacı:** "Dersler olmasaydı siz geçen haftaki aktiviteyi yapabilir miydiniz?" sorusuna yanıt]
Öğrenci A: Fen işlemedik ne yapacağız? (Diğerleri de onaylamak için başlarını sallarlar).
Araştırmacı: Hayır, hayır. Hani hiç dersleri yapmasaydık, önünüze de malzemeleri koysaydım sonra da hoca böyle sorsaydı, yapabilir miydiniz?
Herkes: Hayır, hayır.
Öğrenci D: Bilmediğimiz için, alışkan olmadığımız için yapamazdık.
[151] **S1-P4-18 ocak-(290, 292, 294)**
Öğrenci G: Ya şimdi böyle bir şey yapacağımız, yüz yıl düşünsem de aklıma gelmezdi.
Öğrenci G: Mesela, böyle bir şeyi benim başka birisine uygulatmaya çalışmam? Bence gayet iyi bir şey yani.
Öğrenci G: Mesela, böyle bir şey düşünsem. Eee ben birilerine bunu denetsem. Bence gayet iyi olur. Yani ben beğendim açıkçası.
[152] **S1-P4-18 ocak-(113-123)**
[**Araştırmacı:** "Örneğin hani hocanız yapabileceğiniz bir soru olduğunu düşünmüştü, ama çoğunuz yapamamıştınız. Şey, peki zor muydu soru sizin için?" sorusuna yanıt]
Öğrenci A: Biraz. (**Öğrenci C:** kafa sallar).
Araştırmacı: Zorluğu neresindeydi? Hani size direkt kesir sorusu olarak verilmemesinden mi kaynaklı? (**Öğrenci D:** Kafa sallar. **Öğrenci C:** Evet.) Hani, sizin kendinizin bulması gerektiği için mi bu soruda?
Öğrenci A: Evet.
Öğrenci C: Kesirlerle verilse daha kolay olurdu.
Öğrenci A: Evet, evet, kesirlerle ilgili. Kesir soruları veriyorlar, işte toplayın, çıkartın.
Öğrenci C: Herkes normali buldu ama kesrini bulamadı.
Öğrenci A: Aslında 1 cm geçse boğulur çocuk yani.
Öğrenci C: Öyle düşündük.
Araştırmacı: Ama onu, ona oranlayamadınız yani.
Fen bilgisi öğretmeni: Hocam gerçekten burada çocukların yorum yeteneğinin zayıf olduğunu görüyoruz yani.
[153] **S1-P4-18 ocak-(170-172)**
Öğrenci G: Ama öğretmenim, sıkıntı şey şimdi. Ben Ahmet Öğretmen'e soruyorum, "Öğretmenim tam olarak nereyi boyayacağız?" diye.
Araştırmacı: Ne dedi?
Öğrenci G: Şimdi ben şurayı şöyle boyayacağım dedim. Peki başka boyayacağımız yer var mı dedim. "Evet, var" dedi, ama yine boyadığım yeri gösterdi.
[154] **S1-P4-18 ocak-(210-212)**
[**Araştırmacı:** "Geçen haftaki yaptığımız şey için […] Sizin problem hoşunuza gitmedi mi?" sorusuna yanıt]
Öğrenci D: Yoo, gitti. Biz hayal ettik de yapamadık. Malzemeleri kullanamadık biz.

Öğrenci E: Öğretmenim ayakkabı kutusu koysaydınız oraya, çok güzel bir şey yapabilirdik.
[155] **S1-P4-18 ocak-(271-274 and 278-279)**
[**Araştırmacı:** "Peki fen ile ilgili cevap doğru düzgün çıkmamış galiba hocam." sorusuna yanıt]
Fen bilgisi öğretmeni: Zaten sosyalle de ilgili hani böyle ayrıntılı cevap verememişler. Çok kısa geçmişler.
Araştırmacı: Neden böyle cevapladınız arkadaşlar?
Öğrenci A: Biz makete daha çok zaman kalsın diye öyle yaptık.
Araştırmacı: Yani soruları önemsemediniz mi sırf makete geçmek için?
Öğrenci A: Yok, önemsememek değil de maketlerden çok yapmak istiyorduk. Zaten makete benim ilgim var.
[156] **S1-P4-18 ocak-(406-412)**
[**Araştırmacı:** "Sizde ne oldu Öğrenci G? Sen mi, Öğrenci K mı soruları cevapladı? Ya da beraber mi baktınız?" sorusuna yanıt]
Öğrenci G: Biz beraber yaptık.
Fen bilgisi öğretmeni: Onun da cevapladığı kısımlar oldu mu yani?
Öğrenci G: Evet.
Araştırmacı: Ya da sana fikir verdiği oldu mu?
Öğrenci G: Mesela, bizim bir pervane olayı vardı. Ben sadece pervaneyi söyledim, sonra aklıma nasıl çalışacağı gelmemişti. Öğrenci K da bana nasıl yapabileceğimizi söyledi.
[157] **S1-P4-18 ocak-(379-381)**
Öğrenci A: Ben zaten Öğrenci M ile iyi anlaşıyordum. Öğrenci M ile bir problemimiz olmadı. Zaten biz Öğrenci M ile yaptık, anlaştık, kolaydı.
Fen bilgisi öğretmeni: Fikir alışverişi?
Öğrenci A: Bir tane ben yaptım şeyi, Öğrenci M yazdı. Öğrenci M çizdi, ben yazdım. Öyle sırayla yaptık.
[158] **S1-P4-18 ocak-(404-405)**
Öğrenci D: Öğretmenim, biz Öğrenci E ile fikir alışverişi yaptık mesela. Kısa sorular vardı, ikimiz düşündük mesela, Öğrenci E yazdı. Bazen ben şey yaptım.
Fen bilgisi öğretmeni: Güzel, fikir alışverişinde bulundunuz yani.
[159] **S1-P4-18 ocak-(440-442, 453)**
Öğrenci E: Ben maket isterim.
Researcher: Maket gibi bir şey. Ders değil de sadece aktivite yapmayı mı tercih edersin?
Öğrenci E: Evet ben aktivite isterim.
Öğrenci D: Küçük sorular belki iyi olabilir ama (**Öğrenci G:** Evet, küçük, küçük) onun dışında yine de aktivite.
[160] **S1-P4-18 ocak-(449-451)**
Öğrenci G: Yine aynısı olabilir yani. Bence bu da güzeldi.
Araştırmacı: Dersler artı aktivite mi? Yoksa sadece aktivite mi?
Öğrenci G: Ders artı aktivite.
[161] **S1-P4-18 ocak-(443-447)**
Fen bilgisi öğretmeni: Öğretmenim kusura bakmayın araya giriyorum şimdi. Öğretmeninizin dediği gibi hani 3 aşamada oldu ya. Bir tane soru soruldu ve cevap istendi, sonra başka bir soru soruldu, sizin yapmanız istendi gibi. Şimdi tasarım yapmayı, maketi hepiniz istiyorsunuz ama öncesinde sorular sorulması gerekli. Yani sadece aktivite mi olmalı yoksa daha öncesinde vermiş olduğumuz böyle bilgilerinizi ölçebilecek sorular da olmalı mı? Hani o sorular aslında sizin bilgilerinizi ölçmek ve ardından o bilgileri kullanmanızı amaçlamaktaydı. Sonuç itibariyle siz o soruyu cevaplarken o halleşme olayını bilerek bir tasarım yaptınız, o şekilde soruyu cevapladınız fende. Yani sorular da sorulmalı mı? Cevapları istenmeli mi? Sadece maket mi olmalı?
Herkes: Bence sorular da sorulmalı.
Öğrenci G: O zaman sadece tek bir maket yapınca da, fikir de çıkmıyor.
Öğrenci A: Bu neyle ilgili diye diyemiyoruz da.

Fen bilgisi öğretmeni: Hah süper. Tamam çok güzel.
[162] **S1-P4-18 ocak-(158-163)**
Öğrenci D: Mesela, Speaking'de o keklerle şekiller yapmıştık. Mesela, onun gibi bir şey yine yapsak daha iyi olabilir diye düşünüyorum.
Fen bilgisi öğretmeni: Hocam bir saniye. Yediler mi o keki?
Araştırmacı: Evet yediler.
Fen bilgisi öğretmeni: Hmm, anladım şimdi.
Araştırmacı: En sevdiğiniz hangisiydi bir buçuk ay boyunca yapılanlar da?
Öğrenci E: Kekli olan.
[163] **S1-P4-18 ocak-(202-205)**
Öğrenci D: Bizi de ilgilendiren bir şey olsa mesela.
Araştırmacı: Ne gibi?
Öğrenci A: Kek.
Öğrenci D: Oyuncak mesela. Onun gibi.
Öğrenci G: Çocuklara hitap ediyor.
[164] **S1-P4-18 ocak-(454)**
Öğrenci C: Her şey aynı kalabilir, sadece zamanı arttırın ve lütfen eşleri değiştirin.
[165] **S1-P4-18 ocak-(177-182)**
Öğrenci A: Bir şey söylesem. Hepsini farklı günlerde yapmaya ne dersiniz?
Araştırmacı: Bir haftaya yaysak daha iyi olabilir miydi sence?
Öğrenci A, E ve C: Evet çok güzel olurdu.
Araştırmacı: Hepsini farklı derslerde yapmaya ne dersiniz?
Öğrenci E: Evet, evet, çok güzel olurdu.
Öğrenci D: Çok iyi olurdu yani.
[166] **S1-P4-18 ocak-(462-464)**
Öğrenci A: Bence şöyle bir şey yapabiliriz. Hani artık üst üste her hafta Speaking dersinde yapmak yerine, sosyal etkinlikte matematik yapabiliriz. Artık beynimiz burada "matematik, matematik, matematik" diye çınlıyor. Mesela, sosyalle fen daha çok birbirleriyle alakalı ya, sosyalle fen bir hafta olsa, matematik bir hafta olsa, sosyal ile matematik.
Araştırmacı: Siz ne diyorsunuz Öğrenci A'nın dediğine?
Öğrenci D: Bence olabilir.
[167] **S1-P4-18 ocak-(98)**
Öğrenci C: Eee yani bu mesela, maket yapmamızı pekiştirmemiz açısından daha güzel oldu. Derslerin birbirleriyle bağlantılarını öğrendik. Mesela, işte matematikle İngilizcenin, sosyalle fen' in bağlantısı gibi.
[168] **S2-P1-1 mart-(11-18)**
Fen bilgisi öğretmeni: Ama tabii ki o zaman çektiğimiz eziyetin bir avantajı var mı, bilemiyorum. Ama doğal olarak çok uzun bir süremizi vermiştik ve hiç bilmediğimiz bir alanda çalışıyorduk. Bir şeyler anlamaya çalışıyorduk. O yüzden o çalışmalarımız bizim için temel oldu. Bu, sanki üzerine koyuyormuş gibi oldu. Daha rahat oldu. Mesela, kendi açımdan söylüyorum, algılamam çok daha kolay oldu.
Matematik öğretmeni: Daha rahat fikir geliştirebildik.
Fen bilgisi öğretmeni: Aynen.
Matematik öğretmeni: Bir kere ilk döneme göre daha az yorulduk. Bu dönemin konuları bence daha STEM' e uygun ve en azından zevkli. Hani uzay, şu bu, hepimizin merak ettiği şeyler. Bence daha zevkli olacak.
Araştırmacı: Tema da ilginizi çekti.
Matematik öğretmeni: Tema da ilgimizi çekti, STEM' ide öğrendik diyelim. Ha o yüzden zevkli geçti.
Araştırmacı: Siz hocam?

Resim öğretmeni: Sayın hocam, bir çalışmada olayı kavramak önemli, birinci dönem biz bunu iyice kavradık, kavradığımız için de zaten kolay oldu.

[169] **S2-P1-1 mart-(409-418)**

Matematik öğretmeni: Hem başarının çok da önemli olmadığını anladım. Mesela, Öğrenci K akademik olarak zayıf bir öğrenciydi, ama en iyi cevapları o verdi.

Fen bilgisi öğretmeni: Evet.

Araştırmacı: Evet, Öğrenci M ve Öğrenci L de vardı.

Fen bilgisi öğretmeni: Gerçekten, Öğrenci M ve Öğrenci L de var.

Matematik öğretmeni: Öğrenci M ve Öğrenci L zayıf grubu aslında, ama daha iyi olduğunu öğrendik. Öğrenci C, Öğrenci D ve Öğrenci G' nin o soruları cevaplamalarını beklerken, onlar beni çok büyük hayal kırıklığına uğrattı.

Fen bilgisi öğretmeni: Evet.

Resim öğretmeni: Katılıyorum arkadaşlara, öğrenci zaten değişkendir.

Fen bilgisi öğretmeni: Tabii değil mi hocam?

[170] **S2-P1-1 mart-(338-346)**

[**Araştırmacı:** "Disiplinlerarası çalıştık biz aslında. Sadece ben ve siz değil, ama sizler de farklı disiplinlerden gelen öğretmenlersiniz sonuçta. Anlaştığınız ya da ayrı düştüğünüz konular oldu mu bu 2 gün içinde?" sorusuna yanıt]

Matematik öğretmeni: Olmadı, yani ben bir uyumsuzluk, farklılık görmedim. İlk dönem de olmadı.

Fen bilgisi öğretmeni: Aynen, yani fikir üstüne fikir çıktı ve farklı şeyler, farklı bir ürün çıktı ortaya.

Resim öğretmeni: Evet.

Matematik öğretmeni: Evet, yani en azından birinin kelimesinden benim aklıma daha farklı şeyler geldi.

Araştırmacı: Yani birbirinizi tetiklediniz anlamında mı?

Matematik öğretmeni ve Fen bilgisi öğretmeni: Evet, evet.

Matematik öğretmeni: Yani uyumluydu.

Fen bilgisi öğretmeni: Yoksa uyumsuzluk yok sanıyorum.

[171] **S2-P1-1 mart-(348-352)**

Resim öğretmeni: Ben mesela, görsel sanatlar öğretmeni olmama rağmen İngilizce' de davetiye sistemleri varmış, ben bunun olabileceğini hiç düşünmezdim.

İngilizce öğretmeni: Yani bir parti yapıp, o partiye bir broşür hazırlayıp, davetiye yollayabileceğinizi düşünmezdiniz değil mi?

Resim öğretmeni: Yani, yarın bir gün, başka bir olayda.

İngilizce öğretmeni: İşte ben haberdar olmak derken bunu kastediyorum. (**Fen bilgisi öğretmeni**: Evet) Birbirimizin müfredatından biraz haberimiz olsa aslında, "Bunlar birbiriyle çok alakalı" diye.

Resim öğretmeni: İşte zümre, bütün mesele zümre.

[172] **S2-P1-1 mart-(529-533)**

Resim öğretmeni: Ben özellikle buna çok açığım. Yani çok istiyorum arkadaşlar gelsinler, bir şeyler sorsunlar diye.

Fen bilgisi öğretmeni: Yardımlaşalım değil mi?

Resim öğretmeni: Evet.

Fen bilgisi öğretmeni: Aslında, hocam bu çalışmayla, biz bunu yapabileceğimizi de gördük.

Resim öğretmeni: Evet, evet.

[173] **S2-P1-1 mart-(259-261)**

İngilizce öğretmeni: Ben ilk başta açıkçası 5 kişinin ders programını, müfredatını, konularını, birbirine nasıl uyarlayacağız diye bayağı bir düşündüm. Çok zor falan olacak diye düşündüm. Korktum yani, bir önyargım vardı.

Fen bilgisi öğretmeni: Ha, ilk başta ben de onu düşünmüştüm.

İngilizce öğretmeni: Ama oldu yani, gayet güzel oldu.

[174] **S2-P1-1 mart-(282, 285-289)**
[**Araştırmacı:** “Peki, tasarım odaklı düşünme metodunu kullanarak yine 5 disiplin bir arada çalıştınız, metot size bu 5 disiplini bir araya getirme anlamında kolaylık ya da zorluk açısından ne sağladı?” sorusuna yanıt]
Fen bilgisi öğretmeni: Basamak, basamak olduğu için, bir sıra olduğu için.
Matematik öğretmeni: Bir kuralı olduğu için.
Fen bilgisi öğretmeni: Bir kuralı olduğu için, doğal olarak karmaşıklık olmadan önce, neyi düşünmeliyiz, ardından hangi basamaklara geçmeliyiz’ i önümüze verdiğiniz için.
Matematik öğretmeni: Hani durup, durup çalışırken, ne yaptık ya da neyi yapacaktık diye düşünmedik. Bunu yaptık, bunu yaptık, şimdi bunu yapacağız dedik.
Fen bilgisi öğretmeni: Yol gösterici bir sistem vardı. Anlatabiliyor muyum?
[175] **S2-P1-1 mart-21-26**
Matematik öğretmeni: Yani şöyle, ilk sefer için evet, o basamaklara ihtiyacımız vardı, çünkü neyin ne olduğunu bilmiyorduk, ilk dönem öğrendik.
Fen bilgisi öğretmeni: Lafını bölüyorum hocam, mesela, basamakların ismi, hatta genel olarak ismi bile korkutuyordu.
Matematik öğretmeni: Evet, evet.
Fen bilgisi öğretmeni: Mesela, basamaklı gitmesi bizim için ilk dönemin başından beri çok iyi.
Matematik öğretmeni: İlk seferde öğrenmek için herkesin bu basamaklara tek tek çalışması gerekir.
Fen bilgisi öğretmeni: Evet, uygulanması gerekiyor.
[176] **S2-P1-1 mart-(205-212)**
[**Araştırmacı:** “Peki siz 4 ya da 5 hocayı buraya getirsem, oturun arkadaşlar desem, bir arada bir gününüzü beraber geçirtsem, bu şekilde aktiviteyi tasarlayıp çıkabilir miydiniz işin içinden?” sorusuna yanıt]
Fen bilgisi öğretmeni: Eksikleri olurdu diye düşünüyorum.
İngilizce öğretmeni: Eksiklikleri olurdu, çünkü sizin katkınız çok fazla.
Araştırmacı: Hiçbir şey vermeyeceğim ve ben de yokum.
Matematik öğretmeni ve Fen bilgisi öğretmeni: O zaman bir günde halledemezdik.
Resim öğretmeni: Bir günde halledemezdik, yalnız matbu planları olursa…
Matematik öğretmeni: Hani şu tarz elinizdeki kâğıtlarla geliyorsunuz ya, onun benzerleri olsa da, yine de bir günde…
Resim öğretmeni: Ama şundan yönetiriz yani (Onlara dağıttığım dokümanları gösterdi.)
[177] **S2-P1-1 mart-(403-408)**
[**Araştırmacı:** “Hani ilk dönem beklentilerimiz vardı ve sonradan öğrencilerle uyuşmadığı noktalar olduğunu fark ettik. Bununla ilgili ne söyleyebilirsiniz?” sorusuna yanıt]
Fen bilgisi öğretmeni: Bununla ilgili şimdi ben, çocuklar değişkendir diyorum, (**Matematik öğretmeni**: Evet, çocukların değişkenlikleri ile çok alakalı bir durum.
Matematik öğretmeni: Biz onlar için- ilk dönem için konuşuyorum- fazla hayal kurduk. Beklentimiz çok yüksekti, ama onların değişebileceğini, yani hiç olumsuz bir şey düşünmedik. Çözerler, yaparlar diye düşündük.
Fen bilgisi öğretmeni: Olumsuz düşündüğümüz bize ters köşe yaptı.
Matematik öğretmeni: Evet, işte onu diyorum. Çok hayal kurduk.
Fen bilgisi öğretmeni: Yani, biraz gerçekten ben öğrenciye bağlıyorum bunu, biz öğrenci odaklı düşündük sonuç itibariyle, hep onların üzerinden plan yaptık. Gruplandırmalar, vesaireler. İşte başarı durumları, birbiriyle olan ilişkileri […] Ama o kadar değişken ki, yani kısa süre içerisinde o kadar çok değişebiliyor ki, bu bizi çok etkiledi. Aldığımız sonuçlar da tabii ki çok etkilendi.
[178] **S2-P1-1 mart-(148-157)**
[**Araştırmacı:** Peki, sınıfı birinci dönemden beri tanıyorsunuz. Peki, bu sizin aktiviteyi planlamanızı kolaylaştırdı mı?” sorusuna yanıt]
İngilizce öğretmeni ve Matematik öğretmeni: Evet.

Araştırmacı: Ne açıdan?
Resim öğretmeni: Kişilikler.
Matematik öğretmeni: Çocuklarla ilgili, hayal dünyaları olarak nelere ilgileri var, bunları keşfettik.
İngilizce öğretmeni: Mesela, meslek seçiminde dedik ya şunu seçelim diye. Mesela, Öğrenci L terzi olmak istemiş. Yani kimin avukat, kimin ne isteyebileceğini az çok kestirebiliyoruz.
Matematik öğretmeni: Doktor, uzay doktoru olsun. Faydası tabii ki oldu.
Fen bilgisi öğretmeni: Mesela, gruplandırmalardan yola çıkarsak, o etkinliği de yaptıktan sonra, demek ki bu gruplandırma böyle olmamalı, bunu değiştirmeliyiz diyebiliyoruz artık.
Matematik öğretmeni: Yani problem diye gördüğümüz çocuğun problem olmadığını, farkına varmadığımız çocuğun en büyük problem olduğunu gördük.
Fen bilgisi öğretmeni: Aynen.
[179] **S2-P1-1 mart-(161-168)**
[**Araştırmacı:** "Bu aktiviteyi seneye, farklı bir sınıf için aynı şekilde mi uygulardınız?" sorusuna yanıt]
İngilizce öğretmeni: Ben olsam yine aynı yaparım, deneme yanılma da bir yöntemdir yani.
Araştırmacı: Yani ilk dönem bir deneyip ondan sonra ikinci dönem belki değişiklik yaparsınız.
Resim öğretmeni ve İngilizce öğretmeni: Tabii, tabii.
İngilizce öğretmeni: Sonuçta tanıdığımız öğrencilerin bile ne tepki vereceğini kestiremeyip şaşırabiliyoruz.
Fen bilgisi öğretmeni: Kestiremeyebiliyoruz, aynen.
İngilizce öğretmeni: Yani şaşırabildiğimizi de göz önüne alabiliriz, bu sefer, ikinci aktiviteyi yaparken.
Resim öğretmeni: Her seferi bir tecrübedir.
[180] **S2-P1-1 mart-(158-159, 173)**
[**Araştırmacı:** "Peki o zaman bu dönem 5. sınıflara yaptığınız şeyi seneye gelen başka bir 5. sınıfa yapmak isteseniz, aynı şekilde mi bu aktiviteleri yapardınız? Ya da değişiklik yapar mıydınız?" sorusuna yanıt]
Matematik öğretmeni: En azından 2. dönem tek bir aktivite yapardım ki 1. dönem onları çözümleyeyim. İlk dönem yaşadığımız gibi bir hayal kırıklığına uğramayayım diye.
Matematik öğretmeni: Yani şöyle, her 2 dönem de yapardım ama derslere girmeden, çaktırmadan, daha da çaktırmadan yapardım. Şimdi her şeyin farkındalar, diyorum ya üç beş kişiyi bir arada görünce STEM' i yapıştırıyorlar.
[181] **S2-P1-1 mart-(469-475)**
[**Araştırmacı:** "Siz nasıl STEM yapmak isterdiniz?" sorusuna yanıt]
Fen bilgisi öğretmeni: Yani, evet, bunlar çocuk. Tabii ki oyun isteyecekler, tabii ki oyun içerisinde olsun, hem eğlensinler, hem de öğrensinler. Motamot eğer biz sadece ders anlatacaksak ya da çocuklar hiçbir şekilde bir farklılık görmeyecekse bunu yapmanın da bir anlamı yok. Ama STEM' in zaten amacı ne? Aslında STEM' de ne yapıyorlar? Bizim teorikte verdiğimiz şeyi uygulamaya döküyorlar.
Araştırmacı: Zaten bilginin kullanımı diyoruz.
Matematik öğretmeni: Evet, evet, bilgi kullanılabilir mi?
Fen bilgisi öğretmeni: Aynen, mesela, işte prototip yaptırdık değil mi? Ne kadar hoşlarına gitti. Bu olsun zaten. Kesinlikle olsun.
Matematik öğretmeni: Çok sevdiler.
Fen bilgisi öğretmeni: Zaten, birebir sürekli teorik anlatmak, vs. oyunda olsun ve eğlensinler.
[182] **S2-P1-1 mart-(476-481)**
Matematik öğretmeni: Ama işte bunun en baştan sistemli bir şekilde, 1. sınıftan itibaren eğitime modellenmesi gerekiyor.
Araştırmacı: Yani bir anda verince tepki çekmesi doğal.
Fen bilgisi öğretmeni: Aynen.

Matematik öğretmeni: Yani çocuk büyürken bu sistemin içinde büyürse, hem öğretmen dersi oyunla eğlendirerek anlatır, daha kalıcı olur; hem de çocuk eğitimin böyle olduğunu anlayacağı için karşı çıkmaz.
Fen bilgisi öğretmeni: Ve öğrenciye fizik anlatıyorsunuz "Ben bunu hayatımın neresinde kullanacağım hocam?" diyor. Hâlbuki hayatın içerisinde. Atıyorum, kimya anlatıyorsun "Bu ne işe yarayacak?" diye soruyor, aslında hayatının içinde. Bu STEM baştan beri getirilmiş olsa, çocuk bu sistemin içerisinde olur yani. Eğitimini almaya devam ediyor olsa, zaten kafasında oturtacak ve öyle bir soru olmayacak.
[183] **S2-P1-1 mart-(523-528)**
Resim öğretmeni: Yeni öğretmen arkadaşım ne yapmalı? Gelmeli bana, iki dakika, üç dakika bir dersime girmeli veyahut da imkân yaratmalıyız birbirimize.
İngilizce öğretmeni ve Matematik öğretmeni: Evet, evet.
Resim öğretmeni: Veya derse bile girip "Çocuklar, cetvel bu, şöyle bir şey var, hadi şunları birleştirin." Ayaküstü yani, ayaküstü.
Matematik öğretmeni: Bu eğitimin modellenmesi gerekiyor.
Resim öğretmeni: Oturması gerekiyor. Yoksa ben ne İngilizce öğretmeninin işine karışmış oluyorum böyle yapmakla, ne de o benim işime karışıyor.
Fen bilgisi öğretmeni: Tabii ki, aynen. (İngilizce öğretmeni onaylamak için başını salladı)
[184] **S2-P1-1 mart-(117-119)**
Araştırmacı: Konuları bu şekilde seçer miydiniz diye sormak istiyorum.
İngilizce öğretmeni: Bu ayrımı yapabilirdim yani, eğer o konunun benim şu konumla alakalı olduğunu fark etseydim. Ama bundan haberim olursa tabii.
Matematik öğretmeni: Evet, en azından dönem başında benim konularım bu dense.
[185] **S2-P1-1 mart-(106-109)**
Fen bilgisi öğretmeni: Mesela, bu tamamen benim ilk ünitemle alakalı, yani genel olarak o yaşam alanının oluşturulması, uzayda olması. Çocuklar ilk ünitede o kadar çok şeydiler ki istekli, çok araştırmayı seviyorlar yani. Tabii ilgileri de olduğu için, bazı öğrencilerin çok fazla ilgisi var. Diğer sınıflarda da mesela çok ilgisi olan öğrencilerimiz var. Keşke bu aktivitenin içinde olabilseler, inanın öyle farklı şeyler çıkar ki.
Araştırmacı: Kütüphanede birkaç çocuk bana gelip biz de yapacak mıyız diye sordular ve ben de hayır dedim.
Matematik öğretmeni: Çünkü orada kitap dışında farklı bir şey gördüler.
Fen bilgisi öğretmeni: Yani ne oluyor mesela, ilk ünitede ben işlediğim için, çocukların nasıl tepkiler verdiğini, neler istediklerini bildiğim için, doğal olarak daha farklı şeyler düşündüm. Şu da olabilir mi diye düşünmeye insan ister istemez yöneliyor yani. O yüzden benim açımdan çok faydası oldu. Yani ilk dönemin ünitesinden de yararlanmış oldum.
[186] **S2-P1-1 mart-(323-326)**
Matematik öğretmeni: Bence sizin için de aynı şey geçerli. Mesela, hepimiz biliyoruz Bahçeşehir kaynaklı. Mesela, tesadüf eseri orada çalışan biriyle tanıştım, hani onlar düzenli olarak STEM eğitimi almaya İstanbul'a gidiyorlar. Belki sizin de karşınızda düzenli olarak bunun eğitimini almış öğretmenler olsa, çok daha farklı şeyler ortaya çıkardı. Sizin için de aynı şeyler geçerli.
Fen bilgisi öğretmeni: Tabii, aynen.
Araştırmacı: Daha farklı ürünler ve şeyler isteyebilirdim.
Matematik öğretmeni: Evet, daha farklı, daha yaratıcı, daha özgün şeyler çıkabilirdi.
[187] **S2-P1-1 mart-(388-401)**
[**Araştırmacı:** "Peki benim çalıştaydaki rolümü tarif etmenizi istesem ne dersiniz?" sorusuna yanıt]
Resim öğretmeni: Olmazsa olmaz.
Fen bilgisi öğretmeni: Aynen, olmazsa olmaz.
Matematik öğretmeni: Öğretici.
Araştırmacı: Peki bir sıfat yükleseniz?
Matematik öğretmeni: Her şey, fikir geliştirici, öğretici,

Fen bilgisi öğretmeni: Uzman, öğretici, hepsi.
Matematik öğretmeni: Uzman, yönlendirici, planlayıcı.
Resim öğretmeni: At gözlüğüyle değil, daha geniş yelpazede görebilmek.
Matematik öğretmeni: Evet. Yani bize katkınız büyük.
Araştırmacı: Tek bir sıfat söylersiniz diye düşünmüştüm.
Fen bilgisi öğretmeni: Çünkü şimdi bakıyorum biz tek başımıza olsaydık, siz her şeyi hazırlıyorsunuz, ediyorsunuz, yol gösteriyorsunuz.
Matematik öğretmeni: Bizi yönlendiriyorsunuz.
Fen bilgisi öğretmeni: Baştan zaten bu sistemi bize öğretmeye çalıştınız öncelikle, o yüzden bir sıfat bence haksızlık diye düşünüyorum ben kendi adıma.
[188] **S2-P1-1 mart-(308-309)**
[**Araştırmacı:** "Benle tekrardan bir araya geliyorsunuz yani siz hepiniz öğretmensiniz ama farklı branşlardan öğretmenlersiniz ve ben öğretmen değilim. Nasıl bir deneyimdi?" sorusuna yanıt]
Matematik öğretmeni: Hani, ilk dönem söylediğim şeyleri hatırlıyorsunuzdur. Hani bir tasarımcının eğitime katkısı nasıl olacak? Hani kişisel olarak değil de, tasarımcı ile eğitimi kafamda bağdaştıramadım ben. (**Fen bilgisi öğretmeni**: Aynen) Ama şimdi düşünüyorum ki bu işin böyle olması gerekmekte, çünkü eğitimde tasarım yapıyoruz biz. Çünkü STEM bu artık, bunu öğrendim, anladım, biliyorum. Değil bir eğitimciyle, sizin yerinize eğitim fakültesinden biriyle bile bunu yapamazdık. O zaman, öyle düşünmüştüm, ama şimdi karşımdaki insanın kesinlikle bir tasarımcı olması gerekir. Çünkü sizin tasarımcı düşüncenizden ben çok iyi anlamda etkilendiğimi düşünüyorum, yani çok fazla.
[189] **S2-P1-1 mart-(315, 317-319)**
Fen bilgisi öğretmeni: Yani bir öğretmen ile bir tasarımcı bir araya geldiğinde, öğretmenin öğrenciye vereceği şeyi nasıl vermesi gerektiğini öğretmen biliyor, ama tasarlama kısmını tasarımcı yapıyor. Siz de dediğim gibi mesleğinizin vermiş olduğu bir oturmuşluk var sizde yani bu anlamda (**Matematik öğretmeni**: Evet.). O yüzden bizim yapamayacağımız çoğu şeyi, dediğim gibi mesela şablon vs. siz her şeyi halletmişsiniz.
Matematik öğretmeni: Her şeyi siz önümüze getirdiniz. Onun da bir kolaylığı var.
Fen bilgisi öğretmeni: Evet, yani biz öğrendik onu. Bunu oraya nasıl aktarmamız gerekiyor? Tabii ki kendi bilgimizi ortaya koyarak konu anlamında, o şekilde biz de çocuklara aktarımını yaptık. Sizsiz kesinlikle olacağını zannetmiyorum.
Matematik öğretmeni: Yok, yok, bir tasarımcısız bu iş yürümez. Yani en azından 5-6 yıl kemik kadro olarak tasarımcı ile beraber çalıştıktan sonra belki "Ha tamam, artık tasarımcıya gerek yok, biz bunu hallederiz" e anca geliriz.
[190] **S2-P1-1 mart-(337)**
Resim öğretmeni: Resim öğretmeni: Eğitim ve öğretimle paralelliğiniz mükemmel, (**Matematik öğretmeni:** Evet), STEM' i soyutluktan kurtarıp somut hale getirdiniz. Bizler için bu çok önemli. (**Fen bilgisi öğretmeni:** Aaa, tabii). Yani buradaki eğitim bilginiz ve müfredata olan hâkimiyetinizi hissettim ben. Mümkün olduğunca aynı paralelde gitti yani çalışma. Yani, bir tasarımcı da aynen bir öğretmen gibidir. Ben öyle düşünüyorum. Yani işte bulup farklılığı çıkartma, farklıyı yaratabilmek adına, soyutluktan kurtarıp somut hale, hem bizler hem de öğrenciler için getirdiniz.
[191] **S2-P1-1 mart-(331-333)**
İngilizce öğretmeni: Tasarımcı olarak sizin fikirleriniz daha böyle geniş olabiliyor. Daha hayal edip tasarlayabiliyorsunuz bir şeyleri. Mesela, ben bir şeyleri tasarlamak konusunda iyi değilimdir. Ama tasarlanmış bir şeyi sunma konusunda iyiyimdir. Herhalde bu da öğretmenliğin vermiş olduğu bir şey. Bilmiyorum ya da aldığım eğitimin. Olan bir şeyi çok iyi sunarım, olan bir şeyin taklidini de çok güzel yaparım. Ama olmayan bir şeyi oldurtmak da (**Matematik öğretmeni**: Var etmek gibi.) O fikir aklıma gelene kadar herhalde akla karayı seçerim. Yeni bir fikir bana gelene kadar çok uzun sürer.
Araştırmacı: Yaratıcılık kısmını diyorsunuz.

Fen bilgisi öğretmeni: Aynen öyle.

[192] **S2-P1-1 mart-(67-69)**

Fen bilgisi öğretmeni: Birinci dönemin başından beri söylediğim şey şu, tasarım odaklı düşünme metodu ile disiplinlerarası eğitimin olabileceğini ve disiplinlerin birbiriyle bağlantılı olduğunu ben bu çalışmaya girdiğimde gerçekten net bir şekilde gördüm. Diyorum ya, derse girdiğim zaman atıyorum, bu belki çok basit, belki kuvvet konusunu anlattım, bu tamamıyla matematik. Yani ben bunu gerçekten hocamla beraber girip anlatabilirim. Yani bu şekilde bir planlama yapılabilir.

Matematik öğretmeni: Evet.

Fen bilgisi öğretmeni: Bugün ya da dünden beri, işte tasarlamış olduğumuz, düşünmüş olduğumuz konular birbiriyle bağlantılı olabilir mi? Bunları inanın artık düşünmeye başladım yani. Çok büyük katkısı da oldu.

[193] **S2-P1-1 mart-(353-355)**

Matematik öğretmeni: Yani ben perspektif konusuyla kesirleri ölsem bağdaştıramazdım.

Resim öğretmeni: Yaa.

Matematik öğretmeni: Yani ilk dönem "ya resim ne alaka" diyordum. "Ne alaka" dedim, çok alakalı. Hani şöyle, aslında diyoruz her şeyin içinde matematik var ama realiteye dökmek onu biraz zor oluyor.

[194] **S2-P1-1 mart-(548-556)**

[**Araştırmacı:** "Bir dahaki dönem ben olmayacağım, zaten bu dönem çalışmayı bitiriyoruz. İlerde bu çalışmadan öğrendiğiniz herhangi bir şeyin tamamını ya da bir parçasını kullanmayı düşünüyor musunuz?" sorusuna yanıt]

Fen bilgisi öğretmeni: Diyorum ya evet, ben şahsen evet.

Matematik öğretmeni: Evet.

Resim öğretmeni: Tabii canım evet, zümrelerin dayanışması, kesinlikle kullanmamız lazım, ayaküstü ya da derse giderken.

Matematik öğretmeni: 5 dakika.

Resim öğretmeni: Benim şöyle, şöyle bir konum var, gibi.

Matematik öğretmeni: Mesela, ben şimdi geometri konusuna giriyorum, resim öğretmenine soracağım ya da materyal hazırlayacağım. Yani tamamen görselle alakalı geometri öyle değil mi hocam?

Resim öğretmeni: Yani, görselle alakası var.

Fen bilgisi öğretmeni: Aynen, aynen. Tabii ki de, devam etmeyi düşünüyoruz.

[195] **S2-P1-1 mart-(506-508)**

İngilizce öğretmeni: Yoo benim zihnimi açtı. Ya mesela, bu olay neden böyle değil diye sorgulamaya başladım. Keşke, müfredatta üniteler birbirine uyumlu olsa, di mi?

Matematik öğretmeni ve Fen bilgisi öğretmeni: Tabii, tabii.

İngilizce öğretmeni: Daha hani böyle kolay olsa.

[196] **S2-P1-1 mart-(88-94)**

Resim öğretmeni: En başta araştırma, eskiz, tasarım, araç gereçlerin uygunluğu ve üretim.

Araştırmacı: Doğru, sizin açınızdan tamamen bunlar aslında.

Resim öğretmeni: Evet, yani beni daha çok şeye yöneltti bunlar. Önceden pratikten (**Araştırmacı:** Direkt uygulamaya) evet direkt uygulamaya giriyorduk. Ama şimdi gerek evimde, gerek yastığa kafamı koyduğum zaman, "Acaba şu tutkal şuna uyar mı?" diye düşünüyorum.

Araştırmacı: Çok güzel bir şey ama (**Matematik öğretmeni:** Evet).

Resim öğretmeni: Size bir basit daha örnek vereyim. Silikon kullanıyorum straforların yapıştırılmasında. Geçen sene Çanakkale anıtını yaparken ilk önce straforları beyaza boyadım, fakat o silikon kullanacağım noktalara çapaklar geldi ve kuvvetli yapışmadı. Yapışmadı, yani zayıf yapıştı, sonradan kopmalar, çıtırdamalar oldu. Bu sene öyle yapmadım bak, bu sene direkt straforu prizma şekline getirdim boyayı sonradan yapacağım.

Araştırmacı: Test ettiniz, olmadığını gördünüz.

Resim öğretmeni: Bakın işte, araç gereç uygunluğu, üretim diyorum. Yani orada üretim daha zayıftı, bu seneki daha kuvvetli mesela.

[197] **S2-P1-1 mart-(558-563)**

İngilizce öğretmeni: Okulda sadece sorun olduğunda, bir şeye zarar geldiğinde ya da bir veli bir şey dediğinde toplanılmamalı bence.

Matematik öğretmeni: Şu dersi nasıl anlatmalıyız gibi.

İngilizce öğretmeni: Evet, evet, bakın benim müfredatım, konum bu. Şöyle, böyle hadi yani tecrübeli olanlardan ziyade hani tecrübesiz olanlarımız var. 1. yılı, 2. yılı, 3. yılı olanlar var, 5. yılındaki bile bence tecrübesizdir.

Matematik öğretmeni: Aynen, tabii ki resim öğretmenimize göre.

İngilizce öğretmeni: Yani yol yordam göstermek gibi olabilirdi bence. Ama olmadı, yani direkt öyle ateşin ortasına atıldık. İşte gördüğümüz gibi, ben sınıfımda ders programını öğretiyim derken cetvel kullanmayı öğretmeye başladım.

Resim öğretmeni: Zaten ilk 5 yılında öğretmenlik mesleğini, kafasını gözünü yararak öğreniyorsun.

[198] **S2-P1-1 mart-(71-78, 80-81)**

Fen bilgisi öğretmeni: Hocam inanın, çocuklar da bunun farkında, samimi söylüyorum. Derse girdiğimiz zaman, eğer başka bir dersten bir parça görüyorlarsa...

Matematik öğretmeni: Hemen birleştiriyorlar.

Fen bilgisi öğretmeni: "Al işte STEM, STEM işte" diyor. Gerçekten.

Matematik öğretmeni: Ya da diyor, senle mi konuşmuştuk?

Araştırmacı: İyi bir şey.

Fen bilgisi öğretmeni: Yani iyi bir şey.

Matematik öğretmeni: Çocukların farkındalığı arttı.

Fen bilgisi öğretmeni: Farkında olmaları güzel bir şey hocam. Tabii ki.

Matematik öğretmeni: Yok, yok, ilişkilendiğinin farkındalar aslında disiplinlerin birbiriyle.

Fen bilgisi öğretmeni: Mesela, maddenin erimesini düşündük ya biz, ilk dönem Öğrenci D veya Öğrenci G benim dersimde söylemişlerdi "Hocam maddenin erimesi değil de elektrik konusu mu bir şey vardı, bu konuyla da birleşirdi." Fikir geliştiriyorlar, bizim düşünmediklerimize dikkat ediyorlar.

[199] **S2-P1-1 mart-(46)**

Resim öğretmeni: Şimdi STEM de tasarım odaklı düşünme, yapıcı, yaratıcı yönün ağırlıklı olduğunu dile getireceğim. Etkinliklerde tabii buna göre yapıcı, yaratıcı tarafını içeren önceden bir çalışma yapıyoruz, bir şeylerle uğraşıyoruz, ama şimdi daha pratik şey yapıyoruz. Zaten benim anladığım kadarıyla, olay tamamen tasarıma dayalı bir şey.

[200] **S2-P2- English1-8 mart-(48)**

Basamak, basamak gittik, aslında bu daha iyi oldu. Çünkü bir şeyleri plansız yaptığınızda, es kaza kaçırdığınız şeyler olabilir. Ama hani, çocukların birbiriyle gruplaşırken kimin kiminle olacağına kadar düşündük. Bunlar bence önemli ve olması gereken şeylerdi ve bunlar yapıldı da.

[201] **S2-P2-Art-13 mart-(42)**

Evet, onu izleriz hocam. Sizin o bize verdiğiniz başlıklar bizi yeni şeylere yöneltiyor, yani birleşmeye yöneltiyor. Tartışmaya yöneltiyor, çocuğu tanımaya yöneltiyor, yani öyle değil mi? Ben öyle görüyorum. Yoksa şunlar olmazsa, başlıklar olmasa, siz bize o başlıkları sunmasanız, bu iş biraz soyut kalır. Yani, sizin verdiğiniz bu şeyler onu somut yapıyor. Orada ne demek istediğini anlıyoruz ve bizde ona göre öğretmen arkadaşlar karşılıklı diyalog içine girerek zümre öğretmenleriyle işbirliği yapıyoruz.

[202] **S2-P2- English1-8 mart-(67-70)**

[**Araştırmacı:** "Tasarım metodunun kullanılmasının size STEM öğretmeye nasıl bir katkısı oldu?" sorusuna yanıt]

İngilizce öğretmeni: Çok az da olsa, birazcık da olsa tasarımcı düşünme fikri beynimde oluşuverdi, yani bir şeyler belki tasarlayabilirim. Hani takvim konusunda konuşmuştuk ya, mesela, ben şimdi

çocukların bir takvim tasarlamalarını isteyeceğim "party time" ünitemde. Bu takvimi tasarladıkları zaman birbirlerinin doğum günlerini falan üzerinde işaretlemelerini isteyeceğim. Bana da böyle bir katkısı oldu.
Araştırmacı: Daha önce nasıl bir şey vardı aklınızda?
İngilizce öğretmeni: Daha önce takvim tasarlamalarını düşünmüyordum açıkçası. "Party time" ünitemde ben materyallerimi hazırlayıp ve sınıfta onlara bir parti ortamı yaratıp, nasıl parti yapılıyor, arkadaşlar nasıl davet ediliyor, bunları gösterecektim. Ama belki konumuzla alakalı olur diye bir takvim tasarlamak fikri de STEM' le birlikte aklıma geldi ve ben derste bunu yaptıracağım. Tasarlatacağım.
[203] **S2-P2-Science-13 mart-(51-54)**
[**Araştırmacı:** "İtiraz edenler var demiştiniz, bahsettiğiniz bu 3 kişi dışında başka kimler var?" sorusuna yanıt]
Fen bilgisi öğretmeni: Şimdi, neyle ilgili biliyor musunuz? Aslında Öğrenci B öyle tepki veriyor ya, karşınıza alıp konuştuğunuz zaman diğer arkadaşlarından etkilenme şeyi de var aslında. "Aslında güzel olmuştu" da diyor. Bu çocuğun bir dediği, bir dediğini tutmuyor aslında.
Araştırmacı: Kaç kişidir hatırlıyor musunuz?
Fen bilgisi öğretmeni: Öğrenci B bir şey söylediği zaman diğer öğrenciler de onun etrafında toplanır. Yani kızlar şey yaptığı için, belli bir rakam size bu yüzden söyleyemiyorum.
[204] **S2-P2-Math-8 mart-(24-27)**
[**Araştırmacı:** "Hatırlarsanız ilk dönem çocukları tanımak için bir hafta gözlem yapmıştık. Sizce bunun yapılmasına gerek yok muydu?" sorusuna yanıt]
Matematik öğretmeni: Şimdi şöyle, işe yaradı ama öğretmenlerin eş zamanlı olarak bunu yapması sorun oldu, çocuk her öğretmene aynı cevabı verdi. Belki eş zamanlı yapılması da bizi yanıltmış olabilir. Farklı zamanlarda yapılsa ya da hissettirilmeden yapılsa ya da tek genel bir anket gibi, rehberlik anketi gibi yapılsa, belki daha reel sonuçlar alabilirdik. Çünkü peş peşe sorduk soruları, hepsine aynı şeyi yazdılar.
Araştırmacı: Anladım, yani 5 kişi yerine belki tek bir kişi bunu üstlense.
Matematik öğretmeni: Evet, evet, daha genel, daha profesyonel sorular sunmuş olsaydık; belki daha verimli cevaplar alabilirdik. Çok dikkat çektik yani.
[205] **S2-P2-Art-13 mart-(30-39)**
[**Araştırmacı:** "Şöyle hocam sınıfı tanımak gerekli miydi, yoksa direk aktiviteleri uygular mıydınız?" sorusuna yanıt]
Resim öğretmeni: Sınıfı tanımak mutlaka gerekir.
Araştırmacı: Yöntem olarak bu şekilde mi tanımak gerekir?
Resim öğretmeni: Evet, bu şekilde tanımak, doğru tanımak, yani sizin o formlarda verdiğiniz şeyler gibi. Hatta ben çocukları o formdan sonra daha çok tanıdım.
Araştırmacı: Öyle mi? Ne açıdan?
Resim öğretmeni: Mesela, hangi mesleği istediğini ben bilmiyordum, dersimde böyle bir soru yöneltmemiştim. Zaten, biz önceden, çok önceki yıllarda rehberlik öğretmenlerinin olmadığı dönemlerde böyle bir form dağıtırdık.
Araştırmacı: Bunun bize aktivite tasarımında faydası oldu mu?
Resim öğretmeni: Tabii canım, çocukların ruh hallerini, girecekleri meslekleri, yaklaşımlarını anladım en azından.
Araştırmacı: Sorum şu, seneye farklı 5. sınıflar geldiğinde, aktiviteyi vermeden önce, böyle bir şey yapar mısınız, yoksa yapmaz mısınız?
Resim öğretmeni: Tanıma açısından mı? (**Araştırmacı:** Aktivitenin aynısını uygulama, uygulamama açısından.) Tabii, tabii, yapardım hocam, yapmadan olmuyor zaten o işler. Dedim ya fiziki özelliklerini, kapasitelerini, nerden geldiğini, hangi ortamdan geldiğini az çok anladıktan sonra konuma geçerdim.
[206] **S2-P2-Science-13 mart-(12-15)**

[**Araştırmacı:** “Hocam STEM aktivitesini seneye başka bir 5. sınıfta uygular mısınız diye sormuştum. Orada matematik öğretmeni ikinci dönem yapardım, ilk dönem sınıfı tanımaya çalışırdım dedi. İngilizce öğretmeni de hem ilk, hem de ikinci dönem uygulardım demişti.” sorusuna yanıt]
Fen bilgisi öğretmeni: Şimdi şöyle, ilk dönemimizde biz acemilik çektik, biz de bilmediğimiz bir şeyi yavaş, yavaş öğrenmeye başladık. Çocuklar nasıl tepkiler veriyor kısmını aktivite esnasında gördük. Öyle öğrendik ve 2. dönem biraz daha ona nazaran tedbirli davranmaya çalışıyoruz, alacağımız önlemleri almaya çalışıyoruz. Aynı şekilde seneye ben 5. sınıflara bunu yapacak olsaydım, yine aynı şey olurdu diye düşünüyorum. İlk dönem yaptığımız biraz bizim pilot çalışma gibi oldu, belki önceden küçük bir pilot çalışma yapıp sonra asıl uygulanabilir diye düşünüyorum.
Araştırmacı: Hani, biz ilk dönem sınıfı tanımak için gözlem ve görüşme yapmıştık ya, o zaman bunları yapmaya gerek yok mu veya deneme yanılmayla mı yapmak lazım?
Fen bilgisi öğretmeni: Yok, yok yine çocuklara işte sorular sorduk, çocukları tanımaya çalıştık, ya da işte derslerde gözlemlediğimiz kadarıyla bu çocuğun buna ilgisi var şeklinde fikirlerimiz olmuştu. Yine o şekilde fikir toplamakta fayda var, daha sonrasında onun üzerinde bir çalışma tasarlamak gerektiğini düşünüyorum.

[207] **S2-P2-Math-8 mart-(35)**
Güzeldi, çünkü deneyimi olan hocaların deneyiminden yararlanmak güzeldi. Bir yıl, ya da aynı yılda da olsa, 5 parmağın beşi bir değil. Her hocadan farklı bir şekilde tecrübe mutlaka kazandık. Bu etkileşim güzel oldu.

[208] **S2-P2-Math-8 mart-(33)**
Şöyle, en azından temayı kurarken aktivitede, en azından sizin söylediğiniz bir cümle benim aklıma başka bir cümle getirdi. Dedik ya uzayda, şunu yapalım, bunu yapalım. O fikir benim ufkumu daha da çok açtı.

[209] **S2-P2-Art-13 mart-(57-58, 61-62)**
[**Araştırmacı:** “Ortak bir çalışma için bir araya geldik. İki farklı meslek var ortada fakat beraber çalışıyorlar. Öğretmen var, tasarımcı var, öğretmenin bir bakış açısı var, tasarımcının bir bakış açısı var, bununla ilgili ne dersiniz?” sorusuna yanıt]
Resim öğretmeni: Öğretmenin karşılıklı iletişimi son derece güçlü olabilmeli. Geçen yine söylemiştim, “Tanrı daima geometri kullanır”. Gene bak laflar geliyor aklıma, ne konuştuğumun farkındayım o zaman. Tanrı geometriyi kullanırken; bir resim öğretmeni, bir tasarımcı da geometriyi kullanır zümreler arası işbirliğinde. Ben bir matematikteki geometrik şekilleri çocuklara tanıtmak zorundayım, görsel sanatlar öğretmeni olarak. İşte orada geometri olaya giriyor. Bir öğretmen komple olmalı, tasarımcı olmalı, artist olmalı. Bize eğitim psikolojisinde böyle demişlerdi, dramatize etmeli, matematik öğretmeni de dramatize etmeli.
Araştırmacı: Bir öğretmen tasarımcı gibi de düşünmeli mi yani?
Resim öğretmeni: Düşünmeli tabii hocam, başka türlü çıkamayız işin içinden.

[210] **S2-P2- SocialS -8 mart-(114-119)**
[**Araştırmacı:** “Bu kadar çalışma sonunda tasarım kavramına bakış açınız değişti mi?” sorusuna yanıt]
Sosyal bilgiler öğretmeni: Tasarım kavramını […] Önceden materyali kendim yapıp derste hazır olarak önlerine sunuyordum, ama bunda çocuklar kendileri tasarladılar.
Araştırmacı: Hangisini kastediyorsunuz, geçen dönemki aktiviteler mi?
Sosyal bilgiler öğretmeni: Evet aktivite, orada bir değişiklik oldu benim için.
Araştırmacı: Yani onların…
Sosyal bilgiler öğretmeni: Ben materyali ya öncesinden hazırlayıp, ya hazır bulup sınıfa öyle getiriyordum ama şimdi onlar da kendileri bir şey yaptılar, sürece etkin dâhil oldular.

[211] **S2-P2- English1-8 mart-(27)**
Örtüştüğü noktalar şöyle, mesela, bir konu doğrultusunda çocuk bir materyal hazırlıyor ve bunu hazırlarken materyalin konuyla alakalı olması, sonra hazırlarken bunu yaparak öğrenmesi, benim tamamıyla örtüşen noktam. Çünkü çocukların gerçekten yaparak ya da yaşayarak öğrenmesinden

yanayım ben. Direk bilginin öyle saf bir şekilde, sözle, yazılarak, çizilerek değil de, uygulayarak yapılmasından yana olduğum için. Bu bakımdan benim zihnimde örtüştü. Mesela, bir şey tasarlaması, bu aşama boyunca tabii bir şeylerin nasıl gerçekleştiğini sorgulaması, ortaya bir ürün koyması, bir kere zaten onun emeğinin olması, işte bunların tamamı örtüşüyor.

[212] **S2-P2-Science-13 mart-(27-30)**

Fen bilgisi öğretmeni: Tasarım zaten bana çok böyle şey bir kelime gibi geliyor, yani öyle herkesin yapamayacağı bir şey kesinlikle. Mesela, İngilizce hocam da diyor bana bir şeyi verin, ben onu yaparım ama düşünemem. Evet, bende de öyledir, yani tembelliğe kaçmak mıdır bu bilmiyorum ama.

Araştırmacı: Sebep ne hocam? Yanlış anlamayın ama sizce eğitimden mi kaynaklı? **(Fen bilgisi öğretmeni:** Yoo, doğru, eğitimden kaynaklı) Hazır bilgi veriliyor aynısı isteniyor gibi bir durum mu?

Fen bilgisi öğretmeni: Evet, kesinlikle öyle, kesinlikle haklısınız, o şekilde, ama mesela, ben bir deney yapacağım, önce makale tarıyorum. İnsanlar nasıl yapmışlar, ne yapmışlar, ben nasıl yapabilirimi düşünüyorum. Başlangıç yolunu bir önceki çalışmalardan alıyorum. Bu da bir hazırlık.

Araştırmacı: Ama doğru bir şey bu.

Fen bilgisi öğretmeni: Tabii ki. Yanlış değil kesinlikle, ama tasarımı bilmiyorum, yani biraz böyle geniş bakmak lazım olaya, ben mesela o kadar şey yapamıyorum. Nasıl diyeyim karmaşık düşünemiyorum. Bu belki benim yapımla alakalı, eğitimle kesinlikle çok alakalı olduğunu düşünüyorum. Siz şimdi bu işin içerindesiniz, zaten pratikliğinizden belli, konuşmanız bile, bir şeyi algılamanız bile hızlı. Ben mesela, diyorum ya hani algılayamıyorum ilk başta. Mesela, ilk dönem çok zorlanıyordum, algılamada zorlanıyordum. Çünkü çok pratiksiniz, çok hızlısınız doğal olarak olaya hâkimsiniz. Biz olaya hâkim olmadığımız için bizden pratik olmamız beklenemez. Ama ustasınız yani doğal olarak. Muhakkak ben adımların olabileceğini düşünüyorum. Zaten tasarım "hadi ben şunu tasarlayayım" deyip te tasarlanacak bir şey değil. Yani birçok şeyi düşünmek gerekir.

[213] **S2-P2-Science-13 mart-(25)**

Workshop' u yönetmenizle ilgili, ilk döneme birazcık empati de yapmak lazım, çünkü hiç bilmeyen insanlar var karşınızda. Şu an profesyonel miyiz? Tabii ki profesyonel değiliz, ama siz profesyonelsiniz. Ben öyle görüyorum, sonuçta bu sizin alanınız. İlk dönem bir de bize öğretmekle uğraştınız. Tabii ki her bir adımı nasıl yapmamız gerekiyor, nasıl ilerlememiz gerekiyor, nasıl düşünmemiz gerekiyor, bunu öğrettiniz. Bunları öğrettiğiniz için çok daha fazla yoruldunuz elbette bizim gibi. 2. dönem siz bizi tanıdınız, biz sizi tanıdık, az çok ne yapmamız gerektiğini ilk dönemden kaptık ve ona göre biraz daha hızlı ilerledik. Tabii ki birbirimizi tanıdığımız için, çocukları gördük, aktivite nasıl ilerledi, hata nerede yaptık, nerede yapmadık; bunların hepsini baştan zaten birinci dönem siz gördüğünüz için ona göre önlemlerinizi aldınız ve karşımıza geldiniz. Bu anlamda zaman tasarrufumuz çok büyük oldu. Yine düşünmemiz neyi nasıl ilişkilendirmemiz gerektiği konusunda da her zaman destek oldunuz zaten.

[214] **S2-P2-Math-8 mart-(18, 21-22)**

Matematik öğretmeni: Bir kere, siz, ders, ders, konu, konu, ayırmışsınız. Bize seçenek sundunuz ve o an seçeneklerden bir kombinasyon yarattık, dolayısıyla elimizde var olanlardan seçtik. Diğer türlü olsaydı, en azından bunları tek, tek ayırıp, listesini çıkarmak için çok fazla zaman kaybedecektik.

Araştırmacı: Bu şablonu çıkarmasam zorluk çeker miydiniz?

Matematik öğretmeni: Zamandan zorluk çekerdik, yoksa bir sıkıntımız olmazdı. Zaman kaybı olurdu, zamansal olarak en az 1.5 saatimizi kısaltmıştır.

[215] **S2-P2-Math-8 mart-(14-15)**

[**Araştırmacı:** "Tasarım odaklı düşünme size ne kattı diye sormuştum, siz de farklı bir tecrübe kattı demiştiniz, onu biraz açabilir miyiz?" sorusuna yanıt]

Matematik öğretmeni: Farklı bir tecrübe derken; bu kadar disiplini bir arada uygulayabileceğimizi bilmiyordum, en azından bunun farkındalığı artmış oldu. Mesela, konu işlerken, özellikle diğer şubelerde “Aaa hocam bunu şu dersle birleştirebiliriz” lafını duyuyorum artık hani. Demek ki biz de ders anlatırken sadece 5X sınıfı için değil, diğer sınıflar için de farkında olmadan dersleri birleştirerek anlatıyoruz ki STEM yapmadığımız gruplarda bile bazı öğrencilerin bilinçaltında STEM i oluşturmuşuz. En azından, en azından kişisel olarak benim ders anlatımıma ufak da olsa bir katkı sağlamış farkında olmadan, bilmeden de bizde oturan bir şeyler var demek ki.

[216] **S2-P2- English1-8 mart-(42)**

Ben uygulamak isterim ama diğer öğretmenlerle bir araya gelip bunu uygulamamız, boş saatlerimizi birbirimize uyarlamamız ya da uyumlu olan ders saatlerimizi ya da uyumlu olan konularımızı planlamamız. Yani, buna pek kimsenin yanaşacağını zannetmiyorum.

[217] **S2-P2-Math-8 mart-(59)**

Demek ki o çocuklarda geleneksel yöntemler değil, daha farklı, keşfederek öğrenme metoduyla yaklaşmamız gerekiyor. Demek ki o çocuklar özel çocuklar. Onlara daha özel programlarla konuyu anlatmamız gerektiğini, daha farklı yaklaşımlarla daha başarılı olabileceklerini gözlemledim.

[218] **S2-P2-Science-13 mart-(61-64, 69-72)**

[**Araştırmacı:** “Öğrenci K, Öğrenci M ve Öğrenci L 9 Ocakda diğerlerine göre sınıfın biraz daha önüne geçenlerdi, size göre bu bir tesadüf müydü ya da sizin tespitiniz nedir?” sorusuna yanıt]

Fen bilgisi öğretmeni: Ben buradan şunu çıkardım, yani grup çalışmasına gayet yatkın olduklarını görmüş olduk burada. Öğrenci K için konuşacak olursam, Öğrenci G çok çalışkan ve zeki bir öğrenci. Öğrenci K’ nın rahatsızlığı da var, tabii ki dolayısıyla bir düşüşte, ama belki de Öğrenci G’nin de çok gayretli olmasından dolayı tetiklenmiş olabilir diye düşünüyorum. Öğrenci L’nin arkadaşı da Öğrenci A idi değil mi?

Araştırmacı: Öğrenci L ile Öğrenci N, Öğrenci A ile de Öğrenci M idi.

Fen bilgisi öğretmeni: Öğrenci A ile öğrenci M iyi anlaşıyorlar zaten, ama ikisine baktığımız zaman Öğrenci A daha iyi gibi akademik olarak. Ama baktığımız zaman Öğrenci M de elinden geleni yaptı.

Araştırmacı: Öğrenci L ilk sorudaki matematik sorusunu bireysel olarak en doğru yapan kişiydi. O da ilginç bir nokta, yanındakilerin hepsi yanlış yapmış, yani yanındakilerden kopya çekebileceği bir insan yok, o da şaşırtıcı bir nokta. Öğrenci L erken çıkmıştı bir de o gün. Öğrenci N tek başına devam etti.

Fen bilgisi öğretmeni: Tesadüfen olmaz zannetmiyorum ama belki bilmediğimiz yönlerinden bir tanesini orada görmüş olduk.

Araştırmacı: O tür şeylere daha mı yatkınlar?

Fen bilgisi öğretmeni: Daha yatkın olduklarını düşünüyorum, çünkü ders esnasında bu kadar değil, yani Öğrenci L çok sessizdir, katılmaz ve başarı olarak çok iyi değildir. Bir Öğrenci G ile kıyaslanamaz mesela.

[219] **S2-P3- SocialS -19 nisan-(21-27)**

Sosyal bilgiler öğretmeni: Evet. Hayvan göç uzmanlığını çok değişik buldular. Orada hatta Nuh’ un gemisini örnek verdim ben çocuklara.

Araştırmacı: Ne dediler?

Sosyal bilgiler öğretmeni: Şaşırdılar, yani hiç bilmedikleri bilgiyle karşılaşınca, tepkileri birazda şaşkınlık oluyor.

Araştırmacı: Sorgulama çok oldu mu?

Sosyal bilgiler öğretmeni: Hayır, 5X sorgulamadı, işte dediğim gibi diğer sınıflar çok sorguladı.

Araştırmacı: Onlar ne dedi? Mantıksız mı buldular?

Sosyal bilgiler öğretmeni: Evet, mantıksız geldi. Uzayda oksijen yok, bu insanlar nasıl yaşayacak dediler, işte yer çekimi yok, havada mı uçacaklar diye sordular.

[220] **S2-P5-7 mayıs-(4, 8)**

Matematik öğretmeni: İlk döneme kıyaslama yaparsak, bence başarılıydı, gayet başarılıydı. Çocuklara STEM olmayacak dedik ama “STEM oldu.” dediler, “Aaa bizi kandırdılar.” falan dediler. Ama yine de aktivite güzeldi, hani etkinlik güzel çıktı sonuç olarak. Şöyle tek sıkıntıları materyal ve silikon tabancası oldu. Onu da versek herhalde harikalar yaratacaklardı. Ama bence ilk döneme göre güzel, başarılı ürünler çıktı.

[221] **S2-P5-7 mayıs-(6-7)**

Matematik öğretmeni: Bu dönemin konuları evet, bizim için de zevkliydi (**Sosyal bilgiler öğretmeni**: Başını salladı.) İlk dönem, ya ilk olduğu için çok zorlandık ya da 2. döneme alıştık artık, sistematiğini öğrendik.

Sosyal bilgiler öğretmeni: Ama 2. dönem daha şeydi. (**Matematik öğretmeni**: Konularımız zevkliydi, uyuştu.) Konular zevkliydi, ortaya çıkan hani somut bir ürün vardı en azından. Mesela, tasarımları, bir şehir planlamaları, çok hoş olmuştu.

[222] **S2-P5-7 mayıs-(56-62)**

Matematik öğretmeni: İngilizce' de Öğrenci F' in bence 10 olmasının sebebi üstüne işaretlemeyi unutmasındandır.

Araştırmacı: Hocam onu çoğu unutmuş durumda gerçekten.

İngilizce öğretmeni: Evet ben de onu diyecektim, şaşırdığım bazı isimler var. Mesela, Öğrenci D ve Öğrenci B gibi. Onlar çünkü genelde İngilizce' de çok iyi öğrencilerdir.

Araştırmacı: Ama burada başarısız olmuşlar, unutmuşlar gerçekten.

İngilizce öğretmeni: Bir Öğrenci Y' ye şaşırdım. İyi değildir ama 14 yapmış, 15' te 14 yapmış.

Araştırmacı: Ama Öğrenci Y hatırlamış. Hatta Öğrenci Y' nin hatası şuydu; aynı mesleği iki defa yazmış, yoksa normalde Öğrenci Y tam puan alacaktı.

Matematik öğretmeni: O zaman Öğrenci Y' nin eğitim modeli bu.

[223] **S2-P5-7 mayıs-(65-66)**

İngilizce öğretmeni: Nesli tükenmekte olan hayvanlara tik koyun dememe rağmen, orada böyle tik' i göstermeme rağmen…

Matematik öğretmeni: Okumuyorlar ki, soruyu okumuyorlar.

[224] **S2-P5-7 mayıs-(91-92)**

[**Araştırmacı:** "Peki aklınıza takılan sorular var mıydı aktiviteyle ilgili?" sorusuna yanıt]

Matematik öğretmeni: Ben Öğrenci C' lerin olduğu taraftaydım, hani diğer tarafa baktığımda, maketleri, hayal ürünleri hiç benlik değil. Hani şöyle, yapmak istediklerini malzemelerle hayal edip de yapamıyorlar. Hani sıkıntıları oydu. Biraz zaman azalıyor diye hayal ettiklerini veya düşündüklerini uygulamakta zorluk çektiler, tek zorlukları oydu.

[225] **S2-P5-7 mayıs-(31, 48)**

Matematik öğretmeni: Ben Öğrenci F ile Öğrenci C' ninkini beğenmiştim aktivite sırasında. (**Araştırmacı:** Biz 50 puan verdik ona, onları yaratıcı bulduk.) Evet, benim birincim oydu […] Öğrenci C ile Öğrenci F inki güzel, iki numarada Öğrenci D ve Öğrenci E, benim üçüncümde Öğrenci H ve Öğrenci Z, hani hastane fikri falan vardı.

[226] **S2-P5-7 mayıs-(102, 104, 106-108)**

[**Araştırmacı:** "Başından beri STEM' i nasıl söylemeliyiz diye tartıştık. Hep soru işareti vardı aklımızda." sorusuna yanıt]

Matematik öğretmeni: Yani şöyle çocukların kaygısına bakarsak, nerede söylediler hatırlamıyorum ama sınıfta konuştuk galiba. Çocuklarda STEM karneye geçecek mi, geçmeyecek mi endişesi vardı. Atıyorum, dersler arası işbirliği oluyor diye o derslerden geri kalırız korkusuna sahiptiler. Yani STEM, hani eğer eğitime entegre edilecekse, hani sosyal etkinlik saati gibi bir STEM aktivite saati olabilir. Hani çocuklara STEM en baştan beri söylenmeli. Ama zaten STEM aktivitesi olacağı için, hani ilk dönem yaptığımız gibi her öğretmen etkileşimli olarak derse girerse, belki daha farklı sonuçlar çıkabilir. Hani böyle çaktırmadan bir şeyler yapılınca bu tarz zorluklar çıkıyor, ama bunu sabitlersek çok daha farklı sonuçlar çıkar diye düşünüyorum. Çocukların yorumuna göre bu geliyor aklıma.

Sosyal bilgiler öğretmeni: Hani hocam söyleseydik de bence sorun olmazdı, çünkü geçen dönemki gibi 2- 3 öğretmen derse girmedik veya siz gelmediniz. Kamera olmadı, fotoğraf çekimi olmadı. Bunlar olmadığı için bilebilirlerdi, ama yine bence rahat olurlardı. Çünkü her dersin öğretmeni kendi dersini işler gibi işledi.

Araştırmacı: Evet bu dönem bir farklılık da o oldu. Hepiniz kendi derslerinizde konularınızı anlattınız, o yüzden hiç bağlantı varmış gibi gözükmedi (**Sosyal bilgiler öğretmeni**: Evet, **Matematik öğretmeni**: Yok, **İngilizce öğretmeni:** Başını salladı).
Sosyal bilgiler öğretmeni: İki veya üç öğretmen derse girip çocukların gözlerinde işte bir korku yaratmadık, onlarda biz neyin içindeyiz endişesi olmadı. Söyleyebilirdik aslında.
[227] **S2-P5-7 mayıs-(190-191)**
Sosyal bilgiler öğretmeni: STEM atölyesi olabilir.
Matematik öğretmeni: Atölye. Küçük, küçük masaların olduğu, rahat oturabilecekleri minderlerin olduğu bir yer.
[228] **S2-P5-7 mayıs-(163-169)**
[**Araştırmacı:** "Sizce STEM yaklaşımının bu şekilde okula dâhil edilmesinde, **(İngilizce öğretmeni:** Bir sakınca olur mu?) bir sakınca olur mu?" sorusuna yanıt]
Matematik öğretmeni: Şöyle mesela, en başta dediğim şey, hani STEM yaklaşımı okul bazında eğitim sistemine dâhil edilecekse, evet bence de edilmeli, ama bir etkinlik saati gibi bunun da bir saati olmalı. (**İngilizce öğretmeni:** Seçmeli ders gibi) Seçmeli veya sosyal etkinlik dersi gibi, sosyal etkinlik de STEM grubu olmalı.
İngilizce öğretmeni: Teknoloji tasarım veya bilişim dersi gibi bir ders olabilir. (**Matematik öğretmeni**: Bir ders olmalı.) Yani ekstradan ona bir şey ayrılmalı, ona bir zaman ayrılmalı (**Sosyal bilgiler öğretmeni**: Evet).
Matematik öğretmeni: Ona bir haftalık ders programında ders ayrılmalı yine öğretmenler çalışıp hatta…
Sosyal bilgiler öğretmeni: Bir koordinatör bence olmalı.
Araştırmacı: Hepimizi şey yapan (**Sosyal bilgiler öğretmeni**: Yönlendiren) ayarlayan (**Matematik öğretmeni**: Tabii tabii ayarlayacak) Dâhil olacak mı, olmayacak mı diye bakacak.
İngilizce öğretmeni: Yani disiplinlerarası hani böyle uyum ya da ortak nokta bulunup çocuğa verildiği zaman, çocuk konuları birbiriyle bağdaştırdığı zaman (**Matematik öğretmeni**: Çocuk için faydalı bir şey) daha iyi algılayabilir. Bağlantı kurunca birbiriyle hani bazı şeylerin, hani puzzle yapmak gibi, daha iyi algılayabilir, bence.
[229] **S2-P5-7 mayıs-273-282**
[Araştırmacı: "Peki bir tasarımcıyla çalışmanız, tasarım metodu kullanmanız size çok yabancı geldi mi ya da size bir şey kattı mı?" sorusuna yanıt]
Matematik öğretmeni: Hani bir tasarımcıyla çalışmanın STEM de bize büyük katkısı var. Çalışılacaksa da bir tasarımcının eşlik edip rehberlik etmesinin çok büyük faydası var.
Sosyal bilgiler öğretmeni ve İngilizce öğretmeni: Evet
Araştırmacı: Ne anlamda olduğunu söyleyebilir misiniz? Çünkü bir eğitimci de olabilirdi burada, sonuçta STEM bir eğitim yaklaşımı.
Matematik öğretmeni: Hani ilk başta ben şey demiştim bir tasarımcı bir eğitimci değil. Eğitime tasarımı nasıl uygular diye hani düşünmüştüm, bir bağdaştıramamıştım. Ama eğitimci mi ve tasarımcı mı diye düşünürsek sonuçta tasarım odaklı düşünme olduğu için, tasarımcı derim.
Sosyal bilgiler öğretmeni: Eğitimci de kendini bir branşta, yani bir alanda geliştirmiş biri olur. Büyük ihtimal disiplinlerarası bu kadar fayda sağlayamazdı.
Matematik öğretmeni: Yaratıcılıksa özümüz, tasarımcı olmalı.
Sosyal bilgiler öğretmeni ve İngilizce öğretmeni: Evet
Araştırmacı: Hocam siz ne diyorsunuz?
İngilizce öğretmeni: Aynı fikirdeyim.
[230] **S2-P5-7 mayıs-(132-133)**
[**Araştırmacı:** "Geçen dönem, biz beraber ders işledik, ama bu dönem öyle bir şey yapmadık. Ayrı, ayrı herkes konularını derslerde işledi. Geçen dönemle bu dönemi karşılaştırdığınızda ne söyleyebilirsiniz?" sorusuna yanıt]
Matematik öğretmeni: Yani şöyle, ilk dönem birbirimizin derslerine girmek, özellikle her derse ben girdiğim için benim açımdan yorucu oldu. Hani düşünmek, birleştirmek, karşılıklı olarak

öğretmenlerle ders işlemek, bunların külfeti, ağırlığı vardı üstümüzde. Ama bu dönem herkes kendi işini yaptı, hani çocuklar da çok üst üste görmedi bizi. Çünkü haftalarca ben girmiştim onların dersine. Böyle bir de şansızlık olmuştu. Bu dönem benim açımdan o bakımdan çok rahattı ve olacaksa hani böyle olması daha iyi. Herkes kendi dersine gitsin, hani gerekli yerlerde aralara disiplinlerarası dersler serpiştirilir, ama kimse kimsenin dersine girip de çocukların gözünü korkutmaz. Çocuklar ciddi anlamda şey yapıyorlar, hani ne oluyor, ne bitiyor endişesi oluyor. Sınıfın işlenme düzeni daha da farklılaşıyor. Hani sizin derse gelmeniz onların dikkatini çekti, kamera, hani bunlar hep sorun oluyor. Yani çocukların söyledikleri onlar.

[231] **S2-P5-7 mayıs-(283-287)**

[**Araştırmacı:** "Bu çalışmalarla ilgili çalıştay olsun, STEM olsun ya da tasarım olsun, ben bunlardan bir tanesini kullanabilirim ya da şöyle bir şey yapabilirim gibi herhangi bir şey aklınızda var mı?" sorusuna yanıt]

Matematik öğretmeni: Hani en azından ilk dönem birbirimizin derslerine girdik. Ama mutlaka bir sonraki basamakta, 5. sınıf olmaz da 6. veya 7. sınıfta, en azından müfredatlara bir ne var ne yok diye bakıp hani disiplinlerarasını kendi tekelimde uygulamaya çalışırım. Tabii ki yani fırsat bulup aklıma gelirse uygularım.

Sosyal bilgiler öğretmeni: Ama tek başına karar vermekle yine olmuyor o zaman.

Matematik öğretmeni: Hani şöyle tabii ki olmuyor ama en azından kimseyle ortak çalışmazsam da kendi tekelimde "Aaa şunu öğrenmiş miydiniz sosyal dersinde?" deyip matematiği kendi tekelimde bağlarım. Mesela, "Bak fende şöyle şeyler var" deyip matematiğe uygularım. Kendi tekelinde bağlarım kendi içimde yani.

İngilizce öğretmeni: Aynen, şey takvim yaptırmamla ders programı hazırlatmam arasındaki farkı işte açığa koyuyor. Ben ilk dönem çocukların cetvel kullanmayı bilmediklerini bilseydim, hiç kalkışmazdım böyle bir şeye.

[232] **S2-P5-7 mayıs-(297-298)**

Sosyal bilgiler öğretmeni: Hocam, okulun bir sistemi olması lazım. Sistemi olmayan bir okulda uygulanır ama (**Matematik öğretmeni**: Zoru başardık.) branş tek başına uyguladığında, bir verim alınmaz, normal konu anlatımı gibi olur, bir ürün yapılmaz.

Matematik öğretmeni: Evet, ürün çıkarma da disiplinler şart (**Sosyal bilgiler öğretmeni:** evet) Ama ürün çıkmayacaksa, konu anlatımı tekelinde bireysel uygulanabilir.

[233] **S2-P5-7 mayıs-(309-310)**

Sosyal bilgiler öğretmeni: Hocam ben kendi dersim adına konuşayım, gerçi tüm branşlarda aynıdır da, ilk dönem konuları biraz daha akademik olarak ağır oluyor. (**Matematik öğretmeni**: Evet, matematikte de öyleydi.) İkinci dönem işte, havalar ısınıyor, tatil yaklaşmış oluyor. MEB de buna göre plan yapıyor müfredatta. (**Araştırmacı:** Daha mı hafif oluyor?) Konular daha hafif oluyor, daha eğlenceli oluyor (**Matematik öğretmeni**: Evet). Bu yüzden, hani ikinci dönem olabilir. Çünkü biz birinci dönem de konuları disiplinlerarası birleştirmede bu bağlamda zorlandık. Çünkü ağır konulardı, her dersin baba konuları vardı. Ama ikinci dönem de daha eğlenceye yönelik, daha zevk alabilecekleri konular olduğu için, (**Matematik öğretmeni**: Evet) 2. dönem bu yüzden de bence verimli oldu (**Matematik öğretmeni**: Kafasını sallar).

Matematik öğretmeni: Çünkü kolay konulardı ilk döneme göre, gerçekten kolay konular vardı. (**Sosyal bilgiler öğretmeni:** Evet)

[234] **S2-P5-7 mayıs-(235-241)**

[**Araştırmacı:** "Hocam siz ne açıdan kendinizi yaratıcı bulmuyorsunuz?" sorusuna yanıt]

İngilizce öğretmeni: Materyal tasarımı konusunda evet hayal gücüm biraz yüksek, ama yani ne bileyim (**Araştırmacı:** Uygulamaya dökmek mi zor oluyor?) Evet.

Matematik öğretmeni: O ki bende de var, uygulamaya dökememe, imkânlar.

İngilizce öğretmeni: Bir fikir geliştirici, böyle bir asistan durumu bende şart. Bir kişiyle konuşurken bir bakıyorum aslında bir şey kendim tasarlayabilirim, ama tek başıma şöyle düşünüp, yok olmuyor.

Araştırmacı: Peki bu çalışma, sizin yaratıcılığınıza bir katkısı oldu mu?

Matematik öğretmeni: Oldu.
İngilizce öğretmeni: Oldu, oldu, benim oldu. Ben takvim yaparken gayet çok yaratıcıydım. Yani bilmiyorum nasıl geldi aklıma, çok yaratıcı bir fikir bence. Yani böyle fikir benim aklıma normalde gelmezdi.
[235] **S2-P5-7 mayıs-(194, 200)**
Matematik öğretmeni: Müfredatlarımıza bakınca, aslında her şeyin içinde matematik var. Ama nasıl uygulayacağız bunu çocuklara? Ama ilk dönemden sonra yok, öyle çalışamam dediğim bir disiplin yok yani.
İngilizce öğretmeni: Ben önceden fen bilgisiyle ne alaka diyordum. Ama o da varmış.
[236] **S2-P5-7 mayıs-(171-178)**
İngilizce öğretmeni: Çocuklar takvim hazırlayacaklardı "party time" da. Bayağı böyle takvim hazırlattım ben onlara.
Araştırmacı: Nasıl oldu peki? İlk dönem pek istediğiniz sonucu elde edememiştiniz galiba?
İngilizce öğretmeni: İlk dönem geometri görmemişlerdi çünkü hani cetvel kullanımını bilmiyorlardı. Çok zorlanmıştım ders programını hazırlatırken. Şimdi ikinci dönemde onlarla takvim hazırladık, yani 12 yaprak yaptılar, ayrıyeten bir tane de kapak hazırladılar. Ben onları kendim dışarda tepelerini deldirtip, tellettim, sonra araya da bir mukavva koydum destek için. O şekilde masalarına koyup, böyle her sayfayı çevirebiliyorlardı. Böyle kare, kare yaptılar, o karelerin içine de o günlerde önemli bir şey ya da ne varsa onları yazacaklardı. Bu sefer cetvel kullanımı daha kolay oldu. Üstelik bunu 5Y ve 5X sınıfıyla yaptım, evet, iki sınıfla yaptım ama 5Z sınıfıyla yapmadım.
Araştırmacı: İstediğiniz sonuçları mı elde ettiniz?
İngilizce öğretmeni: Sonuç olarak evet, çok güzel ürünler çıktı. (**Araştırmacı:** Sevdiler mi peki yaparken?) Sevdiler takvimleri, Öğrenci C'nin falan hatta bazılarının masasındaydı takvimleri.
Matematik öğretmeni: Daha düne kadar 5Y' ninde masasındaydı ve girer girmez takvimlerini bana gösteriyorlardı. "Hocam bakın işte takvimimiz." diye. Takvim oluşturmada resimler istemişsin onlardan, resimlerini gösteriyorlardı ders arasında.
Araştırmacı: Sahiplendiler yani, çok güzel.
İngilizce öğretmeni: Öğretmenlerden resim istediler, doğum günlerini hatırlamak için, o ayın arkasına böyle yapıştırdılar. Mesela, o ay Emine hocasının mı doğum günü var. O ayın arkasındaki sayfaya Emine hocasının resmini yapıştırıyormuş.
[237] **S2-P5-7 mayıs-(202, 204)**
[**Araştırmacı:** "Çalıştay için ve orada kullandığımız metot için şu anda neler düşünüyorsunuz? Ya da önerileriniz var mı bana?" sorusuna yanıt]
Matematik öğretmeni: Metottaki o aşamalar ilk defa yapılacaksa, o ilk dönemin mutlaka 2. döneme, yani bizim anlamımıza çok iyi katkısı oluyor.
[238] **S2-P5-7 mayıs-(306-307)**
İngilizce öğretmeni: İlk dönem, hani mesela, yeni gelen öğretmen olabilir, yeni gelen öğrenci olabilir. Yani tövbe bismillah ne ile karşılaştık diye ilk dönem. (**Araştırmacı:** Alışma anlamında.) Tabii, duraksayabilirler. Zaten öğretmen ile öğrencinin birbirlerini tanımaları ya da öğretmenin birbirlerini tanıması zor olabilir, çocukları gruplandırması daha zor olabilir. Ama ikinci dönem iyidir.
Matematik öğretmeni: En azından 5 sınıflar için. Çünkü öğretmeni yeni, öğrencisi yeni ama şimdi her çocuğu tanıyorsun, biliyorsun, çocuk seni tanıyor. (**İngilizce öğretmeni**: Tabii.) En büyük rahatlığı bu. Ha belki müfredata uygun olur, 6 sınıfta yapılır, o zaman ilk dönem yaparsın, çünkü zaten çocuğu bir senedir tanımış oluyorsun.
[239] **S2-P5-7 mayıs-(16)**
Matematik öğretmeni: 2. dönem ciddi anlamda tasarım yaptılar. Hep tasarım yaptılar. İlk dönem bir şablona odaklamıştık onları, yani onların laflarından düşününce evet ilk dönem şablona şartlanmışlardı, ürün belliydi. Şimdi gerçekten hayal dünyalarını yansıttıkları bir şey oldu (**Sosyal bilgiler öğretmeni**: Evet).

[240] **S2-P4-Art-16 mayıs-(6, 16)**
Birinci dönemden daha hareketli, daha üretken, daha düşünebilen çocuklar gördük. Sanki bakmıyor, yüzüne anlatıyoruz ama çocuk hemen olayı kavramaya çalışıyor, getirilen objelerle nesnelerle bir şeyleri üretmeye çalışıyor. Birinci dönemki ağırlıklarını ikinci dönemki aktivite de ben hiç hissetmedim. Gayet hemen çizimler, işte proje çizimleri, eskizler, anlatımlar, o afişler yapıldı. Ondan sonra uygulamalar gayet seri gitti yani ve belli zaman dilimleri içinde bunu vermeye çalıştılar eldeki malzemelerle.
[241] **S2-P4-Art-16 mayıs-(3-4)**
[**Araştırmacı: "**Hocam hem bu dönem ki aktiviteyi değerlendirip, hem de geçen dönemle karşılaştırsak ne söyleyebilirsiniz bana?" sorusuna yanıt]
Resim öğretmeni: Hocam, bu dönemki aktivite özellikle çocuğun yaratıcı gücünü zorlayıcı bir aktivite oldu, böyle uzay, uzay meslekleri gibi temaları içerdiğinden dolayı. Geçmiş dönemde de, yani geçtiğimiz dönemde de en güzel şekilde somut verilerden hareketle STEM' i ele aldık. Yeri geldi üç boyutlu şekillerle, çocuklarımızın getirebildiği objelerle, nesnelerle, dersleri sunmaya çalıştık ki böyle olması gerekir. Bir konunun anlaşılır olabilmesi için onu soyutluktan kurtarıp işte somuta doğru gitmesi gerekir zaten, eğitimin amacı da budur. Öğretmenliğin amacı da budur, birinci dönemdeki o çalışmalar da gayet güzel götürüldü, böyle olması da gerekiyordu zaten.
[242] **S2-P4-Art-16 mayıs-(1-2)**
STEM' in ve STEM aktivitelerinin uygulama ağırlıklı olması çok hoşlarına gidiyor. Araç, gereç kullanma şeyleri çok hoşlarına gidiyor. Sınıfta da olsa, atölyede de olsa, onlara düzenlemiş olduğumuz fiziki mekânda da olsa, orada gruplar en azından karşılıklı tartışabiliyorlar, konuşabiliyorlar, bir hareket var yani, robotsal bir şey yok. "Bunu böyle koyalım, niye koyduk?" Ben duydum, orada mesela işte "şunu şöyle keselim" diye konuşuyorlar.
[243] **S2-P4-Art-16 mayıs-(36)**
Başarı, yeni bir takım bilgi ve becerileri ne derece kendine mal ediyorlar ile ilintilidir sayın hocam. Burada da çocuk için malzeme kullanmaktan alın, çizim veya afiş tasarımlarına kadar öyle ya da böyle afişte yazıların olabileceğini burada kademe kademe hissetti. Bir malzemenin neyle kesileceği, neyle yapıştırılacağını veya onların bir araya getirilirken nasıl bir form oluşturacağını, çocuk hissetti.
[244] **S2-P4-Art-16 mayıs-1-(52)**
En pasif kişi bile en hareketli kişi olmaya çalıştı. Öğrenci K sakin biriydi, aktivitede bir takım şeyleri, formu, biçimi, eskizi, çizimi falan filan öyle de olsa böyle de olsa verdi. Mesela, Öğrenci Y bile işte önceden defter getirmekte direnen çocuk, şimdi bir şeylerle geliyor, karşılıklı konuşuyor, bu yetmez mi?
[245] **S2-P4-Art-16 mayıs-(26)**
Bende sizin gibi yapardım (Stratejileri kastediyor). Ama başta da söyledim, her yeni şey isyanı, itirazı beraberinde getiriyor. Bu yeni de değil aslında ama toplumun buna artık adapte olması lazım. Yani ben böyle düşünüyorum. Bizler adapte olursak, çocuk da adapte olur, biz önünde bir örneksek eğer, o da adapte olur.
[246] **S2-P4-Art-16 mayıs-(40)**
Üç hocayı birlikte gördükleri için tepki gösterdiler. Ben resim anlattım veya matematikle, sosyal bilgilerle ilintili olduk. O zaman çocuk resim dersinin özgürlüğünü, rahatlığını sanki yaşamamış oldu. Tepkileri ondandı. Ama buna da zaman içinde alıştılar. En azından aktivitede bile birkaç hocaydık.
[247] **S2-P4-Art-16 mayıs-1-(4, 11-12)**
Resim öğretmeni: Bu tür şeyler de fiziki mekânların çok daha iyi olması, belli araç gereçlerle donatılması lazım.
Araştırmacı: Hocam, peki, öğrenci için ayrı bir yer yaratılması gerektiğini söylüyorsunuz, peki öğretmenler için böyle bir çalışmanın yapılabilmesi için neler lazım?

Resim öğretmeni: Öğretmenler için yaratılırken, daha bir takım teknik cihazlarla bunu desteklemek lazım. Mesela, otomatik kesen, küçücük bir dişçi aleti var. (**Araştırmacı:** Fireze) Evet, fireze dediğimiz olması lazım.

[248] **S2-P4-Art-16 mayıs-1-(60)**

Bir defa STEM eğitimi gerek benim için, gerek çocuklar için gerekli, sadece benim için de değil diğer öğretmenler için de devamlı olarak zümre öğretmenleriyle işbirliğinin bir yıl boyunca sağlanması gerekli. Yeri geldiğinde ufak uygulamalar yapılması gerekmekte. Ne bileyim işte bir sahne tasarımında bir konuyla ilgili sosyal bilgiler öğretmeninin görüşünün alınması, neler katabilirizi konuşmak.

[249] **S2-P4-Art-16 mayıs-(2)**

Şimdi sizlerle sene başından bu yana bu STEM çalışmasının içinde olan bir öğretmenim. Gördüğüm kadarıyla bunun planlama ve paylaşmada eğitimde gerekli olduğu kanısına bir defa vardım. Disiplinlerin, disiplinlerarası, dersler arası kaynaşmanın eğitimde gerekli olduğu kanısına vardım. Sadece matematik ile olaya bakmamak gerekir veya bir başka dersle olaya bakmamak gerekir. Görsel sanatların da bu şey içinde, bu bölüm içinde yerinin olduğunu, hem de çokça yerinin olduğunu, özellikle matematik, fen bilimleri ve diğer disiplinler gibi kesinlikle ve kesinlikle, olmazsa olmaz olduğunu ben düşünüyorum eski bir öğretmen olarak. Eğitimin temelinde de zaten bunlar vardır. Bunun daha bilimsel şartlarda, daha çok zaman ayırarak bu çalışmalar ile her an güncellenmesi lazım bence.

[250] **S2-P6-3 mayıs-(36)**

Öğrenci G: Öğretmenim, böyle iyiydi, ama benim dediğim gibi bir zaman sıkıntım oluyor. Mesela, daha önce böyle şeyleri çok yavaş yapan bir insandım, ama süre çok olunca daha iyi yapabiliyorum. Bence güzeldi yani.

[251] **S2-P6-3 mayıs-(30, 32, 34)**

Öğrenci B: Hocam, önceki dönemde birkaç soru tane vermiştiniz. O biraz zordu. Ama bu daha basitti, hani biraz değişik oldu, ama güzeldi bence.

Öğrenci C: Hocam bir öncekinde kâğıtta bir sürü sorular sormuştunuz ya, bence o yüzden bu daha güzel oldu. Böyle şeyler yapmadık, bu daha şeydi (**Öğrenci E:** Akıcı oldu) aynen.

Öğrenci D: Öğretmenim diğerlerine katılıyorum. Kâğıt vermiştiniz. Orada sorular vardı. Ama bunda direkt tasarlama yaptık. İşte o yüzden (**Öğrenci B:** O yüzden) daha güzeldi.

[252] **S2-P6-3 mayıs-(104-107)**

Öğrenci F: Hayvanların olması biraz alanımızı daralttı yani. Normal uzay yaşamı olsaydı yani [...] Hayvanların olması, alanı ikiye bölüyorsun, bir yanda insanlar…

Araştırmacı: İşte probleminiz oydu sizin bu seferde. Hayvanların da olması...

Matematik öğretmeni: Fark etmediğiniz problem buydu aslında.

Araştırmacı: Evet, yani geçen dönem ki gibi bir probleminiz vardı.

[253] **S2-P6-3 mayıs-(82-84)**

Öğrenci D: Ben şimdi kendime göre konuşacağım. Dondurmanın erimemesi için bir sürü kafa yorduk, çünkü bir problem verdiniz. Ona kafa yorduk ve yapmamız da nasıl desem sıkıntılı oldu. Ama şimdi siz sadece bir uzay verdiniz. Uzay konusunu verdiniz. Uzay konusuna göre daha serbest çalışabildik.

Araştırmacı: Burada da bir problemimiz vardı aslında. Sonuçta yeni bir yaşam alanına gidiyorsunuz, hayvanları da götürüyorsunuz, meslekler de var bunun yanında.

Öğrenci D: Tamam ama şimdi şöyle de bir şey var. Her şey hayal gücümüze bağlı. (**Öğrenci A**: Aynen) Yani gelecekte ne olacağını bilemediğimiz için. Mesela, belki gelecekte deniz mor olacak onun da dediği gibi, mesela, denizi mor yapabiliyoruz. Ama buzun erimemesi için yani…

[254] **S2-P6-3 mayıs-(55-60)**

Öğrenci E: Öğretmenim, şimdi biz ilk kâğıda bir şeyler yapacaktık ya, biz hiç bir şey yapmadık. Böyle sadece bir ev çizdim. Biz direkt yani tasarım yaptık.

Araştırmacı: İyi bir şey mi yaptın sence?

Öğrenci E: Öğretmenim, bence daha güzel bir şey oldu.

Araştırmacı: Öyle mi diyorsun?
Matematik öğretmeni: Ama şöyle tasarımcı, ama şöyle şimdi yanımızda bir tasarımcı var.
Öğrenci A: Taslak çizmek lazım.
Araştırmacı: Evet, aynen öyle. Eskiz çizmeden aslında başlayamazsın, çünkü ne yapacağınızı bilmiyorsunuz. Sonradan çözümlerinizde niçin bunu yaptığınızı konuşurken, sonradan ekledik diye cevap verdiniz. Niye eklediğinizin bile farkında değildiniz.
[255] **S2-P6-3 mayıs-(86-92)**
Öğrenci G: Öğretmenim, şimdi bence ikisi de çok zorlamadı, ama bence ilk dönem daha kolaydı. Çünkü kendi adıma konuşuyorum şimdi, ben daha çok gerçek üzerine çalışmayı seviyorum.
Araştırmacı: Daha ayakların yere bassın mı istiyorsun?
Öğrenci G: Evet. Yani böyle nasıl anlatsam…
Araştırmacı: Çok hayal edemedin mi?
Öğrenci G: Şöyle düşünün. Ben % 70 ya da % 60 gerçek düşünür, % 40 hayal edebilirim.
Matematik öğretmeni: Sen realistsin o zaman. Daha reel çalışmayı seviyorsun.
Öğrenci G: Evet, gerçekçi çalışmayı seviyorum.
[256] **S2-P6-3 mayıs-(112-113)**
Öğrenci A: Hocam mesela, problemimiz vardı ya, o problem bence uzayda olunca ve insanlar da olunca çok zor oldu. Mesela, geçen sefer de böyle herkes kutu şeklinde yapmaya çalıştı. Daha kolay bir şekilde yapabildik. Ama bu sefer, kutu şeklinde olmadığı için yapamadık, bir de böyle maket yapmak deyince daha çok sanırım aklımıza ev geliyor.
Araştırmacı: Örneğin, geçen kinde ben sizden kutu şeklinde bir şey istemedim, siz yaptınız. **(Resim öğretmeni:** Evet**)** Onda da hayal gücünüzü kullanabilirdiniz ama siz kullanmadınız. Bu şekilde, Öğrenci F'nin çözümlerini tercih ettiniz sonuç olarak. Çünkü görsel olarak aklınıza dondurucuyu düşününce, kutu şeklinde bir şey geliyor. Neden? Çünkü karşınızda sürekli kutu şeklinde buzdolapları var, dondurucular var (**Öğrenci D:** Alışmışız.).
[257] **S2-P6-3 mayıs-(325-330)**
Öğrenci G: Öğretmenim bence şöyle bir sistem getirebiliriz, yani devam edeceksek. Oylama yapabiliriz mesela o konular arasında.
Araştırmacı: Güzel bir öneri bence bu, güzel bir öneri.
Öğrenci A: 3 konu verirsiniz.
Öğrenci G: Öğretmenim, mesela, konular şu, şu deyip el kaldırma.
Araştırmacı: Tamam.
Matematik öğretmeni: Konuları gruplandırıp ona göre oylama.
[258] **S2-P6-3 mayıs-(40-44)**
Öğrenci F: Bu dönem, Deniz'in partnerim olmadığını biliyordum. Olmayacağını biliyordum. Ama yine de, biraz daha zorlandım.
Araştırmacı: Konu mu zor geldi?
Öğrenci F: Konu değil. (**Araştırmacı:** Ne?) (**Matematik öğretmeni:** Tasarlamak?) Tasarlamak.
Araştırmacı: Tasarlamak zor geldi sana.
Öğrenci F: Aklımdaki şeyi yapamadım.
[259] **S2-P6-3 mayıs-(301-309)**
[**Araştırmacı:** "Arkadaşlar, gruplandırmaları nasıl buldunuz?" sorusuna yanıt]
Öğrenci B: Çok güzeldi.
Öğrenci C: Güzeldi, hocam, Öğrenci Y'den kurtuldum.
Herkes: "Güzeldi, çok güzeldi" diye hep bir ağızdan konuşurlar.
Öğrenci G: Öğretmenim ben biraz böyle karışık orta gibiyim ama (**Matematik öğretmeni:** Başka birisi olsa, daha iyi olurdu.) başka birisi olsa aynen.
Öğrenci D: Öğretmenim şimdi Öğrenci X ile Öğrenci Y dışında onları saymıyorum. Ya bence herkes, eşini iyi idare etti diye düşünüyorum.
Araştırmacı: Öyle mi düşünüyorsun?
Herkes: Öyle hocam. Ben de hocam, evet, evet.

Öğrenci H: Bence arkadaşlar iyiydi. Birlikte yapabiliyoruz yani.
[260] **S2-P6-3 mayıs-(69-71)**
Öğrenci G: Öğretmenim ya ben şunu söylemek istiyorum. Yani, şimdi, gruplar iyi, biraz farklı bir konuya çıktım biliyorum ama gruplar iyi. Ama ben yani, birazcık aramızda kalabilir ya da Öğrenci K ya da söyleyebilirsiniz yani ben Öğrenci K ile biraz yavaş yapıyorum sanki.
Araştırmacı: Hmm, karar verme süreniz mi uzuyor?
Öğrenci G: Karar verme değil yani bir şey koymak için mesela, bunu buraya koyacağız diye (**Öğrenci B:** Yarım saat konuşuyor) aynen, yarım saat konuşuyoruz, düşünüyoruz işte şöyle olur, böyle olur diye. Hep böyle zıtlaşıyoruz fikirlerde.
[261] **S2-P6-3 mayıs-183**
Öğrenci G: Gerçekten yani benim bir tavsiyem var, ama yapmak zorunda değilsiniz. Bence bu kadar bol getirmeyin. Çünkü bu kadar bol getirince böyle herkes "Aaa" oluyor (**Öğrenci B**: Hiç görmemiş gibi saldırıyorlar). Öğretmenim, mesela, ben buradan ne aldığımı hemen söyleyeyim. 2 tane karton şey aldım. Eee, şey aldım, bardak, 3 tane. 3-4 tane de pipet aldım. Sonra da iki tane de chopstick ve zımba aldık.
[262] **S2-P6-3 mayıs-(296, 298)**
Öğrenci G: Bir de mantığına bakılmıyor ki proje yapımının. Böyle şeyine, yani süsüne, püsüne bakılıyor. […] Böyle ışığına, mışığına falan bakılıyor yani. Benim sevmediğim bu.
[263] **S2-P6-3 mayıs-(234-240)**
[**Araştırmacı:** "Hocanıza bu dönem sürekli STEM yapmayalım demişsiniz galiba, değil mi? Siz itiraz etmişsiniz, sen itiraz etmişsin." sorusuna yanıt]
Öğrenci B: Ama hocam, böyle eğlenceli olacağını bilmiyordum ki.
Araştırmacı: Ama bu dönem de eğlenceli şeyler yapmadınız mı sınıfta?
Öğrenci B: Yaptık da hocam çok uğraştık ama.
Araştırmacı: Uğraşmak kötü bir şey mi? Ama bak sonunda mükâfatı olabiliyor bunun.
Öğrenci B: Oluyor da hocam ama yani…
Öğrenci G: Ama hiçbir şey uğraşmadan olmaz ki.
[264] **S2-P6-3 mayıs-(224-226, 280)**
Öğrenci G: Öğretmenim, bence STEM çok güzel bir şey. Neden biliyor musunuz? İlk dönem de şöyle bir algı vardı. Dersleri birleştirme. Bence çok güzel bir şeydi (**Öğrenci D**: Evet öğretmenim, ders birleştirme güzeldi).
Öğrenci G: Öğretmenim, çok şey söyledim ama bence güzeldi. Yani STEM. Ben zaten olmasını istiyorum. (**Öğrenci A**: Bence de, **Öğrenci D**: O da el kaldırarak onay verir.) Çünkü ya sevmesem bile ilk başta, yani sevmeseydim bile bir gün alışacağımı biliyordum yani. Ve yavaş, yavaş seveceğimi biliyordum. O yüzden, zaten baştan sevdim.

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EDUCATION

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WORK EXPERIENCE

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2017- Present	Ondokuz Mayıs University Department of Industrial Design	Instructor
2012-2017	Ondokuz Mayıs University Department of Fine Arts Education	Academic Specialist
2007-2010	Olmuksan-International Paper	Product Development Specialist
2005-2006	XtremeMAC	Industrial Designer
2004-2005	Siemens Business Services	Graphic Designer

FOREIGN LANGUAGES

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PUBLICATIONS

1. Öztürk, A. (2019). PhD Pit-Stop: Co-Developing STEM Activities by Using a Design Thinking Approach. In *DRS Learn X Design 2019: Insider Knowledge* (pp. 989-992). Ankara, Turkey: Middle East Technical University. ISBN 978-1-912294-00-8.

2. Öztürk, A. (2018, October). Creating a start point for continuity of new educational approach by using design. In *Proceedings of BEYOND ALL LIMITS: International Congress on Sustainability in Architecture, Planning, and Design* (pp. 612-616). Ankara, Turkey: Çankaya University. ISBN: 978-975-6734-20-9.
3. Öztürk, A., & Tunç, Ö. A. (2016). The effect of digital storytelling project on fine arts high school students' teamwork skills. *Journal of Educational and Instructional Studies in the World -WJEIS, 7*(4), 46-56, ISSN: 2146-7463.
4. Öztürk, A. (2016). Tasarım eğitiminde disiplinlerarası yaklaşımlar ve tasarımcı düşünüş modeli. *International Journal of Interdisciplinary and Intercultural Art. 5*(1), 57-72. http://dx.doi.org/10.29228/ijiia.1.6
5. Öztürk, A. (2016, June). Tasarım eğitiminde yeni yaklaşımlar: çevrimiçi tamamen uzaktan tasarım eğitimi. *Jret (Journal of Research in Education and Teaching)*, 5, Special Issue, 314-326, ISSN: 2146-9199.
6. Öztürk, A. (2016, February). Tasarım stüdyosuna teknolojinin entegrasyonu: sanal tasarım stüdyosu. *Jret (Journal of Research in Education and Teaching)*, *5*(1),255-262, ISSN: 2146-9199.
7. Öztürk, A. (2014, May). Endüstriyel tasarım eğitiminde yeni yaklaşımlar. In *Proceedings of Anatolian International Art Education Symposium (Transformations in Art Education)* (Book II, pp. 540-549). Eskisehir, Turkey: Anadolu University. ISBN 978-975-06-1741-6
8. Öztürk, A. (2015, April). Endüstriyel tasarım eğitiminde disiplinlerarası oluşumlar. In *Proceedings of 2. Art and Design Education Symposium and Workshop (Interdisciplinary Design)* (pp. 12-16). Ankara, Turkey: Başkent University
9. Karadağ, E., & Öztürk, A. (2013, November). Ürün tasarımında tüketimsel müdahale: form-fonksiyon ile imaj fonksiyonun karşılaştırılması. In *Proceedings of 1.International Art Symposium (Art, Design and Manipulation)* (pp: 329-332). Sakarya, Turkey: Sakarya University. ISBN 978-605-4735-25-9.
10. Öztürk, A., & Karadağ, E. (2013, October). Tüketimin gerekçesi olarak üretimde sürdürülebilirlik ve ürünün reenkarnasyonu. In *Proceedings of 1st National Art and Design Symposium and Exhibition* (pp. 347-353). Konya, Turkey: Selçuk University

AWARD, PATENT, UTILITY MODEL CERTIFICATE AND INDUSTRIAL DESIGN CERTIFICATE OF REGISTRY

1. Have been awarded as the most successful student in the PhD Program of Industrial Design Department in the 2015-2016 Academic Year with CPGA of 4.00/4.00 in METU Graduate Courses Performance Award.

2. Have been awarded in 2008 with “The Golden Package” in the 21. Packaging Contest held by Turkish Standards Institution.
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5. 1 Patent (2009-07510): Packaging design