DEVELOPMENT OF AN INSTRUMENT FOR SCIENCE TEACHERS' PERCEIVED READINESS IN STEM EDUCATION

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ABSTRACT

DEVELOPMENT OF AN INSTRUMENT FOR SCIENCE TEACHERS' PERCEIVED READINESS IN STEM EDUCATION

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The main purpose of this study was to develop an instrument to measure science teachers' perceived readiness in STEM education. For this purpose, 54 items were written after extensive literature review and interviews with experts. Some of these items were rewritten or omitted as a result of expert opinions and finally 50 items were pilot tested. In the thesis, 306 elementary and secondary science (elementary science, physics, chemistry and biology) teachers participated. To finalize the instrument, out of 50 items in the pilot test, 30 items were retained as a result of factor analysis. The analysis extracted 7 factors for these 30 items. These factors are named as engineering and design, making connections, 21st century skills, local/global problems, performance assessment, STEM interest, and technology usage.

With the final version of the instrument, after establishing its validity and reliability, science teachers' perceptions about their knowledge and skills can be analyzed to understand whether or not teachers can implement STEM education effectively. Also, with the result of this test, weaknesses of teachers can be determined and in-service trainings can be organized accordingly.

Keywords: STEM Education, Science Teachers, Readiness

ÖZ

FEN ÖĞRETMENLERİNİN STEM EĞİTİMİNDEKİ HAZIRBULUNUŞLUKLARI HAKKINDAKİ ALGILARINI ÖLÇMEK İÇİN TEST GELİŞTİRME ÇALIŞMASI

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Bu çalışmanın temel amacı, fen öğretmenlerinin STEM eğitimindeki hazırbulunuşlukları hakkındaki algılarını ölçmek için bir test geliştirmektir. Bu amaçla, ilk ve orta dereceli okullarda görev yapmakta olan 306 fen (fen bilgisi, fizik, kimya ve biyoloji) öğretmeni ile pilot test çalışması yapıldı. İlk olarak, literatür taraması ve uzmanlarla yapılan görüşmeler doğrultusunda 54 madde yazıldı. Bu maddeler için, uzman görüşü alındıktan sonra bazı değişiklikler yapılarak 50 maddelik bir test oluşturuldu ve bu maddeler ile pilot çalışma yapıldı. Pilot test sonrasında yapılan faktör analizi sonucunda, 7 faktörden oluşan 30 maddelik bir test elde edildi. Bu faktörler; mühendislik ve tasarım, bağlantı kurma, 21. yüzyıl becerileri, yerel/küresel problemler, performans değerlendirme, STEM alanların yönelik ilgi ve teknoloji kullanımı olarak adlandırıldı.
Bu 30 maddenin güvenilirliği ve geçerliliği sağlandıktan sonra oluşacak olan test ile öğretmenlerin kendi bilgi ve becerilerine dair algıları incelenerek STEM eğitimini etkili bir şekilde uygulayıp uygulayamayacakları belirlenebilir. Ayrıca, öğretmenlerin ortaya çıkan zayıf yanlarına yönelik hizmetiçi eğitimler düzenlenerek öğretmenlerin STEM eğitiminde daha etkili olması sağlanabilir.

Anahtar Kelimeler: STEM Eğitimi, Fen Öğretmenleri, Hazırbulunuşluk

To my family and the memory of Memduh Cinalioğlu

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LIST OF ABBREVIATIONS

CFA	Confirmatory Factor Analysis
DTI	Danish Technological Institute
EFA	Exploratory Factor Analysis
ITEA	International Technology Education Association
MEB	Milli Eğitim Bakanlığı
MoNE	Ministry of National Education
NAE	National Academy of Sciences
NAS	National Academy of Engineering
NGSS	Next Generation Science Standards
NRC	National Research Council
PAF	Principal Axis Factoring
PCAST	The President's Council of Advisors on Science and Technology
STEM	Science, Technology, Engineering and Mathematics

CHAPTER 1

INTRODUCTION

21st century brings many innovations and developments in technology and engineering. Not only people, but also economy depend on technology (International Technology Education Association [ITEA], 2007; National Academy of Sciences [NAS], National Academy of Engineering [NAE], and Institute of Medicine of Medicine of the National Academies, 2006). Innovation of new technologies is the most important aim of the 21st century (Akgündüz et al., 2015). Role of technology is more and more realized, because, it improves and makes easier an individual's life. Communication technologies, nanotechnology applications and robotics are just a few examples invented in the 21st century. They also improve industries such as information technologies, defense systems, energy sector, automotive, and electronics systems, etc. They can be seen as a sign of being developed and powerful for nations. Therefore, having powerful industries become a common goal among nations (Danish Technological Institute [DTI], 2015).

Consequently, skilled labor force becomes a necessity to achieve this goal. The US framed this issue by stating that to be the leading country in the world, citizens must be creative and innovative in the industry (National Economic Council, Council of Economic Advisers, & Office of Science, and Technology Policy, 2011). For example, inventors such as Nicola Tesla, Henry Ford, Wright brothers and many more, built their knowledge on top of the existing information in science and engineering. These people proved that they can change the world by the help of their vision and knowledge which leads to new discoveries and inventions. But, it should be noted that, although scientists and engineers have the most significant role in the creation of new products, contribution of technicians or other workers in the labor force cannot be disregarded. Therefore, being qualified is important for each individual in the industry to make and help discoveries and inventions.

Problems such as national security, shortage of clean water and energy are critical issues in the 21st century. Solution of these problems require some skills, for instance, collaboration, critical thinking or being able to work in different conditions is necessary. Because, many people from different discipline need to work together and share their ideas with each other. Moreover, they need to think about the impacts of their solution on environment and maybe they need to empathize with others. As a result, they are expected to have specialities, which are named by 21st century skills. They are listed by National Research Council [NRC] as “adaptability, complex communication skills/social skills, nonroutine problem solving, self-management/self-development and systems thinking” (2010, p.2).

Moreover, interdisciplinary knowledge in science, technology, engineering and mathematics (STEM) is necessary in the solution of above problems. Although arts and social sciences cannot be disregarded, STEM fields are seen more important due to the fact that they bring novelty in technology that provides remedies (National Science and Technology Council, 2013; National Science Board, 2015). Therefore, STEM fields are more emphasized than other fields in this century.

Another reason for giving importance to STEM fields lies in the fact that there will be more need in the future for qualified workers (DTI, 2015; The President’s Council of Advisors on Science and Technology [PCAST], 2012). Also, there is more need and more vacant position in STEM fields than in non-STEM fields (PCAST, 2010).

Since, educational system does shape the citizen throughout compulsory education, perhaps including higher education, destiny of any nation depends on its educational system. Therefore, besides the success in social sciences or arts, if the aim is to have a powerful industry, raising qualified labor force by training students in STEM areas is the most important task of the system (DTI, 2015; National Economic Council, Council of Economic Advisers, & Office of Science, and

Technology Policy, 2011; PCAST, 2010). Not only the number of students who choose the related disciplines in higher education, but also the number of graduates who choose to be a working members of these disciplines have significance (PCAST, 2012). Because, according to Chen (2014), some of students in STEM fields are not graduated and some of them graduated but do not work in STEM fields. Therefore, the US government try not to lose these possible STEM workforce members by allocating fund from the budget for research to improve STEM education not only in higher education, but also at K-12 levels (National Science and Technology Council, 2013). As a result, STEM education focus on educating students in a way that STEM labor force can increase in the future. Yet, STEM education is required for each student who does not want to be an engineer or a scientist. Because, individauls' acts affect their country as citizens and consumers, hence, they should be aware of developments and problems in the world and make wise decisions.

1.1 What is STEM Education?

STEM education is defined in similar ways such that it involves science, technology, engineering and mathematics education by inquiry approach with an emphasis on real world problems (Akgündüz, Ertepınar, Ger, Sayı & Türk, 2015; Breiner, Johnson, Harkness, & Koehler, 2012; Chen, 2014; Sanders, 2009; Stohlmann, Moore & Roehrig, 2012).

Even though many researchers agree on the definition, application of STEM education can be varied widely (NAE, 2009; Roehrig, Moore, Wang, & Park, 2012). This variation is caused by the integration of engineering and technology fields. Bybee (2013), categorized nine different STEM education perspectives about the integration of the disciplines:

- *STEM Equals Science (or Mathematics):* refers to only one discipline and causes contradictions.
- *STEM Means Both Science and Mathematics:* refers to just these two disciplines separately.

- *STEM Means Science and Incorporates Technology, Engineering, or Math:* refers to put science at the center and also to involve one more discipline if needed, which can be considered as an introduction to integration.
- *STEM Equals a Quartet of Separate Disciplines:* refers to have the four disciplines in a single course or four different courses which is problematic in the inclusion of technology and science.
- *STEM Means Science and Math Are Connected by One Technology or Engineering Program:* refers to integration either technology or engineering tasks in science and math classes.
- *STEM Means Coordination Across Disciplines:* refers to connections in pairs within four disciplines.
- *STEM Means Combining Two or Three Disciplines:* refers to integration of more than one discipline with the same significance, but not all of them.
- *STEM Means Complementary Overlapping Across Disciplines:* means teaching them one by one and not at the same time in a single course.
- *STEM Means a Transdisciplinary Course or Program:* refers to be able to solve problems that requires all of four disciplinary knowledge at the same time.

As it is seen, whether or not engineering and technology are integrated or how they are integrated create differences in STEM education applications. This variation can cause problems, because, most cases in the above, STEM education becomes similar to the current science and mathematics education and loses its two important components. The reason behind this integration problem can be due to the fact that these two fields have not long-standing background in education as science and mathematics (NAE, 2009). Therefore, teaching methods, concepts to be thought or scope of the curriculum, etc. are not exactly known in engineering and technology education. Additionally, researchers do not reach an agreement in these fields (ITEA, 2007; NAE, 2009). Although, K-12 engineering education started in 1990s in the US, very few students have opted and very few teachers have been trained since then (NAE, 2009).

Engineering is defined as "...any engagement in a systematic practice of design to achieve solutions to particular human problems.” (NRC, 2012, p.11). By the definition, engineers find solutions for human needs which requires critical thinking, problem solving, group working and communication skills. The focus in K-12 engineering education also provides real world problem solutions through engineering habits of mind and also applications by using engineering design process, therefore, it also requires the skills. Inevitabiliy, they resemble aforementioned 21st century skills.

Engineering desing process includes concrete products (but not always necessarily). That is, students can engage in hands-on activities which provide deeper and better comprehension. Designing and creating concrete products at the end of a learning process help students to make sense of concepts. Engineering design process involves specific steps, such as identifying the problem, researching about the problem, designing, testing and finally revising the solution.

However, in K-12 education these steps may not be followed as in higher education. For example, limitations and assumptions during a design process can be much more in K-12 applications. Therefore, K-12 engineering education is an incentive for students for their future career choices. In addition, it aims to create a way of thinking, not to train students as an engineer. Since engineering education involves learning by doing, students can be stimulated to develop interest. Thus, students can be the engineers in the future (Honey, Pearson & Schweingruber, 2014).

Technology is the other field to be discussed. According to the ITEA (2007), technology is defined as “…the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants.” (p.2). As per this definition, tools that enhance our life or simplify complex tasks can be considered as technology. However, it is thought to be related mainly with computers (Sanders, 2009). In this regard, equating technology only with computers results in undermining its importance. Hence, it poses problems also in integrating technology in the instruction, and consequently in STEM education.

Today in most cases, teachers assume that using tablet computers and smart boards can cover “T” in STEM education. However, the important role of “T” is to make students technologically literate, i.e. using, controlling, and choosing appropriate technology (ITEA, 2007). Therefore, only using tablet computers and smart boards by watching video or playing with simulations, etc. cannot be enough for students to become technologically literate individuals. It would end in people who can simply use computers, which is not the aim of “T” in STEM education.

The other common problems of technology and engineering integration in K-12 education can be due to the reasons listed below:

- *Alignment of topics in the curriculum* may be unsuitable to connect relations among topics in other subject. For example, a project about solar energy can cover both chemistry and physics, but related topics may not coincide. Therefore, conducting project by integrating technology and engineering cannot be possible.
- *The amount of objectives in the curriculum* may take lots of time to cover and due to time limits, conducting project again cannot be possible.
- *Assessment system in education* may affect stakeholders (students, parents, teachers and administrators) such that if student achievement is measured by their grades in the exams, then main subjects (science, mathematics, history, etc.) and solving standard textbook problems become at the center, rather than conducting projects.
- *Powerful resistance of teachers against change* hinders them trying to conduct projects or make activities (ITEA, 2007).
- *Lack of teachers’ skills and experience* can limit the activities or projects in the lesson. According to Akgündüz et al. (2015), teachers are not competent in other disciplines and they do not have the skill to integrate these different disciplines.

Because of the aim of STEM education, which is to make students literate in STEM fields and increase the number of qualified individuals in STEM areas, “T” and “E” in K-12 education play important role. Therefore, their integration should be maintained properly.

1.2 STEM Education in the US

From the stand point of STEM, National Science Board (2012) articulated that, in 2008, although Hispanics, blacks, and American Indians/Alaska Natives compose 26% of the population, their workforce in science and engineering fields is too low. Moreover, there are more individuals that have STEM degree than the individuals who work in STEM fields (National Science Board, 2012). Also, there is difference between males and females in STEM fields. Although females are 46.9% of the total population, majority of them work in nursery, teaching and only small percentage of them work in engineering fields (US Bureau of Labor Statistics, 2015).

Nations need significant contribution of each citizen in order to improve their economy (Darling-Hammond, 2014). However, as mentioned above, contribution of minorities and disadvantaged groups to workforce, thus to economy, is underwhelming. This situation pushes the US government to take precautions in order to involve them to the workforce. Therefore, the US government thought that they need to make changes in education to fix this problem.

In fact, they had come up with STEM education solution long before it became popular. Although STEM education became the main trend much later, the US had started to make changes related to STEM education when Sputnik had launched in 1957 (Bybee, 2013). Science and mathematics programs were prepared by many different institutions and researchers before; however, technology and engineering programs for K-12 education were paid attention after Sputnik.

Clark stated that up to this time, three major programs, the No Child Left Behind Act (NCBL), America COMPETES Act, and Race to the Top (RTTT), were intended to increase the knowledge and success on science and mathematics of especially underachiever students (2014). Firstly, in 2002, NCBL aimed to standardize performances of students and thereby schools. Then in 2007, America COMPETES Act aimed to make bigger steps in science and/or technology to continue being the arbiter of innovations in the world. In addition, Obama administration placed much importance on closing the achievement gap between students who come from different ethnic and socio-economic backgrounds. Also, with RTTT, it was aimed to decrease dropout rate and to increase the success of students.

Although these programs and STEM education reform have some common points, there are also specific distinctions. According to Bybee (2013), today there are other countries in the global competition, thus the race is much more difficult and complicated than before. Also, different environmental issues require different applications which affect STEM jobs and economy. In addition, 21st century requires some specific skills. Lastly, national security becomes much important issue after terrorist attack in 2001. Defense industry also gained importance; therefore, workforce in this area is needed. Educational system has been needed according to these concerns.

A final reason for the necessity of STEM education in the US is that there is huge achievement gap between students (Clark, 2014). This gap depends on many reasons such as, differences in income, in quality of early childhood education, in teachers' skills and knowledge, and in the curriculum. As a result of these differences, it can be said that the main point to be considered is equity in education. STEM education takes place at this point by having the aim of closing the achievement gap and making everyone to have equal chances to reach qualified education.

Moreover, not only the US, but also other countries have the common aim, to be one of the leading countries in the world. This situation results in countries begin influenced by each other's education system (Treagust, Won, Petersen, & Wynne, 2015). Therefore, STEM education is accomodated by EU countries.

1.3 STEM Education in EU

STEM education is at focus not only in the US but also in EU countries. In general, the same concerns are valid. For example, according to Danish Technological Institute (2015), decreasing number of qualified employees in STEM fields is threatening which causes not being able to protect the position of the country among the world leaders. Moreover, EU STEM Coalition (2016) supports this claim, such that STEM related businesses cannot find qualified employees who are especially good at communication and problem solving. In Belgium, the number of graduates from STEM disciplines is lower than retirees in these fields which results in economic trouble (van den Berghe & de Martelaere, 2012). Therefore, many STEM related communities and programs endeavor to empower STEM workforce for different EU countries.

Despite various perceptions about it, STEM has the same purposes as the US in EU countries. Highlighting on inquiry approaches and 21st century skills; giving importance to equity, to interdisciplinary applications and to real life connections are the significant elements in STEM education (DTI, 2015).

EU countries' STEM strategies center around business, education and government which is called "triple helix" (EU STEM Coalition, 2016). Similar to the US, there are many vacant positions in STEM areas in many EU countries. However, individuals cannot be employed, even though there are many unemployed young people. Because, they do not have the qualifications that businesses expect. Therefore, "triple helix" maintain cooperation between education and business, such that education raises students to meet the needs of the business in the future. In addition, government takes place in arranging educational policies according to business needs. The cooperation among them can solve the problems in STEM areas. However, it should be noted that, shaping education according to business can cause the distinction of some disciplines, such as philosophy or archeology.

There are many examples of STEM education movement in EU countries and some of them are shown in Table 1. Moreover, European Schoolnet is a large-scaled program and 31 European countries participate in the program. The aim is to make more students become interested in STEM fields and provide STEM literacy which is important for the current economic situation.

Table 1. Examples of STEM Programs in EU countries

Program/Institution	Country	Purpose
ROBERTA	Germany	• Encourage especially girls towards technology • Increase teacher qualifications
WISE	UK	• Increase female employement in STEM fields
• Delta Plan Science and Technology • Jet-Net	The Netherlands	• Increase the science and technological success of students • Use the existing graduates appropriately in industry and research institutions • Make technology industry and secondary schools come together to meet and understand the technologies (workshops, activities, lessons etc.)
• The Big Bang science teacher conference • The national science week • Science municipalities	Denmark	• Make young citizens, • to get interested in science careers • to have opinion about science • to be equipped with science subjects
• Estonian Research Council • Research and Technology Pact	Estonia	• Organize various grants and funding • Associate global cooperation for Estonian researchers • Increase quality of education • Make science favored • Make STEM jobs valuable
The Flemish STEM Platform	Belgium	• Make students, teachers and stakeholders participate in STEM education

Source: EU STEM Coalition,2016; Danish Technological Institute, 2015

1.4 STEM Education in Turkey

Schooling is an important variable for a nation in the development process, because, educated minds can make contributions in the process of scientific developments and technological improvements. Schooling ratio refers to the ratio of the number of students over the number of population on that relevant age range. Also, it represents how many people participate in education and how much the country can meet the needs of the population in school age (Günay & Günay, 2016). According to 2016 data, Turkey has the schooling ratio of 94.87% for primary school, 94.39% for junior high school and 79.79% for secondary school (Türkiye İstatistik Kurumu, n.d.). These statistics show that approximately 5% of the population are not graduated even from primary school, while in OECD countries this ratio is 2% (TEDMEM, 2016). The difference indicates that Turkey is one of the countries that has the highest ratio. Moreover, the statistics points that Turkish students drop out school at high school level. Consequently, many possible STEM students, graduates and STEM employees cannot be members of STEM industry. There can be different reasons and solutions of schooling problem, but the main concern of this study is not about schooling. Yet, schooling ratio especially in secondary school affects the possible number of STEM labor in the future, therefore, it can be considered as an important factor in STEM workforce.

In addition, the number of high school graduates who choose STEM fields in higher education decreases in recent years (Akgündüz et al., 2015). According to the researchers, as a result of university exam, 38.23% of the first 1000 students enrolled in STEM fields in 2014, while others choose medical schools. In addition, the same report states that gender difference is seen clearly, such that male ratio is 81.39% and female ratio is only 18.61% for top 1000 students who choose STEM fields. This means that STEM workforce is formed mostly by male population and females do not contribute this workforce as desired. This means that Turkey cannot use its capacity in STEM fields.

According to PISA results in 2015, Turkey is below the OECD average in all areas (OECD, 2016). Such that, while the OECD averages are 493, 493 and 490, Turkey averages are 425, 428 and 420 in science, mathematics and reading, respectively. Moreover, university exam results show that the most of Turkish students do not succeed in mathematics and science. Table 2 shows results of the second stage of the exam (LYS) in 2016 for mathematics and science subjects.

Table 2. Statistics about 2016 LYS mathematics and science disciplines

Subject	Average point/Total question	Standard deviation
Mathematics	10,38/50	11,84
Geometry	4,58/30	7,05
Physics	5,48/30	5,44
Chemistry	10,56/30	7,93
Biology	8,5/30	7,04

According to both PISA and LYS results, most of Turkish students do not succeed in science and mathematics. There can be many reasons for these results. For example, PISA is a sign of equity and quality in education, hence, education in Turkey is not as much good as in many other countries, such as Singapore, Japan or Finland. This can be a cause of unqualified employees in industry. Also, not only achievement but also attitude towards science and mathematics are low, which can mean low STEM interest and which can cause decrease in STEM employee in future. Moreover, there can be difference between lessons and assessments, so that students cannot be successful in exams.

Problems in both schooling and success rate in exams show that Turkey needs educational reforms and STEM education can be a solution. Because, equity and science literacy are important issues in STEM education. It has started to be mentioned notably in our country lately. Ministry of National Education [MoNE] published STEM report (Milli Eğitim Bakanlığı [MEB], 2016). It articulated that like other countries, we need to focused on STEM education, because, the economy and workforce of a country highly depend on STEM knowledge and cognitive skills. A teacher’s role should be as a guide to help students to gain STEM knowledge and cognitive skills. For this purpose, traditional teaching methods should be replaced with inquiry-based approaches.

Moreover, the report emphasizes the importance of Fatih Project and EBA. They are the most extensive educational projects that aim to improve technology usage in education and to reach equity with adequate educational sources. They can be used as STEM materials to improve students critical thinking skills and to create environment for inquiry and investigations (MEB, 2016).

In addition, there has been many projects, programs, etc. conducted by universities before the report of MoNE. For example, Middle East Technical University, Hacettepe University, Bahçeşehir University founded STEM centers and they arrange seminar trainings both for teachers and students, which help them improve their STEM knowledge. Additionally, TÜBİTAK, İstanbul Aydın University and Kayseri Ministry of Education have contributed to STEM education in terms of projects, certification programs and conferences. It can be said that MoNE realized the emphasis on STEM education from many sources and it started to give importance as well.

Facebook, Twitter and other social media platforms include examples of teachers' own experiences and documents about STEM applications. Based on these platforms, some teachers think that their lessons are coherent with STEM education and they have already been implementing STEM education. In some of these examples, inquiry approach is not used, which is very important in STEM education. Also, some of them direct students excessively that can result in missing the critical thinking ability. These examples may be caused by not informing and preparing teachers about what STEM education is and how it should be implemented.

An extensive study about STEM education was conducted by Akgündüz, et al. (2015). The study investigated two of the problems of K-12 STEM education: student attrition and continuing higher education (HE). Participants were asked to make suggestion about curriculum and implementation to eliminate the deficiencies about the aforementioned two problems. The most common cause of both of the problems was insufficient implementations. Secondly, poor teacher quality, and insufficient link between K-12 and HE are the other causes of attrition and continuing HE, respectively. In addition, participants suggested important solutions to implement STEM education effectively: for the curriculum case, 31% of the participants shared the opinion to increase implementations and 14.3% of the participants suggested to increase the cooperation between various disciplines. For implementation case, pushing teachers to make implementations with 19.6% and increasing teacher and academician knowledge and skills with 14.3% were thought as solutions.

Moreover, General Directorate of Innovation and Educational Technologies conducted a survey for teachers who attended Scientix project and the results are written below (MEB, 2016):

- 91.97% of teachers thought that STEM education should be implemented.
- 93.75% of teachers thought that STEM education is a necessity for economic development of our country.
- 94.64% of teachers claimed that current curricula are not suitable and hence, they should be revised according to qualities of successful STEM education.
- 86.61% of teachers agreed that schools need new laboratories and equipments.
- 91.96% thought that teacher training programmes for STEM education for in-service teachers are required.

The report does not include any additional explanations about teachers' opinions. But it is an important point that teachers stated that they need STEM education in-service training programmes. This can be caused due to unpreparedness of teachers and their concerns about inquiry-based teaching, technology and engineering integration, which can be thought as relatively unusual or new.

STEM education may not be considered as a new approach for some countries, but it is an emergent approach in Turkey. MoNE published new curricula for each subject and each grade level in 2017 (MEB, 2017). In the elementary science curriculum, starting from 4th grade, engineering and design skills are articulated explicitly as innovative thinking skills. The positive aspect is that projects and design tasks are included, but as a negative aspect, they are included at the end of each year as a separate unit. Explanations for the related objectives are almost the same in each year. Also, due to there is not any restrictions or suggestions about designs for teachers, it is up to teachers knowledge, skills and willingness to teach these units. Therefore, teachers should be eqipped to be able to handle to conduct projects or to do activites, etc. Otherwise, there would be poor practical contribution of these units.

Moreover, there are some teachers who participated STEM education training programmes and have knowledge about STEM education as mentioned. But, there are some others who do not have an idea about STEM education. This difference among teachers can increase inequality in education; therefore, each teacher needs to participate trainings about STEM education. Otherwise, equity component of STEM education becomes critical.

On the other hand, in the secondary physics curriculum, there is no defined skill about engineering. Yet, design or production term is articulated several times. Different than elementary curriculum, terms are embeded into the objectives, such as:

> *Hayatı kolaylaştırmak amacıyla basit makinelerden oluşan güvenli bir sistem tasarlar.*

Physics curriculum specifically emphasized that students should be innovative, good at communication both in native and foreign languages, competent in mathematics, technology and science (MEB, 2017). Moreover, students should be able to learn how to reach information. These issues include problem solving, critical thinking and complex communication skills, which are parallel with 21st century skills. But the important thing is how to implement them, in other words, how students can improve their problem solving abilities or critical thinking skills is significant. Although inquiry is not emphasized implicitly, aforementioned skills require inquiry-based teaching approaches for students to gain them. These aspects are similar with STEM education. However, lacking in technology and engineering integration are important distinctions between STEM education and the curriculum. Therefore, it cannot be said that STEM education can be implemented with this curriculum. But, it is again up to teachers knowledge and skills whether or not to implement. Moreover, it highly depends on willingness of teachers due to lack of emphasis on design tasks.

Moreover, the blueprint of the physics curriculum suggested teachers to shape students' career choices mostly towards engineering, architecture or medical schools. However, in the final version, this emphasis was removed. The blueprint might be considered that it shared similar intentions with STEM education in this aspect. But, the same concern does not have place in the current curriculum.

1.5 Readiness

Readiness of an individual, as used in this study, is considered as an important determinant for a task to be completed successfully. According to Hersey and Blanchard (1988), readiness is defined as ability and willingness for doing a task. While ability refers to "knowledge and skill", willingness refers to "confidence and commitment" (p.184). Moreover, the importance of teachers' knowledge as ability aspect of readiness is discussed by many scholars (Donovan, Bransford, & Pellegrino, 1999; Steele, Brew, Rees & Ibrahim-Khan, 2012; Windschitl, 2009). For example, teachers' knowledge can be considered as the main factor influencing their students' understandings. In those studies, primarily due to this importance, teachers' knowledge, i.e. ability, was examined. Also, weaknesses and strengths of teachers can be related to their readiness, such that teachers can be considered as ready if they have strenghts in experience, skills, knowledge, and so on.

Readiness is an important indicator of success for any field including education. When a reform is intended to be implemented, readiness of individuals are at focus for that reform to be successful. Pentz stated that if the community is not ready for renovation, unsuccessful result would be inevitable (1991, as cited in Edwards, Jumper-Thurmnan, Plested, Oetting, & Swanson, 2000). Regardless of the topic, readiness of individuals should be ensured for positive outcome.

1.6 Statement of the Problem

Teacher quality is one of the keystones for the success in education (Tytler & Osborn, 2012). In many research studies, teachers' knowledge, ability, attitude and their effects are discussed and it is found that teachers are the major determinants of student achievement and motivation. Therefore; increasing competencies and qualities of teachers should be considered as the first step in education policies (TÜSİAD, 2014).

When a reform is in order, teachers may not be familiar with the requirements of the reform. Therefore, teachers may need trainings to keep pace with the reform act. Today, STEM education is seen as a necessity for this century as mentioned before, and success of STEM education reform depends on the increase in teachers' competencies (David, Won, Petersen & Wynne, 2015). In the US, there has been many professional development (PD) programs conducted to make teachers ready for STEM education (Ashgar, Ellington, Rice, Johnson & Prime, 2012). In 5-year strategic plan, it is claimed that 100,000 STEM teachers will be trained at the end of 2020 (National Science and Technology Council, 2013). Likewise, there is policy change in Turkish educational system towards STEM education and MoNE emphasized the importance of teacher developments in this topic.

In a reform act, before trainings, to provide congruence between real needs and predicted needs of teachers, it is important to investigate teachers' readiness. In the context of Turkey, although some teachers have knowledge related to STEM education, majority of them are not aware of it (E. Çakıroğlu, personal communication, December 14, 2016). Moreover, teachers who claim that they already implement STEM education based on just using tablets or smart boards as technology integration may have a limited preception of what STEM educaiton entails. In addition, there is no study that examines our teachers' perceived readiness in STEM education. In other words, weaknesses and strengths of teachers are not known to develop purposeful and effective PD programmes.

1.7 Purpose of the Study

The purpose of the study is to develop a reliable and valid instrument to investigate science teachers' perceived readiness in STEM education implementations. It should be note that, the purpose is to develop a teachers'perceived readiness tool, not to measure teachers' perceived readiness.

1.8 Significance of the Study

Teachers' significance in success of education system cannot be disregarded. Indeed, they are one of the main determinants for a successful reform. Therefore, their knowledge and skills play crucial role in STEM education. However, there is no instrument which indicates teachers' perceptions about their readiness in STEM education to the best of our knowledge. Hence, we cannot find out whether STEM education would reveal out successful results or not. Moreover, we cannot organize teacher trainings to eliminate their weaknesses and maximize their strengths because of the fact that we have not determined their weaknesses and strengths yet. Therefore, this study will have significant contribution to the literature. Moreover, with this instrument, further studies can reveal weaknesses of teachers and lead the way for teacher trainings. In addition, common weaknesses can give an idea to shape teacher educations. Thus, pre-service teachers may graduate as much effective teachers. As a result, STEM education is more likely to be implemented effectively. This instrument does not include purpose, objective or item specific to our nation. Therefore, it can be used not only in our country, but also in other countries by establising its validity and reliability of the instrument for their own language.

1.9 Assumptions of the Study

There are two assumptions of the study. The first one is that teachers read the information at the beginning of the instrument that includes information as if they do not know STEM education and engineering design. Moreover, it explains how to fill the instrument (explained in Chapter 3). The second assumption is that participants answered items honestly.

1.10 Limitations of the Study

There are two limitations of the study. The first one is that there is no defined criteria for this instrument, such that one cannot determine which teachers are ready and which teachers are not as a result of implementation of the instrument. Because, our aim was only to develop items, rather than to determine if teachers are ready or not in

STEM education. Moreover, defining such criteria requires detailed studies; for example, teachers can be observed during lessons and researchers can determine the extent of teachers' implementation of STEM education. Afterwards, teachers' answers in this instrument can be examined. Then, by comparing class observations and teachers' answers, these criteria can be determined. These processes can be done in further studies.

The second one is about self-reporting technique itself. The assessment in the instrument is based on teachers' beliefs about themselves. As a general negative point of self-reporting techniques, we cannot ensure that teachers answered the items honestly (Frankel, Wallen & Hyun, 2012). Therefore, we relied on honesty of teachers.

Moreover, as a delimitation in the study, willingness part of readiness was not investigated. It is important for readiness construct; however, in case of including willingness would cause that number of items become doubled and instrument becomes much longer. This situation can result in not completing the instrument totally or honestly by participants. Due to these concerns only ability part of readiness was investigated

CHAPTER 2

LITERATURE REVIEW

In this chapter, in accordance with the aim of this thesis, importance of readiness and STEM education components were explained. In the thesis, an instrument was developed about teachers' perceived readiness in STEM education implementations. This instrument consists of ability aspect of readiness construct. The reason of choosing only this aspect was also clarified in this chapter.

2.1 Readiness in Education

In the context of education, each stakeholder (administration, parents, students, teachers, etc.) plays important role for educational reforms. For example, Elkind (2004) claimed that when constructivism was introduced, unprepared society was responsible for unsuccessful implementations of constructivism, as much as unprepared teachers.

Howe and Stubbs (2003) conducted a study to investigate teachers' readiness in leadership in the classroom. Their study was in the scope of SCI-LINK project, which aimed to meet science teachers and scientists together to make teachers become more effective in the classroom in terms of lesson plans, activities, etc. In the project, teachers prepared materials that can be used in lessons after scientists shared their work with teachers. Hence, teachers had chance to integrate scientists' studies into their lessons. At the end of the study, researchers found that being ready is affected by factors in addition to ability and willingness, i.e., personal life, family or work liabilities. In general, participants stated that their readiness depended on the number of children they had and their responsibilities at home. Moreover, their position in the society, such as their ethnicity, had an effect on the possibility of accepting challenges. This finding can be thought that these factors indirectly influences readiness of teachers via willingness component. The reason is that, teachers who do not have much work to do at home have more energy and ambition in class. Also, being a respected member of society, which can be related with ethnicity, can prevent hesitations to try different applications in lessons.

According to Elkind (2004), problems related to teachers' readiness depend much on their training rather than on their personal beings. Therefore, an educational reform must start with the training of teachers to make them ready. Bybee (2013) stated that resistance of teachers against reforms should not be ignored. Veteran teachers may resist change more than novice teachers due to the difficulty of learning new techniques or giving up the usual processes that are applied for years. To make reform successful, it must be necessary to reduce resistance and to convince teachers towards implementing. Consequently, having teachers ready makes the reform more effective and it can be possible through teacher training programmes.

Inan and Lowther (2010) examined the factors that affect teachers' use of laptops during lectures. 379 K-12 teachers from both public and private schools participated in the study. The results showed that teachers' readiness and beliefs were the most effective factors that influence the use of laptops. In the study, readiness was defined as teachers' opinions about their own competencies and abilities to be able to use laptops in the lessons. Therefore, in order to increase laptop usage, researchers suggested that teachers' readiness should be enhanced.

From STEM education perspective, teachers' experience, skills, and knowledge are some of the factors that determine success of the approach. These teacher related factors can be collected under the term "teachers' readiness." Due to the fact that STEM education does not have long history, teachers may not be ready for its specific features; and hence, they can encounter difficulties. For eaxmple, according to Turner (2013), 64% of K-8 teachers in Northeast Tennessee did not feel prepared to implement STEM education. Also, majority of teachers thought that implementations were not as they were expected for meeting the needs of 21st century skills.

Corlu, Capraro and Çorlu (2015) examined whether Turkish mathematics and science pre-service teachers are mentally ready to integrate mathematics and science into STEM education. In the study, mental readiness corresponded to attitudes of teachers towards this integration. The sample was selected from senior students (n=226) and the data were collected with a 12-item survey. The participants enrolled to universities that have either integrated or departmentalized curriculums. The result of the study indicated that the participants in the integrated curriculum had more positive attitude towards STEM education. It can be inferred that teachers are more likely to teach STEM education, if their trainings are in line with the this approach. K-12 education and teacher education should match with each other in terms of approach for the effectiveness of education in schools.

Moreover, teachers have difficulty in mathematics and science teaching when they did not have good experiences in their education life, such as not having chance to conduct experiment or do activity to learn deeply (Steele et al., 2012). Similarly, McDermott and Shaffer (2000) claimed that teacher training programmes do not teach important points to pre-service teachers that they will need in the classroom. This situation results that teachers continue to teach in a way that they were taught, which is not proper for K-12.

2.2 Relationship between Readiness and Self-Efficacy

Self-efficacy is another construct that affects the result of a task. Bandura identified and explained the features of self-efficacy in his studies. According to Bandura, “Efficacy beliefs influence how people feel, think, motivate themselves and behave” (1993, p.118). According to him, self efficacy leads to one’s thoughts in a good or bad way and these thoughts affect the outcome. Moreover, teacher self-efficacy was defined as “the teacher’s belief in her and his ability to organize and execute the courses of action required to successfully accomplish a specific teaching task in a particular context” (Tschannen-Moran, Hoy, & Hoy, 1998, p. 233). Therefore, a teacher with low self-efficacy think about negative and unsuccessful situations about himself in the classroom and this can be a consequence of ineffective teaching experience. Whereas, a teacher with high self-efficacy has motivation and belief to accomplish a good teaching experience. Moreover, Bandura (1993) articulated that self efficacy is one of the determinants whether knowledge and skills can be used or not, thus, having knowledge and skills are not enough to perform a successful teaching practice.

According to Bandura, self-efficacy involves specific attributes: efficacy expectations and outcome expectations (1977). He articulated that efficacy expectations refer to one's belief that can perform a task in a successful way, which can be thought as an initial push to do the task. Also, outcome expectations refer to the belief that one can conceive the product if he enacts the specific behavior. From the definitions, efficacy expectations can be considered as ability aspect of readiness. For example, when a teacher has deep content knowledge, i.e. has the ability, then he probably believes that he will succeed at teaching the content.

Therefore, self-efficacy and readiness have similarities in practice. As articulated above, self-efficacy affects teacher's behavior and determines whether the teacher will exhibit the behavior or not. For example, teachers with low self-efficacy escape from some concepts that seem hard to understand and teach (Baker, 2002; Cakiroglu, Capa-Aydın & Hoy, 2012). Likewise, whenever a teacher thinks he is not ready, i.e. does not have the ability and willingness, then the intended behavior is not exhibited. Also, self-efficacy is an indicator of teachers' opinion about themselves in terms of abilities, similar to readiness (Cakiroglu et al., 2012).

Baker (2002) investigated teacher self-efficacy about classroom management skills, readiness about specific behavioral management strategies and relationship between them. The context was about implementing different management techniques according to variety of students' needs. The study was conducted with 345 public school teachers and by a survey with 100 items. Readiness was defiened as ability and willingness in a task and the survey questions consisted of sentences that mostly begins with "I am able to…" or "I am willing to…" for readiness measurement. Also, self-efficacy was measured with similar sentences. Items about readiness and self-efficacy in the survey are very similar, which shows that they substitute each other. One of the findings of the study was that readiness and self-efficacy of teachers were positively related, which can be expected due to their resemblance.

2.3 Instruments

Being aware of level of teachers' perceived readiness is also important to create appropriate training programmes. However, teachers' perceived readiness in STEM eduaction is not studied as much as other educational contexts. Therefore, it is important to examine level of teachers' perceived readiness in STEM education. In order to increase the effectiveness of teacher trainings, teachers' weaknesses should be recognized.

There are some instruments to measure readiness in STEM education, but they are not specific to teachers' perceived readiness to implement effective STEM education. One of the most extensive resource for instruments is Compendium of Reseach Instruments for STEM Education which was published in 2013. It includes two parts and the first one focuses on teaching, and the second one focuses on understanding student achievement. The first one provides 82 instruments to be used in different grades from elementary through high school. Although the aim is to reveal "teacher practices, PCK, and content knowlegde" in STEM education, the instruments in this resource are general tests for these three area –practice, PCK, and content knowledge-, and not specific to STEM education. As a matter of fact, the aim of the compendium is not to construct original instruments, it is to present the available instruments that can be used in STEM education.

A team in the University of Arizona conducted a project which aims to educate students about importance of water resources and sustainability. "Effective STEM Integration Checklist" was used in the project that measures whether teachers have the competencies in STEM components. The instrument consisted of 10 items which measures the following aspects: interdisciplinary, integration of fields, real world problems, group working, inquiry, challenging tasks, and criteria-based assessment usage. A scale with 3 options was used. However, teachers' competencies cannot be categorized in only 3 options, because, simplifying this measurement to existance, absence and uncertainity can be misleading. For example, participants would mark existance box in the scale while one has little knowledge and the other one has deep knowledge for that item. However, their competencies should not be considered in the same level.

In addition, Lin and Williams (2016) developed an instrument to measure the intention of Taiwanese pre-service science and technology teachers towards STEM education. The general aim was again to provide data to shape teacher education in the future. Since STEM education is not applied in Taiwan, participants in the study had attended courses that includes STEM education implementations. In the study, a factor analysis was conducted and significant Cronbach's Alpha level was established (α=.94). In the instrument there are 21 items which consists of knowledge, value, attitude, subjective norm, percieved behavioral control and behavioral items. 7-point Likert agreement scale was used. In the knowledge dimension, there were 4 items about science, technology, engineering and mathematics. Items in this dimension ask general knowledge of teachers in STEM disciplines, for example, "I am familiar with the Science knowledge in the middle school level (e.g. Newton's laws of motion)" (p.1033). But, answers given to these items may not present enough information about teachers' content knowledge. The other dimension is about values which is consisted of 6 items that asks whether the situations in the items are important and helpful or not. Attitude dimension with 6 items questioned whether they will implement STEM education or not, when other educational stakeholders ask them to. Subjective norm items involved 5 items and ask whether subjects believe that they can handle the given situation; for example, "In the teaching environment, I think I have enough ability in implementing integrative STEM teaching" (p.1034). Items in this dimension can be thought as too general. Percieved behavioral control dimension consisted of 5 items and ask whether they will implement STEM education or not; for example, "I will try to teach students in thinking how to modify their product according to their STEM knowledge during the test and modify process" (p.1034). Lastly, behavioral intention dimension also consisted of 5 items about students' learning outcomes as a result of STEM education. In general, items include integrated STEM education expressions. Besides daily life connections, interest towards STEM fields and design process are the other STEM education components emphasized in the instrument. However, 21st century skills are not much asked, hence it can be considered as deficient part of the instrument. Moreover, items can be thought as too general to measure the related dimension.

Moreover, Dibenedetto (2015) also developed an instrument to find out the status of high school teachers' opinions about their own competencies in making students have knowledge and skills, and be equipped for the jobs in 21st century. For this purpose, the instrument consists of the following constructs: "learning and thinking skills, life skills, career skills, social skills, interdisciplinary topics, knowledge competencies, incidental learning skills, dispositions, and experiences" (p.96). Also, these constructs included different skills such as *accountability, goal management*, etc. for life skills and *honesty, integrity*, etc. for social skills. In total, there are 31 items, which refer to 31 skills. Because, each skill was measured by one item. This may create difficulty in analysis. In addition, these constructs were measured in proficiency, importance and responsibility scales. In the column for proficiency level, it was stated that "I know what I need to know to teach this skill" (p.211) for each construct and skills in the instrument. Also, there is not any explanation or information about what teachers should understand from the skills. This can cause teachers not to answer with the same comprehension from skills.

2.4 Frameworks and Rubrics

Some of the US education departments and educational non-govermental organizations published frameworks and rubrics. They determine factors that teachers or schools need to have for effective implementations of STEM education. In general, they focus on connections between disciplines, engineering and design, technology integration, 21st century skills, interaction with community and business, and career guidance. The degree of practicing these components are defined in a similar way. For example, STEM Education Quality Framework stated that students should have chances to demonstrate their knowledge and skills (Dayton Ohio Regional STEM Center, n.d.). Also, STEM Framework stated that students' developments should be monitored continuously (The New York City Department of

Education, n.d.). These criteria require performance assessment procedures, although they articulated differently.

Actually, they are not designed to determine readiness of teachers or schools, yet they can be utilized to specify the factors that teachers should possess to be able to implement STEM education effectively. As in the examples, teachers can be considered as ready according to the usage of performance assessment procedures. In addition, PD programs can be arranged with respect to the frameworks (Dayton Ohio Regional STEM Center, n.d.).

STEM Education Quality Framework, which was published by Dayton Ohio Regional STEM Center indicates the expectancies from teachers with 10 significant components of STEM education, which are

- potential for engaging students of diverse academic backgrounds,
- degree of STEM integration,
- connections to non-STEM disciplines,
- integrity of the academic content,
- quality of cognitive task,
- connections to STEM careers,
- individual accountability in a collaborative culture,
- nature of assessment(s),
- application of the engineering design process,
- quality of technology integration.

These criteria focus on classroom practices of teachers. In order to put them into practice, teachers need to have deep knowledge in these topics.

Another framework was developed by The New York City Department of Education (n.d.) to guide schools which intend to implement STEM education. There are 4 domains quite different than the domains in the previous framework, because, this framework addresses responsibilities of schools. The first domain is *school vision and structures for success* which refers to the extent of school's vision, culture, resources and plan about STEM education. The second domain is *curriculum, instruction and assessment*, which focus on quality and capcacity of teachers, extent of the instruction and assessment in terms of STEM education. This domain is related to teachers and their content knowledge, hence, it is similar to the domains in the previous framework. The third domain is *strategic partnership* which includes the communication with other stakeholders including communities and business partnerships. The last domain is *college and career readiness* which is about preparing students to contribute STEM workforce in their career.

Moreover, there are rubrics that also guide for effective STEM education. For example, San Diego STEM Quality Criteria Self-Assessment Rubric (2015) was developed by various stakeholders for schools and programs. Similarly, the components are *integrity of academic content*; *STEM climate and culture*; *collaboration among schools, community and industry* and *connections with college and career readiness.*Similar concerns are addressed with different domains. Coherence with standards, proper equipments and environment for STEM implementation, network among stakeholders and STEM career support are included in the domains.

Similarly, Indiana Department of Education (n.d.) developed a rubric for schools. The rubric has four main parts that are looking for answers for the following questions:

- Is a structure and process in place to support the program's mission, vision, and goals?
- Does the instruction environment provide time and PD for educators to develop and improve their craft of pedagogy and content?
- Is your STEM curriculum aligned to the adopted Indiana Academic Standards?
- Does the STEM program offers opportunities outside the school day?

The subdimensions of these four categories mainly invlove the components of STEM education. Similar to others, it gives credit for leadership and support between schools and community, school design and equipments, data collection for the progression of students, teacher trainings and coherence with state standard. But unlike others, this framework articulates teachers content knowledge explicitly. According to the framework, schools that pay attention to teachers content knowledge and provide PD programmes implement STEM education completely. But, STEM Education Quality Framework is specific to teachers, hence, these criteria, which are related to schools, are not included in it.

As a result, these frameworks and rubrics point STEM education components for schools, programs or teachers for effective implementations. Hence, these points gave this thesis a direction to determine the dimensions of teachers' perceived readiness instrument.

2.5 Effective STEM Education

For an effective STEM education, aforementioned significant dimensions must be held. These dimensions are inquiry-based approaches, collaboration, daily life connections, 21^{st} century skills, STEM interest, technology and engineering (Bybee, 2013; Clark, 2014; Honey et al., 2014; Next Generation Science Standards [NGSS], 2013; National Science Foundation, 2012; Yager, 2015). Some of these dimensions are not new for science education such as inquiry-based approach or group work, yet the integrity of them and the ultimate aim of STEM education create difference from other educational approaches. As Chesky and Wolfmeyer (2015) stated that STEM education is seperated from other approaches due to the fact that individuals need to be able to integrate technology and engineering into science and mathematics knowledge in this century.

STEM education can be effective when each dimension is embedded into the lesson. It may not be suitable to integrate each of them in each lesson. Nonetheless, it should be noted that only conducting a project cannot be an effective example of STEM education implementation. Likewise, only using inquiry-based approach does not mean that STEM education is implemented effectively. Therefore, teachers should give importance to include dimensions as much as possible. In the following sections, these dimensions will be explained in detail.

2.6 Dimensions of STEM Education

2.6.1. Inquiry-based approach

Inquiry has an important place in STEM education (Allen, Webb & Matthews, 2016; Bybee, 2010 and 2013; Honey et al., 2014; NGSS, 2013). The relation between inquiry and STEM education can be understood from the following definiton of inquiry:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results (NRC, 1996, p.23).

Considering this definition of inquiry, it can be seen that inquiry is a necessity in STEM education. As mentioned before, inquiry cannot ensure STEM education by itself, but from the definition above, it serves the same purpose with STEM education. For example, STEM education aims to help individuals to gain STEM literacy, which requires knowing how to reach the necessary information for a problem (Bybee, 2013). As another example, finding solutions to human problems requires experimenting, i.e. collecting, analyzing or making conclusions from data, etc. These examples show that inquiry-based approach is appropriate for STEM education.

NRC indicated place of inquiry by stating that students need to gain knowledge and skills by trying at first hand with “modeling, developing explanations, and engaging in critique and evaluation (argumentation)” (2012, p.44). The process of inquiry is different than traditional teaching methods. It provides opportunities for students to take responsibility, which enhance their motivation and curiosity towards science (Donovan et al., 1999). According to Bybee (2010), inquiry helps students to make progress in reasoning skills, making conclusions, thinking critically by changing their negative feelings towards science. For all students, inquiry teaching is important, not just for the ones who pursue engineering or science careers. Because, reasoning, critical thinking, etc. are essential abilites for any individual in 21st century (Bybee, 2010).

According to *Framework for K-12 Science Education*, without inquiry, students do not gain the objectives completely. Because, besides end products, objectives focus on learning process. Also, inquiry develops not only scientific knowledge but also, cognitive skills (NRC, 2012). Indeed, science and engineering practices in the framework are very similar to inquiry definition of NRC.

Inquiry-based approach includes several methods such as problem-based, project-based and 5E learning cycle methods. Moreover, project-based learning (PBL) is seen as one of the most appropriate methods that is in line with STEM education, because, it provides learning by inquiry with higher understanding, creativity and willingness towards the lesson (Bell, 2010; Krajcik, Czerniak & Berger, 1999). It can cover several 21st century skills at the same time. For example, collaboration and communication skills are enhanced during group work, while inquiry approach is being at the center of PBL (Krajcik & Blumenfeld, 2006). Moreover, real world connections and project-based learning are intertwined each other (Blumenfeld et al., 1991). It provides students several problems related to local/global issues which require interdisciplinary knowledge (Capraro & Slough, 2008). Therefore, project-based learning (PBL) is considered as the convenient method in this thesis.

However, from teacher aspect, PBL can be challenging and unappropriate conditions may result in negative outcomes. For example, tasks should be appropriate to students' levels such that students can lose their motivation, if task is too easy or too difficult (Blumenfeld et al., 1991). Consequently, knowledge and skills cannot be gained. Morover, timing is an important issue in PBL. Because, projects can take long time; therefore, teachers should be able to arrange time appropriately in order to complete the project and help students to gain knowledge and skills. Also, teachers need to have deep content knowledge to guide students during a project (Blumenfeld et al., 1991). Otherwise, it would be loss of time.

This method may include different levels of teacher guidence. For example, a teacher may provide related research topics for students or he may not give any additional information for the solution of a problem in the project. Teacher's guidance plays important role. For example, students may get bored, if teacher help them too much without challenging them. On the other hand, students may lose interest, if teacher does not help them at all. Therefore, teacher should be able to decide the level of guidance for an effective PBL. Also, guidance can be related to level of inquiry, which can be implemented in a range from structured (likewise more guidance) to open inquiry (likewise less guidance).

Blanchard et al.(2010) examined students (n=1700), teachers (n=12) and schools (n=12) to reveal the effectiveness of inquiry method. Researchers applied pre-, post- and delayed posttests. Quasi-experimental research design was used. Students from different SES backgrounds were chosen. Also, teachers who had attended to PD programme about inquiry-based appraoch were chosen, but their success in this apprach were different according to Reformed Teaching Observation Protochol (RTOP). All students were given the same fictitious scenerio about suspects in a crime scene by using laboratory equipments. There were two groups as Level 0 inquiry group and Level 2 inquiry group. As a result of 1 week instruction and assessments, students in Level 2 inquiry group showed different results in advanced to students who had more successful teacher in inquiry-based teaching. In Level 2 inquiry group, students with less successful teachers in inquiry-based teaching had the lowest scores among all groups. This means that inquiry-based approach is better if teachers are competent in this approach. In addition, students in Level 0 inquiry group placed in between aforementioned groups. As a result, the findings indicated that inquiry instruction increased students' grades and understandings. Also, teachers with more knowledge about inquiry instruction affected students' learning better.

However, inquiry-based approach may not be suitable for each lesson. For example, it requires more time and teachers do not want to use it (Edelson, 2001). Also, it is not easy to implement in the classroom, hence, teachers need to be trained to be able to meet the goals of inquiry (Bybee, 2010). Besides, as indicated in

National Science Education Standards (NRC, 1996), all inquiry levels may not be proper for each student. Convenience between student levels and instruction type is important for success. As mentioned before, the level of inquiry is an important factor in the success of implementation. Therefore, if students' levels are not appropriate for open inquiry, e.g. due to low prior knowledge, students would not be successful in open inquiry.

2.6.2 21st century skills

Individuals are required to have some specific skills in 21st century. They need the skills to be able to both handle their own problems and think critically about the solution of local/global problems. These skills are *adaptibility, complex communication skills/social skills, nonroutine problem solving, self-management/self-development* and *systems thinking* (NRC, 2010). According to Bybee (2010) and Schunn (2009), they are described as follows:

- Adaptability means accomodating to challenging situations and environments by applying appropriate different approaches to deal with a task.
- Complex communication and social skills are the abilities to express oneself, ideas and findings of a task in a group.
- Nonroutine problem solving skills refer to find the necessary information, patterns and technique to solve a problem.
- Self-management/self-development indicates the discipline and motivation of an individual in a group or by oneself. This skill also includes being respectful towards different opinions.
- Systems thinking is about realizing how parts that are seen individually are actually connected and how they affect each other. Ability of abstract thinking and decision making are important.

Moreover, they can be narrowed down into creativity, critical thinking, problem solving, collaboration (Akgündüz, et al., 2015). According to DTI (2015), theoretical knowledge transformation to practical knowledge, manufacturing ability and creativity are important for an individual to posses in 21st century.

Helping students to gain 21st century skills and teaching by inquiry-based learning are closely related to each other. Because, individuals who conduct experiments, examine and question, in other words, individuals who become inquirers, can find solutions to problems of society. Therefore, gaining 21st century skills is possible with inquiry (Bybee, 2010; NRC, 2010; Windschitl, 2009).

However, despite the focus on 21st century skills in the US, there is a need to increase the weight of them both in the NSES and some of the state standards, which are participated in Partnership for 21st Century Skills (Shunn, 2009). Moreover, Turner (2013) found that teachers do not feel ready to gain these skills. Therefore, emphasis on the skills should be increased in teacher training programmes. When examined our secondary science curricula, it can be seen that abilities are defined similar to 21st century skills, as mentioned in the previous chapter. In physics curriculum, they can be found in the objectives. For example, giving daily life examples is articulated many times and it provides connections between lesson and students' environment. Moreover, several objectives state that students find solutions to prevent

- global warming issue,
- problems that can be due to buoyancy or Bernoulli principle,
- losses from earthquakes

Also, experimenting, using simulations and interpretations of results are paid attention in the objectives. These objectives, that help students to gain skills, could have more weight in the curriculum than other objectives that increase students' knowledge. In addition, collaboration, systems thinking and self-management, which are seen as important skills in 21st century, are not mentioned in the objectives.

21st century skills are also associated with real world connections during learning process. For example, Bouillion and Gomez (2001) conducted a study about interdisciplinary learning by using real world problems through PBL in an elementary school. Chicago River Project was conducted with fifth graders and their teachers. It was designed to be beneficial both for students and local community. Moreover, cultural background of students were taken into consideration to understand how students' different home cultures can enhance the learning process. Because, students in the study were from different cultures. Besides science, laguage arts (writing journals, making presentations, etc.), social studies (learning history of Chicago River) and math (analyzing surveys) were the other disciplines that were addressed in the project.

In the project, students had the chance to learn and connect concepts from different disciplines while their interest and self-efficacy increased. Because, they understood how the concepts, that were learned in lessons, were related to their own life. Moreover, students gained confidence, because, they realized that they can make a difference in their environment. According to researchers, this result is important due to the fact that students from urban areas feel as "outsiders" (p.894). Consequently, the project gave them the idea of they can make changes through education.

According to Windschitl (2009), to have students gain 21st century skills, teachers need to have specific skills. First, content knowledge and the ability to create links between different subjects should be high enough to realize curriculum's main concern, "big ideas" (p.6). This is also important for inquiry teaching, because, understanding the content deeply ensures asking right questions to enhance students' thinking ability (McDermott & Shaffer, 2000). Second, good communication between teacher and students is required to foster learning process. Also, when groups find different results in a group working, teacher should be able to understand and convey these different results to other students. Third, appropriate assessment techniques are important. If the aim is to enhance students' problem solving skills, then the exams or other assessment procedures should be consistent with this objective. Besides, the incompatiblity between content of the lesson and assessment procedures may result in students to lose interest in the content. Lastly, communication and cooperation between teachers, especially helping novice teachers, are very important to improve teaching practices. Because, teaching can be developed by experience. For example, novice teachers may not be good at classroom management during experimenting or they may not be able to make each student learn concepts. Therefore, other teachers can share own experineces to help them to improve themselves.

However, as in many educational context, there are opponents of emphasizing 21st century skills that much. Ravitch (2009) claimed that content knowledge remains at the background due to the emphasis on 21st century skills. Also, she stated that 21st century skills were similar to the skills needed in 20th century. Indeed, she gave several examples from the beginning of 1900s that had focused on including real life situations into the education. Likewise, Silva (2009) argued that, these skills are not specific to 21st century, but they gain significance in this century due to economic reasons. Also, according to Akgündüz, et al. (2015), these skills will be necessary in the future due to the fact that economy will be based on individual industries which is different than the situation in the indiustrial revolution. Criticism about emphasis on 21st century is partly correct. Because, although these skills, such as critical thinking, communication and problem solving, etc. do not emerge in this century, they are presented as if they are new. But it can be said that 21st century has specific problems in terms of economy, environment, security, etc.; therefore, these skills gain importance in this century. Governments need much more citizens that have the skills to be able to overcome the problems. This concern is also valid for individuals, such that they need the skills to handle own problems.

Moreover, it can be thought as helping students to gain skills are more important than gaining knowledge. Content knowledge can change in curricula of a discipline, but skills are definite and more important for curricula. For example, astronomy had been included in Turkish physics curriculum in 2011, but it was removed in the next curriculum. But critical thinking, problem solving, etc. are always important in each curricula. Because, the ultimate aim is to help students to learn how to reach necessary information and find solution, not to have the information. Therefore, Rativch's criticism about more emphasis on skills than content knowledge does not have much significance.

2.6.3 Technology and engineering

Students' comprehension of science can be improved by engaging them into the lesson with variety of softwares and hardwares such as programs for data analysis, sensors or smart boards, etc. (Capraro et al., 2013; Guzey & Roehrig, 2009; Honey et al., 2014; ITEA, 2007). Moreover, these tools increase the effectiveness of projects, but teachers’ ability in using technology plays important role. To be able to increase students’ understandings and interests, teachers should have full knowledge of these tools. Otherwise, in case of a problem about them, students could lose interest, if teachers could not handle the situation.

In Turkey, elementary science education named “science and technology” since 2000s to be able to get involved students with technology and its usage areas in daily life. There were several changes in the lessons’ scope and names in time. Today, there are science program for grades 3-8, information technologies and programming for grades 5 and 6, technology and design for grades 7 and 8.

As mentioned before, EBA is an extensive resource for teachers to use simulations or videos in their lessons. However, as good as it sounds, there are some critics against it. Although it was funded extremely high, some studies showed that smart boards and tablets are not used as expected. For example, in the study of Pamuk, Çakır, Ergun, Yılmaz and Ayas (2013), both students and teachers opinions were asked. Although they claimed that they were using smartboards and tablets often, school observations indicated opposite results. Also, some teachers stated that they did not much need tablets, and they did not use them. On the other hand, it was reported that teachers and students’ motivation increased. But, researchers suggested that to have more effective usage of these technologies, teachers need trainings about this issue. Because, teachers do not know how exactly they should use technology during instruction. Researchers argued that in-service training programmes did not serve this purpose, rather they focus at general technical knowledge and skills in using technology. One of the suggestions of this study was that in-service training programmes should be accomodated to teachers’ knowledge levels, attitudes and skills.

According to a report published by General Directorate of Secondary Education (MEB Ortaöğretim Genel Müdürlüğü, 2016), technology usage in some high schools and some regions did not fit the educational goals to great extent. But in general, according to teachers, internet access limitations, usage of smart boards, insufficient content in EBA and problems in students’ tablets were the main problems. In contrast to the findings of the study of Pamuk et al. (2013), this report found that tablet usage decreases motivation and achievement. The claims were belong to administrators in state national education ministries. But how they reached this conclusion was not included in the report. Moreover, teachers argued that tablets were not useful due to the fact that, each student does not have access to internet at home, MoNE stricts full access in the internet, tablets do not have USB socket, programs in tablets cannot play EBA videos, amount of EBA soruces are not sufficient, there are technical problems about smart boards, internet access and tablets, etc. Some of these comments can be seen as more important than others. For example, internet access might be stricted on purpose, because, full access can cause loss of interest in lesson and loss of time. But insufficient source is an important problem that should be solved.

Nevertheless, bringing technology into classrooms is important to support the needs of individuals in 21st century (Crippen & Archambault, 2012) and therefore, apart from negative aspects, Fatih project can be seen as a step toward in technology integration in education which is equipped with instructional technologies. Yet, more instructional software improvements and more pre-service and in-service teacher training programmes are required.

Guzey and Roehrig (2009) examined the developments of teachers in a program to enhance technology integration into science lessons to increase inquiry-based learning. The program involved trainings for secondary science teachers about inquiry-based approach and technology usage (concept mapping tools, sensors, simulations and videos) in lessons. Besides, teachers shared opinions and resources with researchers, by this way, they had a chance to look from a broad perspective. At the end, teachers prepared lesson plans by including technology into instruction with inquiry-based appraoch. Researchers examined participants with surveys, interviews, lesson plans, and teachers’ reports. According to the results of the study, technology integration besides inquiry teaching were improved. But the degree of integrations varied in terms of teachers’ self-confidence about using technology or believing in the usefulness of tools. Moreover, teachers’ content knowledge, pedagogy knowledge, knowledge of technology influenced teachers’ technology usage. In addition, number of students and equipments available in school were the other determinants.

According to NRC (2011), science education need a different approach to learn science without memorization and to increase students' interest in science lessons. For this purpose, simulations and computer games are at focus, because, they have potential to improve science education by providing active engagement of students in lessons. However, researchers added that, in this topic there is lack of evidence to prove that simulations and games enhance students' learning.

One of the studies in this area was done by Jimoyiannis and Komis (2001). They investigated students' learning in projectile motion by using simulations. In this study, control group received only traditional method and experimental group received instructions with simulations besides traditional method. At the end of the instructions, participants answered three questions about velocity and acceleration of two falling balls. Researchers stated that, experimental group was superior than control group for the first and second questions. However, for the third question there were no significant difference between groups. Researchers argued that the reason of this finding is because of the fact that participants in the experimental group could not use simulation about third question, rather they received only traditional instruction. Consequently, the study showed that students can learn better with simulations, hence, researchers suggested that simulations can be used for meaningful learning.

In addition to technology, studies about engineering applications in K-12 education indicate that students motivation and success are increased by engineering and design. Engineering integration includes not only design process, but also engineering habits of mind, which means to show students how engineers think and behave in a problem situation. But engineering and design is seen as much more important part of K-12 engineering education (Dym, 1999). Because, engineering habits of mind can be gained through engineering and design.

Baran, Bilici, Mesutoğlu and Ocak (2016) conducted a study with 6^{th} grade students to investigate their STEM career perceptions by using engineering design activities. Participants (n=40) in their study consisted of students from disadvantaged groups who are generally successful in lessons. In total, 13 activities, about designing and finding solutions to problems, were done by using inquiry approach. In the activities, everyday materials, that can be found easily, were used. Researchers paid attention to collaboration among students in the activities; for example, each student had assigned work, they learned together, etc. Also, in one of the activities, coding was included to transfer data from android devices. In the study, data analysis was done by considering *subjects learnt and skills that students developed in the activity, how students will make use of the activity and, students' suggestions for the activity*. At the end of the program, students' knowledge and interest in STEM areas were increased. For example, *solid structrure construction* and, *velocity-time graph and distance-time graph* are subjects that most of students learned. Also, *handcraft* and *cognitive skills* were the skills that students mostly gained from the activities. However, researchers stated that participants were already successful students and they were eager to be a part of the project. Hence, positive outcomes of the study can be thought as the expected results.

Moreover, in many examples of engineering integration, robotics is used. Also, in Turkey, robotics is very popular especially among private schools. Besides using them in science lessons, there are many robotics clubs in which students can learn coding.

However, robotics has not long history in education and there is not much research about its influence, but they are used by teachers (Erdogan, Corlu & Capraro, 2013). There are questions that should be answered, such that what actually robotics do to improve in the students' learning, what their place will be in the future, whether they will still be functional or students will get bored of them, how can teachers make the best of robotics (Johnson, 2003). Although these questions are not answered yet, robotics are highly used in Turkey for engineering integration. As a matter of fact, STEM education is associated with robotics mostly.

According to Bergen (2001), creativity, self-esteem and reading skills were enhanced with robotics. Nonetheless, he added that there is a difference between the ready-to-use robots and robots which need to be programmed first. The second type robots improve students' metacognitive skills due to the struggle for coding the program to work (Bergen, 2001). Çavaş and Çavaş (2005) conducted a study with elementary students by using LEGO Mindstorms®, which are needed to be designed and programmed. In the study, students were asked to define problems and then design robots to solve those problems. Researchers and teachers were also participated in the study to guide students and to decide whether or not the robots were appropriate for the solutions of the problems. At the end, students' knowledge, attitudes and abilities in using information and communication technologies were increased.

Likewise, Erdogan et al. (2013) created a robotics program for 11th graders to construct robots in which students can find and move things as if they were on Mars surface. At the end of the program, mathematics, reading and science literacy were analyzed and the t-test analysis revealed that science and mathematics literacy were enhanced.

Although engineering integration has significant effect on student learning, appropriate implementations should be maintained by teachers. Such that, robotics or other engineering designs can be distractive for students; therefore, teachers' guidance is important not to lose students' attention. The aim, which is improving students undertandings and developing their skills, should not be forgotten.

2.6.4 STEM interest

Components mentioned above are complementary parts of STEM education. Such that, inquiry-based approach can be included in technology and engineering applications, and they cover real world conncetions. In addition; these connections include helping students to gain 21st century skills. Moreover, all of these components have potential to increase students' interest towards STEM areas (Ayar, 2015; Berland & Steingut; 2014; Sklar, Eguchi & Johnson, 2003). Because, they have different aspects from traditional method. For example, students feel that they can contribute to their own lives and environments. As in the study of Bouillion and Gomez (2010), students motivation and interest can be increased with these kind of projects. However, according to Wells, Sanchez, &Attridge (2007), as long as teachers continue to teach disciplines by silos with expository teaching and continue not to invlove real world problems, STEM careers cannot be a trend for K-12 students.

In addition, to increase the interest, one other aspect is to engage students with STEM members in the society by giving chance to work with those members (NRC, 2010). Out of school learning environments are important to make students be prepared for STEM careers by increasing their interest (Migus, n.d.). Because, establishing the relationship between lessons and real life situations may not be easy. Also, giving examples from daily life may not be enough to establish this relationship in lessons. To provide it, going on field trips to industries, science centers, etc. can increase not only comprehension of students, but also their interest towards STEM fields.

Increase in interest can lead students to pursue STEM careers in the future, which is the ultimate goal of STEM education, as well as providing an increase in science and mathematics achievement (NRC, 2010). Nonetheless; Bybee (2013) added that each student does not need to be a member of STEM fields, but he needs to be a STEM literate individual. STEM literacy is not just about having knowledge about STEM disciplines. It includes being able to use these knowledge in real-life situations, to have judgements in issues about STEM, to understand how STEM involved in our life and to have eagerness to be involved in issues about STEM (Bybee, 2013). These points are the expected characteristics of individuals even they are not members of STEM workforce.

2.6.5 Performance assessment

Assessment is a supplementary element of education system to built science and engineering knowledge on students (NRC, 2012). Besides of education, graduates will receive evaluations and judgements when they become employees (Bell, 2010). Therefore, both school and business life bring assessments.

STEM education includes designs, projects, etc. that require processes with several steps. Objectives include not only outcomes in terms of knowledge, but also skills that students can gain during these processes. For example, a design task about construction of an earthquake resistant building helps students gain knowledge about seismic waves, materials used in civil engineering, precautions for earthquakes, etc. In addition to these outcomes, students can gain communication and critical thinking skills while questioning and researching which material to use in group working. At the end of such a task, if only paper-and-pencil tests are used, assessment becomes incomplete. Because, teachers cannot determine whether or not students gain aforementioned skills. Therefore, assessment based on students' performances should be included in these lessons as in STEM education.

If the aim is to help students gain 21st century skills, students should be assessed according to their performances during projects or tasks besides standardized tests (Bell 2010; Ernst, 2008; Shunn, 2009; Windschitl, 2009). Because, performance assessment techniques determine the quality of students' gained skills (Barry, 2017). Lessons with performance tasks basically involve searching for information, investigation for an outcome and evaluation of the outcome, which cannot be assessed completely by paper-and-pencil tests.

Morover, according to Lin and Williams (2016), using only paper-and-pencil tests leads teachers not to implement STEM education and stick with teaching according to the questions in the exams. Therefore, it might mean that assessment techniques at the end of learning sessions have influence on teaching technique. For example, in Turkey context, high school and university entrance exams may affect teachers' focus in class. In other words, teachers may pay attention only to subjects which are involved in the exams. Although the importance of these exams cannot be disregarded, it should be note that, aim of education is to raise individuals who can contribute in nations' economy and future by using both their knowledge and skills. Therefore, teachers should not forget this aim and not only focus on exams.

CHAPTER 3

METHODOLOGY

The aim of this chapter was to explain the process of construction of the instrument which includes piloting of the test, and analysis of the data to obtain the final instrument.

3.1 Purpose

The purpose of the study was to construct a valid and reliable instrument that measures perception of elementary and secondary science teachers' readiness in implementation of STEM education. The intent was just to develop the instrument, not to investigate whether or not teachers are ready. Such a study can be conducted after the instrument is developed. As mentioned earlier, there is no STEM readiness instrument to measure teachers' weaknesses and strengths in STEM education implementations. However, in the literature there are instruments about STEM education perceptions and implementations which guided this study, especially during the identification of components of STEM education. Indeed, components are determined by considering the essential points that increase the effect of STEM education in K-12 classrooms.

3.2 Sample

Sample size is an important issue in factor analysis, which will be explained later. According to Tabachnick and Fidell (2007), sample size must be minimum 300 for a good factor analysis regardless of the number of items. Similarly, according to Comrey and Lee (1992) above 300 is good sample size for a better factor analysis. Moreover, Gorsuch (1983) contended that 5:1 ratio of participants to number of items must be ensured, as long as the sample size is more than 100 participants. In this study, we aimed to meet this requirement.

Participants in the study were elementary science, secondary biology, physics and chemistry teachers. Majority of them were working in schools at the Keçiören, Altındağ and Çankaya districts in Ankara. Because of our aim, which is to develop the test and not to infer from the results, we used convenience sampling and we reached as many teachers as we can. Although 439 instrument distributed to elementary and secondary in-service science teachers, 320 instrument were responded. However, 14 of them colud not be analyzed due to the fact that there were lots of missing items and also, there were items that answered in the same pattern. Consequently, 306 instrument were analyzed. As seen in Table 3 majority of the participants were female and experienced teachers. In addtition, number of public school teachers are greater than number of private school teachers in the study. In addition, the table indicates that 71.6% of teachers did not participate any training programme related to STEM education. This statistics may refer that most of teachers do not know how to implement STEM education properly and they may need training programmes.

Table 3. Demographics of the sample

		n	%
Gender	Female	202	66
	Male	101	33
School type	Public school	223	72.9
	Private school	76	24.8
Discipline	Biology	66	21.6
	Physics	53	17.3
	Chemistry	52	17
	Elementary science	130	42.5
Teaching experinence	1-5 years	39	12.7
	6-10 years	50	16.3
	11-20 years	99	32.4
	20+ years	118	38.6
Participation to STEM training programmes	Yes	79	25.8
	No	219	71.6

For the permission of distribution of the instrument, ethics approval was obtained from both the Graduate School of Natural and Applied Sciences (see Appendix A).

3.3 Test Development Process

Readiness, as discussed before, is defined as having willingness and ability on a task (Baker, 2002; Hersey, Blachard & Johnson, 1996; Inan & Lowther, 2010). In this study, we focused on ability part of readiness. The reason was explained in the previous chapter. The verbs at the end of each sentence in the instrument ask ability of teachers in that area; however, at the beginning of the instrument, teachers are asked to answer the items by considering their own existing knowledge levels. Therefore, ability verbs in the items refer to teachers' perceptions about whether or not they can perform the related tasks according to their existing knowledge and skills.

Test development process involves some specific steps: (1) Determine Clearly What It Is You Want to Measure, (2) Generate an Item Pool, (3) Determine the Format for Measurement, (4) Have Initial Item Pool Reviewed by Experts, (5) Consider Inclusion of Validation Items, (6) Administer Items to a Development Sample, (7) Evaluate the Items, (8) Optimize Scale Length (DeVellis, 2017). These steps were considered as a guideline in the development process of this instrument and Figure 1 indicates specific steps that were followed in this study.

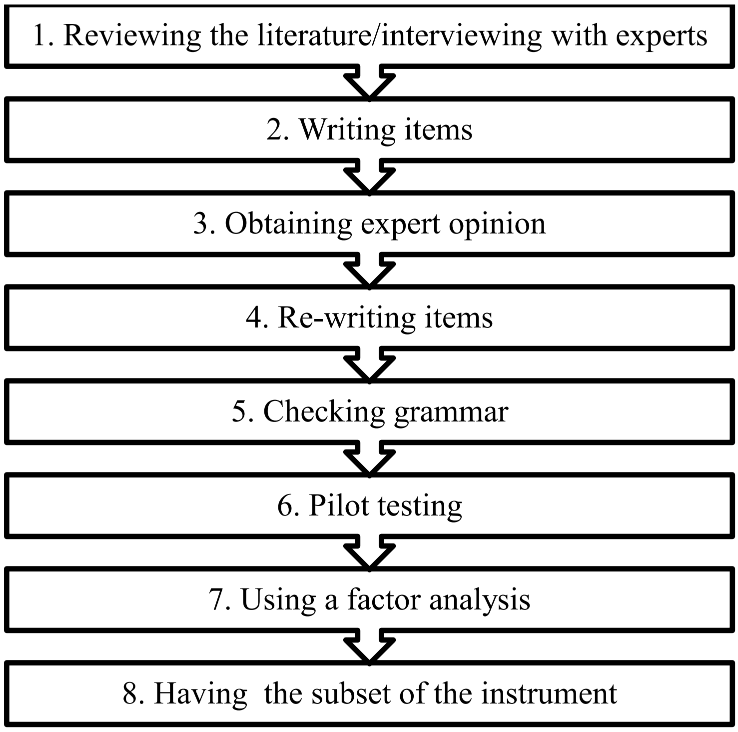

Figure 1. Steps followed in the test development process

In Step 1, we reviewed the literature and interviewed with experts who have studies about STEM education. Interview questions were about the following points:

- definition of STEM education,
- reasons of need for STEM education,
- whether or not STEM education provide equity in Turkey context,
- outcomes that are expected from STEM education,
- difficulties that teachers are faced,
- teacher training programmes on STEM education.

As a result of literature review and interviews, following points were focused for a good STEM education:

- paying attention to increase mnotivation of students from disadvantaged groups and to provide equity for all,
- being able to use technology properly in the classroom,
- being able to include engineering and design, and having students gain engineering habits of mind,
- being able to use appropriate inquiry approaches,
- being able to connect the topics with daily life,
- being able to combine the disciplines,
- having the knowledge in the STEM disciplines,
- informing and directing students towards STEM fields,
- having students gain 21st century skills,
- using appropriate performance assessment techniques.

According to these points, the components of the STEM readiness instrument were thought as inquiry-based approach, engineering and design, technology integration, equity in education, daily-life connections, 21st century skills, interdisciplinary knowledge, performance assessment and STEM interest. However, note that, they were changed according to factor analysis results (explained in the next chapter) and at the end, the underlying dimensions were defined as engineering and design, making connections, 21st century skills, local/global problems, performance assessment, technology usage, and STEM interest.

In Step 2, in the light of literature and interviews with experts, 9 components were decided and 54 items were written. Specifically, there were 6 items in equity, 5 items in technology usage, 7 items in engineering and design, 9 items in inquiry-based approach, 4 items in real life connections, 5 items in STEM interest, 6 items in 21st century skills, 6 items in performance assessment and 6 items in interdisciplinary knowledge domains.

During item writing process one of the main concerns was to write the items with different words. For example, verbs were written differently, such as *can do,can make, can apply*, etc. Also, some items contain the word “students”, some of them do not. In addition, synonymous words were also taken into consideration. The reason for these concerns was that if the items had similar words, then teachers would be bored and answer in a similar way. However, despite grammer concerns and not to loose the meaning of items, some of them were resembled each other; therefore, they might be understood in the same way and caused problems in the analysis, which will be explained in the next chapter. But, in the subset version of the instrument (Appendix D), these problems were paid attention and solved.

Specific examples of items and corresponding literature concerns for each domain are illustrated in Table 4.

Table 4. Sample items in each domain

Domain	Literature	Sample item
Equity	Students from disadvantaged groups should be given a chance to participate in lessons.	Sosyoekonomik açıdan dezavantajlı öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.
Technology usage	Students must be technologically literate individuals even if they will not choose STEM careers.	Öğrencilerime teknoloji okuryazarlığı (teknolojiyi anlama, kullanma, teknolojinin ve toplumun birbirini nasıl şekillendirdiğini değerlendirme vb.) kazandırabilirim.
Engineering and design	Students should develop solutions to real world problems.	Öğrencilerime insanların ihtiyaçlarını karşılamaya yönelik ürünler tasarlatabilirim.
Inquiry-based approach	Inquiry-based approach provides students to participate lessons actively.	Derslerimde öğrenme döngüsü yöntemini (3E, 5E veya 7E) kullanabilirim.
Real life connections	STEM lessons provide real world applications that students can relate lessons with their own lives.	Derslerimde günlük hayattan örneklere yer verebilecek kadar, branşımın günlük hayat ile olan bağlantısına hâkimim.
STEM interest	STEM industry needs qualified members and K-12 students should be motivated towards these areas to be members of STEM industry.	Üniversite ve sanayi gibi kuruluşlara gezi düzenleyerek öğrencilerimin STEM alanlarına ilgi duymalarını sağlayabilirim.
21st century skills	Students need specific skills to find solutions to problems in this century.	Öğrencilerimin, birlikte çalışabilme, sorumluluk alabilme, iletişim kurabilme gibi grup halinde çalışma becerilerini geliştirebilirim.
Performance assessment	STEM education pays attention to processes as well as products; therefore, assessment techniques should be appropriate to objectives of lessons.	Öğrenci projelerinin her bir aşamasını (araştırma, çözüm üretme, çözümü sunma vb.) derecelendirme ölçekleri ile değerlendirebilirim.
Interdisciplinary knowledge	STEM education requires students to combine knowledge in various disciplines as in real world situations.	Derslerimde öğrencilerimin fen alanları arasındaki ilişkileri fark etmesini sağlayabilirim.

As seen in Table 4, domains and items represent the most common STEM education concerns. Note that, these domains were not exactly determined in the literature because of the fact that literature does not define STEM readiness. Therefore, they were named by researcher. Also, items were written according to literature but transformed to make them agree with ability construct. Moroever, they were formulated to be answered in 5-point Likert type agreement scale from strongly agree to strongly disagree. In addition to these items, the instrument also contains items that ask demographic information and whether or not teachers attend any STEM education training programmes.

In Step 3, after the items were written, they were presented in a chekclist (see Appendix B) to 10 academics for expert opinions in terms of item understandability and item convenience with both STEM education and its related dimensions. Related items in each dimension were presented together in the checlist.

Moreover, experts were asked whether or not agreement scale is appropriate for the items, and they confirmed their appropriateness. Seven of the experts gave feedback in detail and filled the checklist. Several suggestions were about understandability of some items. Therefore, explanations were added to the items for such terms. For instance, the following item was written before it was asked experts:

Öğrencilerimin mühendis gibi düşünmelerini sağlayabilirim.

Then, experts stated that the item may not be understood in a same way by each teacher, hence, it was changed as following:

Öğrencilerimin bir mühendis gibi düşünmelerini (problemi, problemin çözümünü, maliyetini ve çevreye olan etkilerini düşünme vb.) sağlayabilirim.

By considering expert opinions some items were dropped and some items were rewritten. Eventually, 54 items were revised and 50 items (Appendix C) were decided to be in the instrument.

In Step 5, grammer check of the instrument was done by a Turkish language teacher before final form of the test. All suggestions were taken into consideration and items were revised accordingly. Moreover, items in each dimension were not placed successively in the final form of the test. By this way, we aimed that participants would not get tired or bored of reading similar items.

3.3.1 Piloting the initial test

In Step 6, the instrument was pilot tested. During data collection, in order to make participants understand the items in the same way, there were no additional explanation about STEM education. There were only the information at the beginning of the test that explains the terms involved in the test. Also, it includes the information that teachers should consider their existing knowledge about related issues in the items, while answering them. By this way, we aimed to measure teachers' perceptions about themselves if they can perform the related tasks in the items. We delivered instruments to teachers in different schools and waited several weeks to take them back. All the instruments were not delivered at the same time due to different locations of schools, i.e. difficulty in getting instruments to schools, and availability of teachers to fill them. Consequently, all the data were collected approximately in 2 months.

Step 7 includes data analysis and it will be explained in the following paragraphs. Moreover, Step 8 will also be explained in detail in the following chapter. However, at the end of this last step, we did not present the final version of the instrument, rather we explained why we deleted, rewrote or kept the items. To develop the instrument in the final version, the items, which were obtained (omitted, rewritten or kept) as a result of factor analysis, should be pilot tested again. Their reliability and validity should be established by collecting new data. Although test development involves this iteration process, due to time limitation and difficulty to reach teachers, this step could not be executed in the study.

3.4 STEM Education Framework

STEM education perceptions and implementations are varied by different researchers and teachers as mentioned before. Within the scope of this study, STEM education is defined as integration of engineering and technology to science and mathematics classes by using inquiry-based approaches.

Moreover, as explained in the previous chapter, literature points out that there should be other components besides engineering and technology integration, and inquiry-based approach for an effective STEM education: equity in education, 21st century skills, daily-life connections, interdisciplinary knowledge, performance assessment and STEM interest. Therefore, being able to implement STEM education effectively, a teacher should have strengths in these components. In other words, he should be ready to implement these components in his teaching experience.

Moreover, interviews with experts, which will be explained in the following paragraphs, lead us to focus on these components. Therefore, items were constructed within the context of these components (Figure 2).

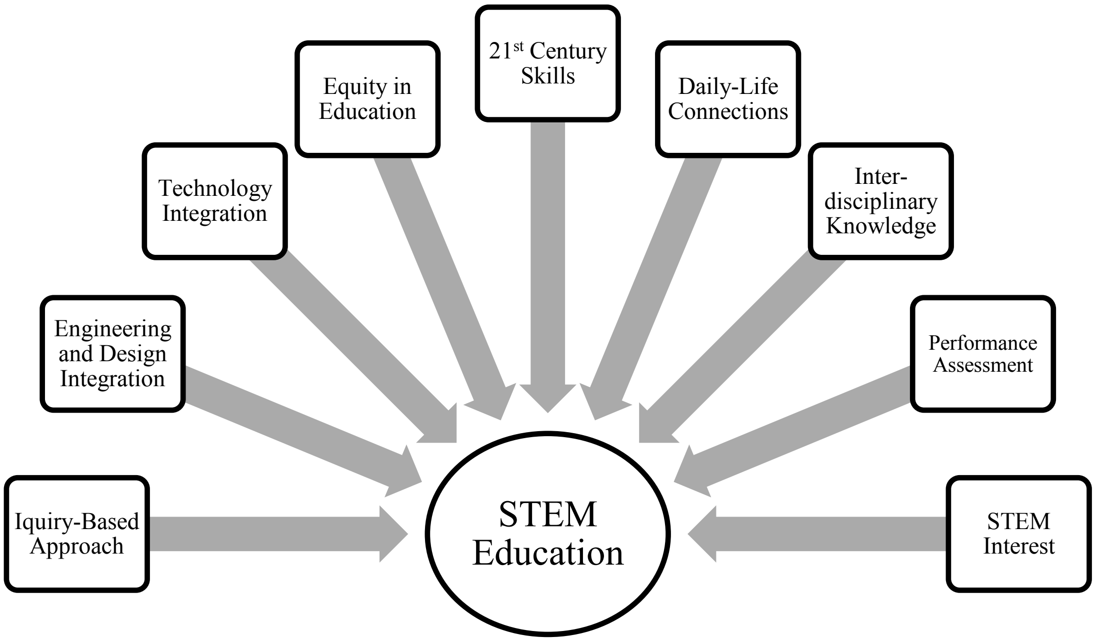

Figure 2. STEM education framework

3.5 Data Analysis

In the data analysis, missing data, reliability of factors and validity were checked. These analyses were explained in the following paragraphs.

3.5.1 Missing data analysis

This analysis was done to determine whether or not missing data were random. According to SPSS results, missing data is non-random. At this point, Tabachnick and Fidel (2007) stated that estimation should be applied in case of non-random missing values. However, in this study, estimation was not logical. Because, as Ali Eryılmaz stated, to be able to conduct this process, we need to know which value will be estimated for that item (personal communication, July, 2017). In addition, we need to know which items are related to the item with missing value. Then, we can estimate those related items' values for the item with missing value. Due to the fact that we did not know the factors and we did not know which items belong to the same factor at the beginning of the analysis, we could not use estimation for missing values. Therefore, rather than estimation, we used pairwise deletion; by this way, not all missing data were deleted and more data could be used (Pituch & Stevens, 2016).

3.5.2 Reliability analysis

Reliability is one of the important issue in test development. Among the variety of reliability techniques, we checked for internal consistency by using Cronbach's Alpha. Researchers have different opinions for minimum accepted Cronbach's Alpha value. For example, according to Nunnally and Bernstein (1994), .70 and according to DeVellis (2003), .80 and above is considered as cut-off point for reliability.

3.5.3 Validity: Factor analysis

Validity is the most important issue in test development. In this study, evidence for validity was esteblished in two different ways. Firstly, expert opinions were obtained, as explained before. In addition, in order to provide evidence for construct validity of the results of the instrument, factor analysis was conducted in IBM® SPSS 24® Statistics. Factor analysis determines the underlying constructs in the instrument (Tabachnick & Fidell, 2007).

There are two types of factor analysis, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). While the amount of correlation among variables is determined by EFA, confirmation of the validity of an already existed instrument is done by CFA (DeCoster, 1998). Consequently, EFA is the proper analysis for the validity of results of this instrument, due to the fact that items were constructed for the first time. In other words, although literature outlined some specific dimensions, we do not know whether or not they are the factors in teachers' perceived readiness in STEM education implementations.

Factor analysis is considered as appropriate to conduct when some assumptions are met. We have discussed already suitability of sample size, and apart from that, there are two main criteria: The first one is Kaiser-Mayer-Olkin (KMO) value which should be greater than or equal to .600, and the second one is Bartlett's test of sphericity which should be statistically significant. Moreover, correlation among items should be checked, such that, if they are more than .320 in general, factor analysis can be conducted (Tabachnick & Fidell, 2007). In this study, as all the assumptions were met, a factor analysis was performed.

In SPSS, there are several techniques for factor extraction which determine number of factors to be extracted. Principal axis factoring (PAF) and principal components analysis are the most common techniques (Tabachnick & Fidell, 2007). According to Gorsuch (1983), there is not much difference between the two techniques in terms of factor extraction if the number of items are not less than 30. Also, according to Meyers, Gamst and Guarino (2006), researchers do not point out which technique should be used in a specific situation. Thus, in this study, PAF was used, because it gave more interpretable results.

Besides these techniques, to determine the number of factors, there are some other criteria to consider. The first one is Kaiser criterion i.e., eigenvalue can be taken into consideration, such that factors that have 1 or greater eigenvalue can be kept. Because, eigenvalue of a factor shows the total variance explained by the factor (Pallant, 2001). Indeed, factors that can explain more variance in the test scores can be retained. The second one is scree test. In the scree test, eigenvalues are plotted and the shape of the plot is investigated. It shows that number of factors can be decided by looking for break point or elbow shape in the graph.

These criteria can be taken into consideration to decide how many factors should be; however, Pallant (2001) and Tabachnick and Fidell (2007) stated that researcher can decide the factor number that can draw better inference for the underlying construct. In this study, the number of factors were determined by the researcher, because, Kaiser's criterion and scree plot would cause improper interpretation which will be explained in the next chapter.

Communality table in the SPSS outcome shows items' ratio in the common variance (Field, 2009). Therefore, greater communality values refers to greater variance explained (Nunnally & Bernstein, 1994), which is intended outcome. According to Pallant (2001), if communality value is low of an item, this means that the item and other items in that component are not in agreement. Thus, the item can be removed; however, communalities highly depend on number of factors and they can increase or decrease rapidly. Therefore, removing or retaining items according to communality values should be done after deciding the number of factors.

Factor rotation is used to interpret the solution in an easier way, not to obtain a different or better result (Pallant, 2001; Tabachnick & Fidell, 2007). There are two techniques, which are oblique and orthogonal rotations. While oblique rotation is used if factors are correlated, orthogonal rotation is used if factors are uncorrelated. Correlations that are more than .300 means that rotation should be oblique (Tabachnick & Fidell, 2007).

In oblique rotation, SPSS brings two matrices, structure and pattern matrix. From structure matrix, the correlation coefficients between variables and factors can be interpreted. More importantly, from pattern matrix, variables' loadings on factors can be interpreted. These loadings are expected to be above .320 (Tabachnick & Fidell, 2007); however, in this study, for Item 6, Item 25 and Item 36, this threshold value was decided to be .200 and the reason will be explained in the next chapter.

3.5.3.1 Development of the subset of the instrument

In the study, all the above mentioned procedures (factor extraction, rotation, etc.) were followed and explained in in detail in the next chapter. In general, the following points were considered:

- Eigenvalues and scree plot to determine number of factors,
- Factor correlations to determine rotation technique,
- Communality values and loadings in pattern matrix to determine items to be retained, deleted or revised (due to the importance of some items for the instrument, even though the loadings were not high, they were kept by rewriting them).

In addition, for each deleted item, the program was run again. Hence, we decided to delete or keep the items according to the results of these many iterations in the anlaysis.

As Tabachnick and Fidell (2007, p.642) stated, the result which can show the best “scientific utility, consistency, and meaning” should be presented. Hence, the instrument was developed by including interpretations of the researcher, although SPSS pointed different results in some steps. As a result, the instrument of *Teachers' Perceived Readiness In STEM Education* was developed.

CHAPTER 4

FINDINGS AND DISCUSSION

For the purpose of developing a valid instrument for science teachers' perceived readiness on STEM education, reliability and factor analysis were conducted. In this chapter, results of these analysis and more detailed explanations of EFA were given.

4.1 Reliability analysis

Cronbach's Alpha was calculated to check internal consistency. The calculated value for 50 item was .952 and for 30 items in the subset of the instrument is .927. In addition, reliability of factors in 7-factor solution of 30 items is shown in Table 10. According to Nunnally and Bernstein (1994), these reliability coefficients were acceptable, except Factor 6. However, this low reliability can be caused by deficiency in understandablity of Item 6 and Item 25. In addition, Item 6 considerably increased the reliability if it was deleted (can be seen in Appendix E). However, as explained in the following paragrahps, because of the importance of these items for purpose of the instrument, they were not deleted, but they were rewritten to increase their understandability.

Table 5. Factor reliabilities

Factors	1	2	3	4	5	6	7
Cronbach's Alpha	.777	.838	.829	.706	.806	.599	.851

4.2 Factor analysis

At the first step of EFA, 50 items were investigated in SPSS by using PAF and direct oblimin rotation as explained in the previous chapter. KMO value was .934, which is acceptable, and Bartlett's test of sphericity was statistically significant ($p<.05$). Both of which indicated that items were appropriate for factor analysis. Moreover, correlation matrix was also an indicator for a good factor analysis, because, there were many measures that exceeded .300 (Appendix F).

This analysis revealed 10-factor solution with eigenvalues equal to 1 or greater. Table 5 shows eigenvalue and the amount of variance explained by each factor.

Table 6. Eigenvalues and total variance explained by 10-factor solution

Components	Eigenvalue	% of variance	Cumulative %
1	16.958	33.038	33.038
2	4.008	7.130	40.168
3	1.777	2.696	42.865
4	1.527	2.198	45.063
5	1.331	1.873	46.935
6	1.282	1.583	48.518
7	1.242	1.512	50.031
8	1.189	1.389	51.420
9	1.140	1.342	52.762
10	1.030	1.091	53.853

As seen in the Table 5, 10-factor solution explained 53.853% of total the variance. But, especially after factor 7, increase in the variance is too small (approximately 1%). This means that last 3 components do not have much contribution in the explanation of the variance for the instrument. Moreover, according to scree plot (Figure 3), there can be different interpretations about the number of factors. Scree plot can be interpretted by looking at factors above the elbow, as mentioned in the previous chapter. In the plot, there is a more clear change in eigenvalues until Factor 5. Nonetheless, it can be said that there is not much change after Factor 7. Due to small changes in the plot, it can be interpreted differently. To decide number of factors, we also examined pattern matrix for 10-factor solution, which will be explained in the following paragraphs.

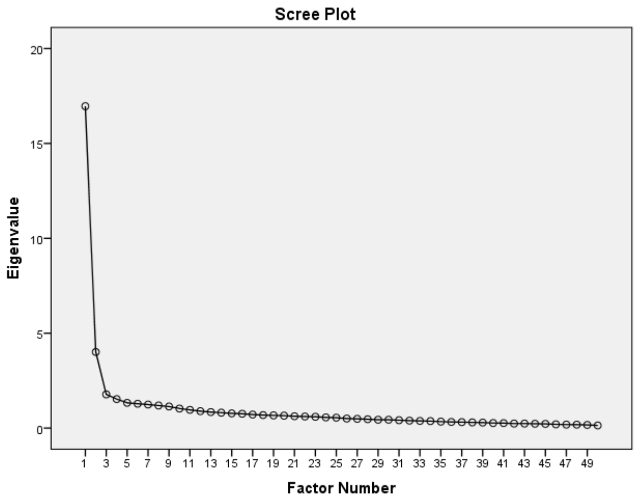

Figure 3. Scree plot for 10-factor solution

In unrotated solution, 3 factors did not have loadings and the majority of items loaded on the first two factors. Therefore, we did not use unrotated solution. To obtain more explicable solution, rotated factor solution was examined.

In the pattern matrix for 10-factor solution with direct oblimin rotation, five items (10, 25, 29, 37 and 40) were not loaded on any of the factors. Moreover, there were items loaded together on the same factor which are not related. For example, items written below were loaded on the same factor:

Derslerimi daha iyi anlatabilmek için konulara uygun yöntemler seçebilirim.
Derslerimde günlük hayattan örneklere yer verebilecek kadar, branşımın günlük hayat ile olan bağlantısına hâkimim.

Moreover, there were other items that made interpretation difficult. For example, items written below consist of the same *giving example* term, although the first one is about teaching method and the second one is about increasing STEM interest of students:

Derslerimde modelleme aktivitesi (kompleks bir yapının basitleştirilerek gösterilmesi) yaptırabilirim.

Derslerimde STEM alanlarına yönelik ilgi uyandırmak için aktivite yapabilirim.

As explained in the previous chapter, in the item writing process, we paid attention not to use the same terms especially for the items that were thought to be related to the same component. However, to prevent meaning loss of the items, we had to use some similar terms in different items. This situation might cause problems such that, teachers understood and answered them in the same way, thus the analysis put them under the same component. In order to prevent this situation, 3 items (6, 25 and 30) were rewritten and 17 items (5, 10, 11, 14, 16, 17, 20, 26, 31, 33, 34, 35, 38, 40, 44, 49 and 50) were omitted in the subset of the instrument.

Because some items were not loaded and some unrelated items loaded together in the first run of factor analysis with 10 factors, the solution was not suitable tointerpret meaningfully. Then, we decided to decrease number of factors. We interpreted scree plot and total variance explained table as mentioned before. As a result, to keep STEM components in our framework and to interpret the analysis in a better way, the most convenient number of extracted factors was determined to be 7. Note that, factor extraction and rotation technique was not changed. High correlations for rotated solution can be seen among factors (Table 6), which indicates that oblimin rotation was appropriate to use.

Table 7. Factor correlations for 7-factor solution

Factor	1	2	3	4	5	6
2	.335					
3	.344	.541				
4	.335	.344	.355			
5	.414	.134	.248	.159		
6	.412	.001	.196	.246	.423	
7	.535	.250	.264	.259	.465	.390

Moreover, the subset of the instrument consists of 30 items and deleted items will be explained in this chapter. As seen in Table 7, KMO value was .923, which is larger than the excepted value of .6 (Tabachnick & Fidell, 2007) and Bartlett's test of sphericity was statistically significant (p<.05).

Table 8. KMO value and Bartlett's test for 7-factor solution with 30 items

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.923
Bartlett's Test of Sphericity	Approx. Chi-Square	4508.746
	df	435
	Sig.	.000

Total variance explained by 7 factors is shown in Table 8. Due to 7 factors explained more than 50% of the total variance, it is acceptable.

Table 9. Total variance explained by 7 factors with 30 items

Components	Eigenvalue	% of variance	Cumulative %
1	10.196	33.988	33.988
2	2.820	9.399	43.388
3	.905	3.018	46.405
4	.769	2.563	48.969
5	.636	2.119	51.087
6	.545	1.818	52.906
7	.489	1.632	54.537

Table 9 shows the pattern matrix of 30 items in 7-factor solution. As previously mentioned, and can be seen in Table 8, there are some items (8, 12, 13, 25, 27, 36, 39, 42, 43 and 48) that are loaded on more than one factor. If an item is loaded to two or more factors, and if the difference between loadings is equal to .200 or greater, then it does not pose significant problem, and does not require any revision. Moreover, there are unexpected loadings of two items (30 and 35), i.e. the loading on a component together with items that are not related. Decisions for each of these items will be explained in the following paragraphs while components are being discussed.

Table 10. Pattern matrix and communalities for 7-factor solution with 30 items

	Factor							Communalities
	1	2	3	4	5	6	7	
Item 30	.612							.561
Item 32	.593							.526
Item 45	.559							.486
Item 39	.533				.378			.589
Item 48	.390						.256	.511
Item 37	.379							.503
Item 36	.224					.208		.371
Item 23		.779						.670
Item 28		.697						.590
Item 24		.604						.588
Item 46		.574						.413
Item 8		.378	.331					.467
Item 3			.895					.818
Item 1			.758					.489
Item 2			.530					.467
Item 7				.646				.460
Item 43	.208	.294		.482				.595
Item 12		.254		.439			.236	.563
Item 19					.663			.590
Item 22					.636			.713
Item 18		.224			.609			.550
Item 9						.868		.784
Item 25						.318	.280	.357
Item 6						.233		.184
Item 21							.558	.543
Item 47	.263						.491	.566
Item 41							.470	.472
Item 42	.309						.468	.632
Item 13				.286			.455	.559
Item 27		.248					.365	.530

4.2.1 Factor 1

The first factor consists of 5 items (32, 37, 39, 45 and 48) related to engineering and design. As seen in Table 9, there is multiple loadings for Item 39. Also, Item 30 was not expected to load with these items. Moreover, there is a special case Item 37. Explanations for these items are as follows:

Item 39 (*Öğrencilerimin mühendislik tasarım basamaklarını izleyerek ürün ortaya çıkarmalarını sağlayabilirim*), loaded on factor 5, which consists of items (18, 19 and 22) related to performance assessment. The reason can be due to common term which is *design*. But, the difference of loadings of Item 39 is .155, which is close to accepted value (.200). Therefore, we did not change the item.

At the beginning, Item 30 (*Öğrencilerimin daha önce gördükleri bir ürünü yapmalarını değil, yeni bir ürün tasarlayarak yaratıcılıklarını ortaya çıkarmalarını sağlayabilirim*) was written to be related to 21^{st} century skills. The reason of its loading together with items related to engineering and design, rather than items related to 21^{st} century skills might be due to the similar terms in the item. Although the intention was questioning the ability of teachers about increasing creativity of students, participants might have focused on the term design and answered accordingly. Therefore, we consider to rewrite the item such that it does not lead teachers to engineering and design.

Item 37 (*Derslerimde proje tabanlı öğrenme yöntemini kullanabilirim*) was considered to be related to inqury-based appraoch. Although the other items related to inquiry-based approach did not loaded on any factor together and reveal an interpretable solution, Item 37 loaded on Factor 1. Moreover, absence of this item, distracts other loadings. Due to engineering design and project-based learning are closely related to each other, teachers might answer this item in parallel of the other items related to engineering design. Therefore, we did not delete the item.

During item writing process, there were also 3 items (4, 17 and 49), written below, that were thought to be related to engineerign design. They loaded on different factors seperately and in their presence, factor had loadings with items related to different issues. In addition, when these items were subjected to factor analysis, total variance explained by 7 factors decreased to 53.045%. In the literature, engineering habits of mind is mentioned frequently in STEM education literature, which is emphasized in Item 4. Therefore, although we could not put it into the instrument, we suggested for further studies to include this item in the instrument by rewriting it and then conduct pilot test again.

Item 4: *Öğrencilerimin bir mühendis gibi düşünmelerini (problemi, problemin çözümünü, maliyetini ve çevreye olan etkilerini düşünme vb.) sağlayabilirim.*

Item 17: *Mühendislik tasarım sürecinde öğrencilerime ihtiyaç duydukları noktalarda rehberlik edebilirim.*

Item 49: *Öğrencilerimin tasarladıkları ürünleri test ettikten/dönüt verdikten sonra iyileştirmelerini sağlayabilirim*.

4.2.2 Factor 2

The second factor consists of 5 items (8, 23, 24, 28 and 46) that are related to making connections with other disciplines and daily life. In the framework, we considered them as two distinct factors; however, it is reasonable that these two topics are in the same factor. Because, giving examples from daily life, or understanding working principle of a device requires interdisciplinary knowledge.

In this component, Item 8 (*Öğrencilerimin günlük hayattan örnekler vermelerini sağlayabilirim*) has loadings also on Factor 3 which consists of items related to 21st century skills. The item asks whether teachers can make students give examples from daily life. However, it is very similar with other items in Factor 2 and also, loading is greater in this factor. Therefore, Item 8 should be together with the items in Factor 2.

There were one more item (Item 35*: Kendi alanım dışındaki branşlara (fizik, kimya veya biyoloji) yer vererek, öğrencilerimin disiplinlerarası bağlantı kurmalarını sağlayabilirim*.) that were expected to be in the same factor. This item did not loaded properly and it made the interpretation too difficult by distracting all other items. we decided to omit this item also due to the fact that its similarity with Item 24 (Derslerimde öğrencilerimin fen alanları arasındaki ilişkileri fark etmesini sağlayabilirim). Therefore, absence of Item 35 is not a sigificant problem for the instrument.

4.2.3 Factor 3

This factor consists of 4 items (1,2,3 and 30) related to 21st century skills. Note that, we discussed earlier that Item 30 will be revised and put together with Item 1, 2 and 3. By this way, group working and questioning skills and, creativity, which are included in 21st century skills, are covered by this factor.

However, Item 26 was also written related to critical thinking (*Derslerimi, öğrencilerin eleştirel düşünme becerisini geliştirecek şekilde işleyebilirim*), but it loaded on Factor 2, which cannot be interpreted meaningfully. But, Item 2 includes questionning skills which is related to critical thinking skills. Therefore, we decided to omit this item. In addition, due to grammer mistakes in Item 33 and 34, we deleted them.

Also, there was a mistake about Item 3 (*Öğrencilerime bilimsel okuryazarlığı (okuduğu bilimsel yazıyı anlama, bilimin hayatımızdaki önemini anlama vb.) kazandırabilirim*) during printing the instruments for the pilot testing. It was printed out as the same item with Item 1. Therefore, we replace the item as it should be.

4.2.4 Factor 4

This factor consists of 3 items (7, 12 and 43) related to giving place to local/global problems in lessons.

Item 7: *Yerel/küresel problemlere (park/bahçe sulamalarında su tüketimini azaltmak için belediyelerin neler yapabileceği gibi) yer verebilirim*.

Item 12: *İklim değişikliği, enerji tüketimi gibi küresel sorunlara çözüm üretmeleri için öğrencilerimin tartışmalarını sağlayabilirim*.

Item 43: *Öğrencilerimin iklim değişikliği ve enerji tüketimi gibi küresel sorunların çözümü için araştırma yapmalarını sağlayabilirim*.

Rather than just asking questions that can be found in regular books, teachers' knowledge on authentic problems is an important issue in STEM education. At first, we wrote those items by considering inquiry-based approach, 21st century skills and, engineering and design, respectively. However, the analysis revealed a different factor by putting them together. This situation might be the result of several reasons; for example, due to the common term *local/global problems,* items loaded together. Also, teachers might think that local/global problems are much extended than engineering design projects that can be done in class. In addition, engineering may not always point out local/global problems, rather they may find solutions to problems that individuals have in their own environment. Therefore, we decided to keep these 3 items under Factor 4.

4.2.5 Factor 5

This factor consists of 3 items (18, 19 and 22) related to teachers' use of performance assessment techniques. These items focus on using techniques other than paper-and-pencil tests during engineering design process, projects and for the final products as a result of them. However, there were 3 more items that were thought to be related with Item 18, 19 and 22. They are written below and explained.

Item 10 (*Değerlendirme amacıyla bir problemin çözümü için yeterli bilginin verilmediği yapılandırılmamış problemleri sorabilirim*) had not loaded on any factor in 7-factor solution as mentioned before. Moreover, ill-defined problems were covered in different factor with items that are related to inquiry-based approach. Therefore, it was omitted.

Item 11 (*Sınıf içi gözlem, öz değerlendirme, akran değerlendirme gibi performansa dayalı ölçme ve değerlendirme yöntemlerini uygulayabilirim*) loaded on factors with many unrelated items. Likewise, Item 40 (*Öğrencilerimin bir deney esnasındaki performanslarını (araç ve gereçleri doğru kullanma, düzgün veri toplama, bulguları yorumlama vb.) değerlendirebilirim*) loaded on a different factor.

Moreover, including these items to analysis together and seperately, prevented similar items to load together. By considering their less importance on STEM education framework, we decided to delete them. Beceause, use of performance assessmnet techniques in a project or design process is much more important and related to STEM education.

4.2.6 Factor 6

Factor 6 consists of 4 items (6, 9, 25 and 36) which are related to teachers' technology usage. As mentioned in previous chapter, loadings above .32 are better. But in this factor, item loadings were low, except Item 9. Also, low communalities (Table 9) were belong to Item 6, Item 25 and Item 36, which were all loaded on this factor. The reason of retaining these items were explained below.

In the Item 6 (*PhET, Morpa Kampüs ve EBA'da yer alan yazılımlar gibi eğitim materyallerini öğrencilerimin kullanmalarını sağlayabilirim*) the main point was to understand the usage of simulations and videos in lessons. The importance of the item also comes from the importance given to Fatih Project, which aims to increase the usage of softwares. Therefore, although the communality value is .184 which is very low, we did not delete, but rewrote the item.

Communality of Item 25 (*Öğrencilerimin Arduino, Raspberry Pi, LEGO Mindstorms gibi teknolojik araçları kullanmalarını sağlayabilirim*) was .357. It is below the accepted value (.4), but it does not create as much problem as Item 6. Moreover, Item 25 includes specific terms that teachers might not understood the item correctly and in the same way. Therefore, we rewrite the item. The reason of not deleting the item is the aim of this instrument, which is to reveal teachers' weaknesses. It is important to understand the amount of teachers who know how to use these tools. Moreover, according to the stuides in STEM education, usage of these tools increases, hence, teachers should know how to integrate them into their lessons. As a result, we decided to retain the item.

Lastly, in the Item 36 (*Öğrencilerime teknoloji okuryazarlığı (teknolojiyi anlama, kullanma, teknolojinin ve toplumun birbirini nasıl şekillendirdiğini* *değerlendirme vb.) kazandırabilirm*), the communality value was .371 which is more close to the accepted value. In addition, this item loaded on Factor 1, which includes items related to engineering and design. However, Item 36 is obviously related to technology, rather than engineering. Also, the other reason of retaining the item in this factor was to increase the number of items related to teachers' technology usage. But more importantly, it is essential for STEM education, such that STEM education emphasizes technological literacy. Therefore, we decided to keep it in this factor.

Moreover, there were one more item (Item 20: *Araştırma yapma amacıyla öğrencilerimin internette doğru bilgiye nasıl ulaşabilceklerini öğretebilirim*) that was written by considering technology usage. But this item did not load with other items related to this factor and distracted other loadings. Also, negative loadings obtained in pattern matrix. Therefore, we decided to omit Item 20.

4.2.7 Factor 7

The last factor in the analysis consists of 6 items (13, 21, 27, 41, 42 and 47) related to motivate students towards STEM fields, and to give more chances to disadvantaged students to attract their interest in STEM fields. According to our framework, STEM interest and equity in education are two different factors. While STEM interest refers to motivate all students towards STEM career, equity in education refers to include disadvantaged students. Items in these two factors are related to each other such that they all includes terms about motivation towards STEM fields. Therefore, teachers' answers might be closely related to each other for these items.

There are loadings more than one factor for Item 13, Item 27 and Item 42. But, the difference between two loadings for Item 13 is .169 and for Item 42 is .159. Differences are close to .200; therefore, we decided not to make any changes for these two items. For Item 27, the difference is .117 and the greater loading is on Factor 2. This component includes items related to making connections. But the meaningful interpretation can be done, when Item 27 is in Factor 7; because, all other similar items loaded on this factor.

There were one more item related to STEM interest (Item 5: *STEM alanlarından konuşmacılar davet ederek öğrencilerimin STEM alanlarına yönelik ilgilerini artırabilirim*) that we deleted. In order to obtain items related to STEM interest together in a factor, we deleted items one by one and run the analysis. Interpretable solution was obtained only when we omited Item 5. In addition, it caused negative loadings in the pattern matrix. There are already 6 items that measures STEM interest in the subset of the instrument; therefore, we decided to delete this item.

Moreover, there were two items that were expected to load together with items in this factor. The first one (Item 38: *Bir STEM etkinliği yapılacağı zaman genelde başarılı öğrencilerden oluşan bir grup seçerim*) had very low communality value (.113). Besides, providing equity in terms of gender and socio-economic status is more meaningful than in terms of success of students. Therefore, we decided to delete the item. The second one (Item 44: *Derslerimde verdiğim bir örnek ile kız ve erkek öğrencilerin aynı anda ilgisini çekebilirim*) was written with the same concerns as Item 13. Both items put focus on girls' interest in STEM fields and give girls and boys equal opportunities. However, in the analysis, while Item 13 loaded on Factor 7 with .451, this item loaded on the Factor 2 which includes items related to making connections. The reason of this loadings might be due to the common term *giving examples*; because, all items include this term loaded on Factor 2. Consequently, we decided to omit this item.

4.2.8 Dimension related to inquiry-based appraoch

In the literature, there is much emphasis on inquiry-based approach. As mentioned in the Chapter 2, science and engineering cannot be thought without inquiry. Moreover, critical thinking, questionning, researching, etc., are very important for 21st century skills, and they are also closely related to inquiry. Therefore, we defined and framed STEM education by including inquiry-based approach. In the first version of the instrument there were 8 items as listed in Table 11.

Table 11. Items related to inquiry-based approach

Item 7: *Yerel/küresel problemlere (park/bahçe sulamalarında su tüketimini azaltmak için belediyelerin neler yapabileceği gibi) yer verebilirim.*
Item 14 : *Derslerimi daha iyi anlatabilmek için konulara uygun yöntemler seçebilirim.*
Item 15: *Derslerimde öğrenme döngüsü yöntemini (3E, 5E veya 7E) kullanabilirim.*
Item 16: *Öğrencilerimin, düşüncesinin farkında olma, düşünme sürecini kontrol edebilme ve izleme gibi üst düzey düşünme becerilerini geliştirmek için çaba harcayabilirim.*
Item 29: *Yarı yapılandırılmış ya da yapılandırılmamış problemleri merkeze alan probleme dayalı öğrenme yöntemini kullanarak ders işleyebilirim.*
Item 31: *Öğrencilerimin derse hem zihinsel hem bedensel olarak aktif katılmaları için aktivite yapabilirim.*
Item 37: *Derslerimde proje tabanlı öğrenme yöntemini kullanabilirim.*
Item 50: *Derslerimde modelleme aktivitesi (kompleks bir yapının basitleştirilerek gösterilmesi) yaptırabilirim.*

As understood from the table above, Item 7 was loaded on Factor 2 with items related to local/global problems. The reason that why we accept this item in Factor 2 was explained before. Also, Item 14 is too general and covers all other items. Item 16 and 50 might not be clear and teachers might not understood in the same way. Item 31 does not specify a method and it might not refer to an inquiry-based approach always. Therefore, Item 7, 16, 31 and 50 were not included in this factor.

Item 15, Item 29 and Item 37 are included methods which are mentioned in the literature very often. Therefore, we wrote these items at the beginning. However, when we run the analysis with Item 15 and Item 29, we could not get any explicable result. In their presence for both 10-factor and 7-factor solutions, the other related items loaded on different factors, with low or negative loadings. Therefore, we could not keep them in the analysis. But in further studies, we suggested to include them in the instrument and collect new data before conducting factor analysis. In addition, items can be revised by focusing on increasing students' inquiry skills. Also, note that Item 37 loaded on Factor 1, as explained before.

4.3 Summary

By using PAF technique, a factor analyisis was conducted with direct oblimin rotation on originally 50 items. Both KMO and Bartlett's test of sphericity verified that EFA can be conducted without any problem. In the initial analysis, 10 factors were extracted according to Kaiser's criterion with the explanation of 53.853% of total variance. Yet, we decided to determine the number of factors to be 7 for the interpretability of the analysis results. After careful analysis, 30 items were subjected to the EFA that loaded on 7 factors. Some of items deleted due to low loadings or low communality values. Also, some of items were rewritten to make the items more clear and understandable. In the result of the final analysis, with 30 items, the 7 factors explained 54.507% of total variance which is acceptable.

As explained previously, there are items related to inquiry-based approach and one item related to engineering habits of mind. We suggest that in the next pilot tests, these items can be included by emphasizing inquiry skills (data interpretation, etc.) and engineering thinking. Then, accoding to factor analysis with new data, they can be included in the instrument. But, as a result of this study, *Teachers' Perceived Readiness in STEM Education Instrument,* was developed with 30 items related to 7 factors (Table 12).

Table 12. Factors and items in the subset of the instrument

	Factors	Related items	Number of items
1	Engineering and design	32, 37, 39, 45, 48	5
2	Making connections	8, 23, 24, 28, 46	5
3	21st century skills	1,2,3, 30	4
4	Local/global problems	7, 12, 43	3
5	Performance assessment	18, 19, 22	3
6	Use of technology	6, 9, 25, 36	4
7	STEM interest	13, 21, 27, 41, 42, 47	6

As seen in the above table, each factor is measured by at least 3 items. As explained one by one, due to difficulties and some problems in the analysis or the instrument itself, we cannot increase the number of items in factors. Nonetheless, we believe that by using this subset of the instrument, teachers' perceived readiness in STEM education can be examined. Because, there is strong background of items and test development process in terms of not only extensive literature review and interviews with experts but also, with high reliability and validity results by factor analysis.

CHAPTER 5

CONCLUSION

In this study, the aim was to develop a valid and reliable instrument for the assessment of science teachers' perceived readiness to implement STEM education. The basic premise of this study in preparing the instrument was that teachers would complete this instrument based on their existing knowledge, skills and experience. Whether science teachers are ready to implement effective STEM education in their classes or not was the main concern of the instrument. The aim was only to develop the instrument, not to make inferences based on their scores.

In addition, this instrument can be implemented only to in-service teachers. Because, items in the instrument requires knowledge and ability that are taught throughout teacher education. Therefore, pre-service teachers may answer items negatively due to lack of their education. They may answer in a different way when they take all the courses in their faculty. In case of applying the instrument to pre-service teachers can caused mistakes in interpretion of results; therefore, we aimed to use this instrument with in-service teachers to reveal out their weaknesses and strengths.

Readiness of active agents in a system is a crucial determining factor for the success of any reform in that system. In education, this means the perceived readiness of teachers, in the implementation a curricular change or STEM integration, etc. Even though STEM education recently gained attention by governments and researchers around the world, the idea behind STEM education goes further back in time. The US actually started to sow the seeds of STEM education after Sputnik (Bybee, 2010, 2013; Chesky & Wolfmeyer, 2015). In Turkey, especially after STEM education trainings conducted by several universities, it became much popular. In the last period, considerable steps were taken by MoNE by publishing STEM education report and integrating units about design tasks in elementary science curricula. Due to these developments in our country about STEM education, teachers' qualifications should be taken into consideration. Since STEM education has been made a part of the 5-8 Science Curricula by MoNE and since it has been argued earlier that teachers are the most influential factors in the success or failure of any curricula, it is important to reveal whether teachers are ready for the implementation of STEM integrated science curricula.

In the item writing process, firstly literature review and interviews with experts were done to comprehend STEM education and its position in our context. Then, 50 items were written based on our STEM framework after expert opinions. As the last step, a factor analysis was conducted to validate the instrument results. However, as a result of the analysis, 30 items were retained. Interpretation of the factor analysis results with the remaining items was difficult and also, due to some other reasons such as usability, they were omitted from the suggested subset of the instrument.

Reliability analysis of the 30-item subset of the test revealed that alpha coefficient of .927. EFA was used for construct related evidence of validity. Seven factors were extracted as a result of PAF technique with direct oblimin rotation. In conclusion, there are 7 factors with 30 items in the instrument. Factors are named as engineering and design, making connections, 21^{st} century skills, local/global problems, performance assessment, STEM interest, and technology usage.

With those items, teachers' opinions about their knowledge, skill and/or experience can be assessed. By this way, teachers' perceived readiness can be determined. Because, in the study, perceived readiness refers to whether or not teachers can perform the task based on their opinions about their existing knowledge.

5.1 Suggestions for Further Studies

It was a necessity to obtain such an instrument because of deficiency in the literature and the importance to determine teachers' weaknesses and strengths. Yet, this subset is not the final version of this instrument. But we believe that it is an important step for future studies in which the final version will be developed. In this final version, pilot test(s) should be conducted by including items related to engineering habits of mind and inquiry skills, as explained in the previous chapter.

When the final version is developed as a valid and reliable instrument, professional development programs and in-service trainings can be structured for better STEM implications. Therefore, this subset should be implemented with large samples and its validity and reliability should be established.

Morever, as explained in Chapter 2, willingness part of readiness should be assessed, too. Because, belief in ability may not enough to ensure that the task will be performed accurately. Therefore, to determine teachers are ready or not, their willingness should also be examined.

Another suggestion for further studies is that, as mentioned in limitations, cut-off points should be defined to indicate teachers as ready or not. For this step, detailed field studies can be conducted. Teacher observations and result of the final instrument can be used as a guide to determine cut-off points.

Also, providing information about readiness of schools, administrators, students or other educational stakeholders can be beneficial to understand whether STEM education can be succesful or not. Because, besides teachers, other stakeholders have impact on education. Determining of their positions can help researchers to draw a better picture of STEM education. Therefore, policy makers can take precautions for better implementations with proper investments in terms of money and effort.

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APPENDIX A

HUMAN SUBJECT ETHICS COMMITTEE APPROVAL FORM

The approval form is on the next page.

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05 Mayıs 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç.Dr. Ömer Faruk ÖZDEMİR ;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Ayşe Nihan ŞATGELDİ ***"Ortaokul ve Lise Fen Öğretmenlerinin STEM Eğitimi Yaklaşımındaki Hazır Bulunuşluklarını Anlamak Üzere Anket Geliştirilmesi"*** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-EGT-081** protokol numarası ile **05.05.2017 – 30.10.2017** 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

Doç. Dr. Yaşar KONDAKÇI

Üye

Doç. Dr. Zana ÇITAK

Üye

Yrd. Doç. Dr. Pınar KAYGAN

Üye

Yrd. Doç. Dr. Emre SELÇUK

Üye

APPENDIX B

EXPERT OPINION FORM

The expert opininon form is on the next page.

UZMAN GÖRÜŞ FORMU

Sayın uzman,

Bu anket, yüksek lisans tezi kapsamında, öğretmenlerin STEM eğitimine karşı hazır bulunuşluklarını tespit etmek amacıyla Dr. Ufuk Yıldırım danışmanlığında geliştirilmiştir.

Anketteki maddeler aşağıdaki başlıklara önem verilerek gruplandırılmıştır. Ancak anket öğretmenlere verilirken, maddeler gruplar halinde değil, karışık olarak yazılacaktır.

- Eğitimde fırsat eşitliği
- Ders işlenişi
- Gerçek hayat ile bağlantı
- Bilgi boyutu
- Mühendislik tasarım
- Teknoloji kullanımı
- 21.yüzyıl becerileri
- Performansa dayalı ölçme ve değerlendirme
- Meslek seçimi/STEM alanlarına yönelik ilgi uyandırma

Maddeler hazırlanırken literatürden ve uzmanlar ile yapılan görüşmelerden faydalanılmıştır.

Sizlerden beklenen,

- Başlıkların maddeler ile uyumlu olup olmadığını, **uygunluk** sütununda, **Evet** için **E, Hayır** için **H** yazarak,
- Maddelerin anlaşılır olup olmadığını, **anlaşılırlık** sütununda, **1-5 aralığında** (1=hiç anlaşılır değil, 5= tamamen anlaşılır) puanlandırma yaparak,
- Maddelerin öğretmenlerin STEM eğitimi konusundaki hazır bulunuşlukları ile ilişkili olup olmadığını, **ilişkililik** sütununda, **1-5 aralığında** (1=hiç ilişkili değil, 5=tamamen ilişkili) puanlandırma yaparak görüş bildirmenizdir.

Aşağıda başlıkları, maddeleri ve doldurmanız beklenen boşlukları içeren tablo verilmiştir. Geliştirmek istediğiniz maddeler için, her bir maddenin altında bulunan boşluğu kullanabilirsiniz. Anketin alt kısmına ayrıca eklemek istediğiniz görüşlerinizi belirtebilirsiniz. Anketin sonunda genel olarak cevaplamanız beklenen sorular bulunmaktadır.

Katkılarınızdan dolayı teşekkür ederim.

Araş. Gör. Ayşe Nihan Şatgeldi
Orta Doğu Teknik Üniversitesi
Eğitim Fakültesi
Matematik ve Fen Bilimleri Eğitimi Bölümü

Başlık	Uygunluk	Madde	Anlaşılırlık	İlişkililik
Eğitimde fırsat eşitliği		1. Sosyoekonomik açıdan dezavantajlı öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.		
		2. Kız öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.		
		3. Başarı düzeyi düşük öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.		
		4. Bir etkinlik yapılacağı zaman genelde başarılı öğrencilerden oluşan bir grup seçerim.		
		5. Bir etkinlik yapılacağı zaman öğrencileri herhangi bir ayrım yapmadan seçerim.		
		6. Derslerimde hem kız hem erkek öğrencilerin ilgisini çekecek şekilde örnekler verebilirim.		
Ders işlenişi		7. Dersimi daha iyi anlatabilmek için konuya uygun yöntem seçebilirim.		
		8. Probleme dayalı öğrenme yöntemini kullanarak ders işleyebilirim.		
		9. Öğrencilerime yapılandırılmamış problemler sorabilirim.		
		10. Derslerimde proje tabanlı öğrenme yöntemini kullanabilirim.		
		11. Derslerimde öğrenme döngüsü yöntemini (3E, 5E veya 7E) kullanabilirim.		
		12. Derslerimde modelleme aktivitesi yaptırabilirim.		
		13. Derslerimde öğrencilerin derse aktif katılmasını sağlayabilirim.		
		14. Öğrencilerimin üst düzey düşünme becerilerini (kendi düşüncesinin farkında olma, düşünme sürecini kontrol edebilme ve izleme vb.) geliştirmek için çaba harcayabilirim.		
		15. Derslerimde öğrencilerimin deney yapmaları için çaba gösterebilirim.		

Başlık	Uygunluk	Madde	Anlaşılırlık	İlişkililik
Mühendislik tasarım		16. Öğrencilerimin küresel sorunların (iklim değişikliği, enerji tüketimi vb.) çözümü ile ilgili araştırma yapmalarını sağlayabilirim.		
		17. Küresel sorunlar (iklim değişikliği, enerji tüketimi vb.) hakkında çözüm üretmeleri için öğrencilerimin düşünmelerini sağlayabilirim.		
		18. Öğrencilerimin mühendislik tasarım süresince ürün ortaya çıkarmalarını sağlayabilirim.		
		19. Derslerimde insanların ihtiyaçlarını karşılamaya yönelik ürünler tasarlatabilirim.		
		20. Mühendislik tasarım sürecinde öğrencilerime dönüt verebilirim.		
		21. Öğrencilerimin tasarladıkları ürünleri iyileştirmelerini sağlayabilirim.		
		22. Öğrencilerimin mühendis gibi düşünmelerini sağlayabilirim.		
21. yüzyıl becerileri		23. Derslerimde öğrencilerimin grup halinde çalışmalarını sağlayabilirim.		
		24. Öğrencilerimin yaratıcılıklarını ortaya çıkarmalarını sağlayabilirim.		
		25. Derslerimi öğrencilerimin eleştirel düşünme becerisini geliştirecek şekilde işleyebilirim.		
		26. Öğrencilerimin problem çözme becerilerini geliştirebilirim.		
		27. Öğrencilerime bilimsel okuryazarlığı (okuduğu bilimsel yazıyı anlama, bilimin hayatımızdaki önemini anlama vb.) kazandırabilirim.		
		28. Öğrencilerime teknoloji okuryazarlığı (teknolojiyi anlayabilme, kullanabilme vb.) kazandırabilirm.		

Başlık	Uygunluk	Madde	Anlaşılırlık	İlişkililik
Performansa dayalı ölçme ve değerlendirme		29. Derslerimde performansa dayalı ölçme ve değerlendirme (sınıf içi gözlem, öz değerlendirme, akran değerlendirme vb.) yöntemlerini uygulayabilirim.		
		30. Öğrencilerimin deney esnasındaki performanslarını (deneyi zamanında tamamlama, materyalleri doğru kullanma, düzgün veri toplama vb.) değerlendirebilirim.		
		31. Öğrencilerimin projelerinin her bir aşamasını (araştırma, çözüm üretme, çözümü sunma vb.) derecelendirme ölçekleri ile değerlendirebilirim.		
		32. Mühendislik tasarımı sonucunda ortaya çıkan ürünü veya öneriyi değerlendirmek için derecelendirme ölçeği uygulayabilirim.		
		33. Araştırma yapma, grup halinde çalışma, ürün veya öneri ortaya koyma vb. mühendislik tasarım basamaklarını derecelendirme ölçeği ile değerlendirebilirim.		
		34. Sınavlarda yapılandırılmamış problemler sorabilirim.		
Meslek seçimi/STEM alanlarına yönelik ilgi uyandırma		35. Öğrencilerimi STEM alanlarını tercih etmeleri için yönlendirebilirim.		
		36. Derslerimde STEM alanlarına yönelik ilgi uyandırmak için ekstra aktivite/bilgilendirme vb. yapabilirim.		
		37. STEM alanlarından konuşmacılar davet ederek öğrencilerimin STEM alanlarına yönelik ilgilerini arttırabilirim.		
		38. STK, üniversite, sanayi vb. kuruluşlar ile işbirliği yaparak öğrencilerimin STEM alanlarına ilgi duymalarını sağlayabilirim.		
		39. Derslerimde STEM alanlarının günümüzdeki önemini vurgulayabilirim.		

Başlık	Uygunluk	Madde	Anlaşılırlık	İlişkililik
Teknoloji kullanımı		40. Öğrencilerimin mühendislik tasarım süresince teknolojiyi etkili bir şekilde kullanmalarını sağlayabilirim.		
		41. Ders süresince öğrencilerimin simülasyon kullanmalarını sağlayabilirim.		
		42. Öğrencilerimi, araştırma yapmak için teknolojiyi kullanmalarına teşvik edebilirim.		
		43. Öğrencilerimin veri toplamak/veri analizi yapmak amacıyla teknolojiyi kullanmalarını sağlayabilirim.		
		44. Derslerimde arduino, raspberry pi, LEGO Mindstorms vb. araçları kullanabilirim.		
Gerçek hayat bağlantısı		45. Öğrencilerime günlük hayatta karşılaşabilecekleri problemler sorabilirim.		
		46. Derslerimde günlük hayattan örneklere yer verebilirim.		
		47. Derslerimde günlük hayattan örneklere yer verebilecek kadar, branşımın günlük hayat ile olan bağlantısına hakimim.		
		48. Sınavlarımda günlük hayattan problemlere yer verebilirim.		
Bilgi boyutu		49. Derslerimde fizik, kimya ve biyoloji branşlarına da yer vererek, öğrencilerimin aynı anda disiplinlerarası bağlantı kurmalarını sağlayabilirim.		
		50. İlişkili konularda, fizik, kimya ve biyoloji alanları arasındaki ilişkileri biliyorum.		
		51. Derslerimde yerel ve/veya küresel konulardaki problemlere yer verebilirim.		
		52. Bilimsel gelişmeleri takip ederim.		
		53. Teknoloji konusundaki gelişmeleri takip ederim.		
		54. Deney yapma, grup çalışması, etkinlik yapma vb. durumlarda sınıf yönetimi konusunda problem yaşamam.		

Sorular

1. Anketteki soru sayısı öğretmenlerin STEM eğitimindeki hazır bulunuşluklarını ölçmek için sizce uygun mudur?

2. Soruların "kesinlikle katılıyorum" – "kesinlikle katılmıyorum" aralığında değerlendirilmesi sizce uygun mudur?

Eklemek istedikleriniz:

APPENDIX C

ORIGINAL FORM OF THE INSTRUMENT

The instrument is on the next page.

Değerli öğretmenler,

ODTÜ Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü, Fizik Eğitimi A.B.D. yüksek lisans tezi kapsamında oluşturulan bu ölçek, sizlerin STEM/FeTeMM eğitimi konusundaki hazırbulunuşluğunuzu gösteren ifadeleri içermektedir. Bu ifadeler ***yapabilirim***, ***sağlayabilirim***, ***kullanabilirim*** vb. fiiller ile bitmektedir. Ölçeği doldururken, her bir ifadede bahsi geçen konuyu şimdiye kadar gerçekleştirip gerçekleştirmediğinizi değil, ifadedeki konuya hâkim olup olmadığınızı dikkate alınız. Her bir ifadeyi dikkatlice okuduktan sonra "Kesinlikle Katılıyorum"-"Kesinlikle Katılmıyorum" aralığında bir işaretleme yapınız. Bu çalışma bir ölçek geliştirme çalışması olduğundan verdiğiniz cevaplardaki samimiyetiniz oldukça önemlidir. Bu yüzden kimlik bilgileriniz istenmemektedir. Ölçeğe vermiş olduğunuz cevaplar saklı tutulacak ve yalnızca araştırmacı tarafından analiz edilecektir. Ölçeğin tamamen cevaplanması yaklaşık olarak 15 dakika sürmektedir.

Anket içerisinde bahsi geçen terimlerin tanımları aşağıda verilmiştir:

STEM/FeTeMM: Fen, teknoloji, mühendislik ve matematik alanlarını ifade eder.

STEM Eğitimi: Fen, teknoloji, mühendislik ve matematik alanlarını içeren, 21.yüzyıl becerilerini (problem çözme, işbirlikli çalışma, eleştirel düşünme ve yaratıcılık) geliştirmeyi amaçlayan, ürün odaklı eğitim modelidir.

Mühendislik tasarım: Bireylerin yaşamlarını kolaylaştıracak, problemlerine çözüm olabilecek, mühendislik tasarım basamaklarını (problemi anlama, problemi çözme, test etme, modeli iyileştirme) izleyerek ürünler ortaya çıkarmak/öneri sunmaktır.

Bu çalışma sonucu geliştirilecek olan ölçek ile ileride yapılacak çalışmalar sayesinde öğretmenlerin STEM eğitiminde ihtiyaç duyabilecekleri noktaları ortaya çıkarabilecektir. Böylece, gerekli hizmet içi eğitimler ve seminerler düzenleyerek öğretmenlerin ihtiyaçları doğrultusunda mesleki gelişimlerine katkıda bulunmak mümkün olacaktır.

İlginiz ve ayırdığınız zaman için teşekkür ederim.

Arş. Gör. Ayşe Nihan ŞATGELDİ
ODTÜ Eğitim Fakültesi

Cinsiyetiniz: ○ Kadın ○ Erkek

Çalıştığınız okulun türü: ○ Devlet Okulu ○ Özel Okul

Branşınız: ○ Biyoloji ○ Fizik ○ Kimya ○ Fen Bilgisi

Öğretmenlik tecrübeniz: ○ 1-5 yıl ○ 6-10 yıl ○ 11-20 yıl ○ 20+ yıl

Eğitim Durumunuz: ○ Lisans Mezunu ○ Yüksek Lisans Öğrencisi ○ Yüksek Lisans Mezunu ○ Doktora Öğrencisi ○ Doktora Mezunu

Lisans derecenizi aldığınız fakülte: ○ Eğitim Fakültesi ○ Fen-Edebiyat Fakültesi ○ Diğer

STEM/FeTeMM ile ilgili bir etkinliğe (hizmetiçi eğitim, çalıştay, sertifika programı, vb.) katıldınız mı? ○ Evet ○ Hayır

Cevabınız evet ise, kaç kez olduğunu belirtiniz: ....

STEM/FeTeMM Hazırbulunuşluk Ölçeği – Öğretmen Versiyonu	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Öğrencilerimin, birlikte çalışabilme, sorumluluk alabilme, iletişim kurabilme gibi grup halinde çalışma becerilerini geliştirebilirim.	○	○	○	○	○
2. Öğrencilerimin sorgulama becerilerini geliştirmek amacıyla öğrencilerime deney yaptırabilirim.	○	○	○	○	○
3. Öğrencilerimin, grup içinde çalışabilme, sorumluluk alabilme, iletişim kurabilme gibi grup halinde çalışma becerilerini geliştirebilirim.	○	○	○	○	○
4. Öğrencilerimin bir mühendis gibi düşünmelerini (problemi, problemin çözümünü, maliyetini ve çevreye olan etkilerini düşünme vb.) sağlayabilirim.	○	○	○	○	○
5. STEM alanlarından konuşmacılar davet ederek öğrencilerimin STEM alanlarına yönelik ilgilerini artırabilirim.	○	○	○	○	○
6. PhET, Morpa Kampüs ve EBA'da yer alan yazılımlar gibi eğitim materyallerini öğrencilerimin kullanmalarını sağlayabilirim.	○	○	○	○	○
7. Yerel/küresel (bahçe sulamalarında su tüketimini azaltmak için belediyelerin neler yapabileceği gibi) problemlere yer verebilirim.	○	○	○	○	○
8. Öğrencilerimin günlük hayattan örnekler vermelerini sağlayabilirim.	○	○	○	○	○
9. Öğrencilerimin sensör ile veri toplama ve Excel ile grafik çizme gibi amaçlarla teknolojiyi kullanmalarını sağlayabilirim.	○	○	○	○	○
10. Değerlendirme amacıyla bir problemin çözümü için yeterli bilginin verilmediği yapılandırılmamış problemleri sorabilirim.	○	○	○	○	○
11. Sınıf içi gözlem, öz değerlendirme, akran değerlendirme gibi performansa dayalı ölçme ve değerlendirme yöntemlerini uygulayabilirim.	○	○	○	○	○
12. İklim değişikliği, enerji tüketimi gibi küresel sorunlara çözüm üretmeleri için öğrencilerimin tartışmalarını sağlayabilirim.	○	○	○	○	○
13. Kız öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.	○	○	○	○	○

Lütfen sonraki sayfaya geçiniz ▶

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
14. Derslerimi daha iyi anlatabilmek için konulara uygun yöntemler seçebilirim.	○	○	○	○	○
15. Derslerimde öğrenme döngüsü yöntemini (3E, 5E veya 7E) kullanabilirim.	○	○	○	○	○
16. Öğrencilerimin, düşüncesinin farkında olma, düşünme sürecini kontrol edebilme ve izleme gibi üst düzey düşünme becerilerini geliştirmek için çaba harcayabilirim.	○	○	○	○	○
17. Mühendislik tasarım sürecinde öğrencilerime ihtiyaç duydukları noktalarda rehberlik edebilirim.	○	○	○	○	○
18. Öğrenci projelerinin her bir aşamasını (araştırma, çözüm üretme, çözümü sunma vb.) derecelendirme ölçekleri ile değerlendirebilirim.	○	○	○	○	○
19. Araştırma yapma, grup halinde çalışma, ürün veya öneri ortaya koyma gibi mühendislik tasarım basamakları için derecelendirme ölçeklerini uygulayabilirim.	○	○	○	○	○
20. Araştırma yapma amacıyla öğrencilerimin internette doğru bilgiye nasıl ulaşabilceklerini öğretebilirim.	○	○	○	○	○
21. Sosyoekonomik açıdan dezavantajlı öğrencilerimin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.	○	○	○	○	○
22. Mühendislik tasarımı sonucunda ortaya çıkan ürünleri veya önerileri derecelendirme ölçekleri ile değerlendirebilirim.	○	○	○	○	○
23. Konuların daha iyi anlaşılabilmesi için günlük hayattan örneklere yer verebilirim.	○	○	○	○	○
24. Derslerimde öğrencilerimin fen alanları arasındaki ilişkileri fark etmesini sağlayabilirim.	○	○	○	○	○
25. Öğrencilerimin *Arduino, Raspberry Pi, LEGO Mindstorms* gibi teknolojik araçları kullanmalarını sağlayabilirim.	○	○	○	○	○
26. Derslerimi, öğrencilerin eleştirel düşünme becerisini geliştirecek şekilde işleyebilirim.	○	○	○	○	○
27. STEM alanlarını tercih etmeleri için öğrencilerimi yönlendirebilirim.	○	○	○	○	○
28. İşlediğimiz konuların günlük hayatımızda nasıl karşımıza çıktığını gösterebilirim.	○	○	○	○	○
29. Yarı yapılandırılmış ya da yapılandırılmamış problemleri merkeze alan probleme dayalı öğrenme yöntemini kullanarak ders işleyebilirim.	○	○	○	○	○
30. Öğrencilerimin daha önce gördükleri bir ürünü yapmalarını değil, yeni bir ürün tasarlayarak yaratıcılıklarını ortaya çıkarmalarını sağlayabilirim.	○	○	○	○	○
31. Öğrencilerimin derse hem zihinsel hem bedensel olarak aktif katılmaları için aktivite yapabilirim.	○	○	○	○	○
32. Öğrencilerime insanların ihtiyaçlarını karşılamaya yönelik ürünler tasarlatabilirim.	○	○	○	○	○
33. Öğrencilerimin probleme problem çözme becerilerini (farklı çözümler üretebilme, uygun olan çözümü seçip uygulayabilme ve değerlendirebilme vb.) geliştirebilirim.	○	○	○	○	○
34. Öğrencilerimin çözme becerilerini (farklı çözümler üretebilme, uygun olan çözümü seçip uygulayabilme ve değerlendirebilme vb.) geliştirebilirim.	○	○	○	○	○
35. Kendi alanım dışındaki branşlara (fizik, kimya veya biyoloji) yer vererek, öğrencilerimin disiplinlerarası bağlantı kurmalarını sağlayabilirim.	○	○	○	○	○
36. Öğrencilerime teknoloji okuryazarlığı (teknolojiyi anlama, kullanma, teknolojinin ve toplumun birbirini nasıl şekillendirdiğini değerlendirme vb.) kazandırabilirm.	○	○	○	○	○
37. Derslerimde proje tabanlı öğrenme yöntemini kullanabilirim.	○	○	○	○	○
38. Bir STEM etkinliği yapılacağı zaman genelde başarılı öğrencilerden oluşan bir grup seçerim.	○	○	○	○	○
39. Öğrencilerimin mühendislik tasarım basamaklarını izleyerek ürün ortaya çıkarmalarını sağlayabilirim.	○	○	○	○	○
40. Öğrencilerimin bir deney esnasındaki performanslarını (araç ve gereçleri doğru kullanma, düzgün veri toplama, bulguları yorumlama vb.) değerlendirebilirim.	○	○	○	○	○
41. Üniversite ve sanayi gibi kuruluşlara gezi düzenleyerek öğrencilerimin STEM alanlarına ilgi duymalarını sağlayabilirim.	○	○	○	○	○
42. Başarı düzeyi düşük öğrencilerimin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.	○	○	○	○	○

Lütfen sonraki sayfaya geçiniz ▶

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
43. Öğrencilerimin iklim değişikliği ve enerji tüketimi gibi küresel sorunların çözümü için araştırma yapmalarını sağlayabilirim.	○	○	○	○	○
44. Derslerimde verdiğim bir örnek ile kız ve erkek öğrencilerin aynı anda ilgisini çekebilirim.	○	○	○	○	○
45. Öğrencilerime günlük araç gereçlerle (kürdan, makarna, balon vb.) bir probleme çözüm olabilecek ürün tasarlatabilirim.	○	○	○	○	○
46. Derslerimde günlük hayattan örneklere yer verebilecek kadar, branşımın günlük hayat ile olan bağlantısına hâkimim.	○	○	○	○	○
47. Derslerimde STEM alanlarına yönelik ilgi uyandırmak için aktivite yapabilirim.	○	○	○	○	○
48. Öğrencilerimin mühendislik tasarım süresince teknolojiyi etkili bir şekilde kullanmalarını sağlayabilirim.	○	○	○	○	○
49. Öğrencilerimin tasarladıkları ürünleri test ettikten/dönüt verdikten sonra iyileştirmelerini sağlayabilirim.	○	○	○	○	○
50. Derslerimde modelleme aktivitesi (kompleks bir yapının basitleştirilerek gösterilmesi) yaptırabilirim.	○	○	○	○	○

APPENDIX D

SUGGESTED ITEMS FOR THE INSTRUMENT

Mühendislik ve Tasarım

32. Öğrencilerime insanların ihtiyaçlarını karşılamaya yönelik ürünler tasarlatabilirim.

37. Derslerimde proje tabanlı öğrenme yöntemini kullanabilirim.

39. Öğrencilerimin mühendislik tasarım basamaklarını izleyerek ürün ortaya çıkarmalarını sağlayabilirim.

45. Öğrencilerime günlük araç gereçlerle (kürdan, makarna, balon vb.) bir probleme çözüm olabilecek ürün tasarlatabilirim.

48. Öğrencilerimin mühendislik tasarım süresince teknolojiyi etkili bir şekilde kullanmalarını sağlayabilirim.

Bağlantı Kurma

8. Öğrencilerimin günlük hayattan örnekler vermelerini sağlayabilirim.

23. Konuların daha iyi anlaşılabilmesi için günlük hayattan örneklere yer verebilirim.

24. Derslerimde öğrencilerimin fen alanları arasındaki ilişkileri fark etmesini sağlayabilirim.

28. İşlediğimiz konuların günlük hayatımızda nasıl karşımıza çıktığını gösterebilirim.

46. Derslerimde günlük hayattan örneklere yer verebilecek kadar, branşımın günlük hayat ile olan bağlantısına hakimim.

21. Yüzyıl Becerileri

1. Öğrencilerimin, grup içinde çalışabilme, sorumluluk alabilme, iletişim kurabilme gibi grup halinde çalışma becerilerini geliştirebilirim.

2. Öğrencilerimin sorgulama becerilerini geliştirmek amacıyla öğrencilerime deney yaptırabilirim.
3. Öğrencilerime bilimsel okuryazarlığı (okuduğu bilimsel yazıyı anlama, bilimin hayatımızdaki önemini anlama vb.) kazandırabilirim.
30. Öğrencilerimin daha önce gördükleri bir ürünü yapmalarını değil, yeni bir ürün tasarlayarak yaratıcılıklarını ortaya çıkarmalarını sağlayabilirim.

Yerel/Küresel Problemler

7. Yerel/küresel konulardaki (bahçe sulamalarında su tüketimini azaltmak için belediyelerin neler yapabileceği gibi) problemlere yer verebilirim.
12. İklim değişikliği, enerji tüketimi gibi küresel sorunlara çözüm üretmeleri için öğrencilerimin tartışmalarını sağlayabilirim.
43. Öğrencilerimin iklim değişikliği ve enerji tüketimi gibi küresel sorunların çözümü için araştırma yapmalarını sağlayabilirim.

Performans Değerlendirme

18. Öğrenci projelerinin her bir aşamasını (araştırma, çözüm üretme, çözümü sunma vb.) derecelendirme ölçekleri ile değerlendirebilirim.
19. Araştırma yapma, grup halinde çalışma, ürün veya öneri ortaya koyma gibi mühendislik tasarım basamakları için derecelendirme ölçeklerini uygulayabilirim.
22. Mühendislik tasarımı sonucunda ortaya çıkan ürünleri veya önerileri derecelendirme ölçekleri ile değerlendirebilirim.

Teknoloji Kullanımı

6. PhET, Morpa Kampüs ve EBA'da yer alan yazılımlar gibi eğitim materyallerini öğrencilerimin kullanmalarını sağlayabilirim.
9. Öğrencilerimin sensör ile veri toplama ve Excel ile grafik çizme gibi amaçlarla teknolojiyi kullanmalarını sağlayabilirim.
25. Öğrencilerimin *Arduino*, *Raspberry Pi*, *LEGO Mindstorms* gibi teknolojik araçları kullanmalarını sağlayabilirim.

36. Öğrencilerime teknoloji okuryazarlığı (teknolojiyi anlama, kullanma, teknolojinin ve toplumun birbirini nasıl şekillendirdiğini değerlendirme vb.) kazandırabilirm.

STEM Alanlarına Yönelik İlgi

13. Kız öğrencilerin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.

21. Sosyoekonomik açıdan dezavantajlı öğrencilerimin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.

27. STEM alanlarını tercih etmeleri için öğrencilerimi yönlendirebilirim.

41. Üniversite, sanayi gibi kuruluşlara gezi düzenleyerek öğrencilerimin STEM alanlarına ilgi duymalarını sağlayabilirim.

42. Başarı düzeyi düşük öğrencilerimin STEM alanlarına ilgilerini artırmak için ekstra olanaklar sağlayabilirim.

APPENDIX E

CRONBACH'S ALPHA VALUES IF ITEM DELETED

Table 13. Cronbach's Alpha if item deleted

Item	Cronbach's Alpha if Item Deleted	Item	Cronbach's Alpha if Item Deleted
1	,951	26	,952
2	,951	27	,951
3	,951	28	,952
4	,951	29	,951
5	,952	30	,951
6	,953	31	,951
7	,952	32	,951
8	,952	33	,951
9	,952	34	,951
10	,952	35	,951
11	,951	36	,951
12	,951	37	,951
13	,951	38	,953
14	,952	39	,951
15	,952	40	,951
16	,951	41	,951
17	,951	42	,951
18	,951	43	,951
19	,951	44	,952
20	,951	45	,951
21	,951	46	,952
22	,951	47	,951
23	,952	48	,951
24	,952	49	,951
25	,952	50	,951

APPENDIX F

ITEM CORRELATIONS

Correlations between 50 items are on the next page.

Tablo 13. Correlation matrix of 50 items

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
50	,307	,232	,330	,321	,182	,181	,197	,304	,197	,305	,348	,272	,329	,334	,190	,375	,364	,417	,391
49	,246	,231	,267	,349	,256	,237	,211	,247	,344	,332	,293	,260	,365	,244	,310	,350	,442	,434	,488
48	,295	,272	,332	,436	,331	,212	,160	,219	,376	,307	,336	,338	,369	,310	,311	,438	,474	,371	,462
47	,314	,358	,339	,398	,385	,213	,121	,306	,292	,300	,403	,371	,442	,281	,277	,309	,372	,380	,433
46	,389	,374	,331	,227	,096	,135	,185	,371	,100	,215	,260	,320	,181	,442	,179	,402	,220	,334	,235
45	,294	,268	,249	,340	,230	,243	,177	,316	,266	,339	,304	,354	,343	,327	,280	,394	,329	,276	,349
44	,410	,277	,294	,205	,092	,201	,190	,428	,118	,170	,290	,383	,231	,422	,173	,443	,188	,326	,175
43	,382	,372	,315	,228	,193	,211	,397	,340	,151	,258	,272	,595	,369	,335	,220	,323	,273	,261	,279
42	,241	,246	,289	,414	,369	,148	,167	,166	,444	,357	,283	,251	,540	,216	,294	,345	,430	,410	,514
41	,261	,292	,264	,351	,316	,167	,214	,201	,320	,266	,309	,329	,440	,288	,118	,241	,379	,316	,404
40	,402	,445	,358	,401	,156	,149	,216	,326	,259	,336	,324	,326	,282	,383	,175	,348	,427	,428	,381
39	,225	,164	,254	,356	,290	,177	,256	,081	,406	,285	,219	,244	,382	,196	,298	,317	,527	,358	,552
38	,130	,090	,076	,133	,199	,026	,006	,004	,206	,236	,005	,037	,166	,131	,039	,062	,132	,025	,152
37	,395	,381	,401	,428	,368	,287	,242	,254	,415	,340	,348	,341	,435	,300	,330	,367	,417	,370	,450
36	,289	,256	,286	,406	,193	,222	,206	,285	,387	,337	,240	,318	,347	,272	,247	,429	,396	,369	,381
35	,277	,246	,332	,364	,197	,222	,255	,263	,208	,333	,228	,348	,305	,327	,190	,407	,254	,295	,294
34	,389	,267	,418	,329	,172	,172	,180	,374	,232	,360	,353	,365	,330	,407	,178	,472	,304	,468	,404
33	,358	,324	,404	,318	,239	,192	,302	,340	,256	,320	,386	,359	,370	,379	,216	,374	,322	,426	,424
32	,310	,287	,308	,320	,288	,214	,244	,316	,325	,315	,293	,358	,456	,235	,308	,335	,323	,247	,451
31	,441	,314	,403	,379	,237	,240	,263	,354	,314	,308	,309	,416	,348	,361	,185	,458	,312	,373	,329
30	,331	,315	,352	,466	,239	,228	,193	,236	,427	,318	,330	,273	,371	,339	,312	,412	,449	,259	,470
29	,273	,213	,311	,366	,178	,207	,104	,188	,283	,365	,355	,218	,272	,264	,348	,431	,410	,341	,387
28	,372	,395	,342	,181	,100	,202	,226	,468	,097	,184	,298	,484	,227	,446	,112	,443	,164	,314	,243
27	,248	,264	,276	,417	,399	,246	,195	,232	,349	,202	,309	,356	,389	,265	,248	,360	,429	,370	,450
26	,416	,292	,364	,283	,191	,105	,208	,334	,194	,243	,267	,319	,186	,410	,139	,443	,325	,430	,295
25	,044	,110	,119	,280	,304	,052	,091	,087	,453	,228	,190	,052	,340	,024	,240	,127	,403	,187	,364
24	,474	,439	,466	,233	,153	,204	,169	,463	,081	,215	,298	,422	,185	,510	,208	,371	,227	,354	,252
23	,475	,407	,422	,255	,167	,196	,162	,526	,115	,238	,294	,462	,139	,501	,144	,369	,179	,280	,209
22	,233	,195	,294	,381	,406	,250	,198	,069	,471	,333	,279	,200	,501	,140	,299	,353	,601	,516	,684
21	,273	,235	,327	,416	,401	,252	,143	,195	,353	,284	,289	,318	,551	,243	,264	,284	,405	,347	,440
20	,448	,415	,459	,322	,266	,292	,194	,360	,333	,277	,343	,419	,337	,463	,237	,450	,339	,368	,372
19	,258	,236	,373	,406	,300	,197	,319	,206	,410	,343	,352	,276	,462	,261	,320	,409	,590	,547	1,000
18	,345	,248	,442	,278	,195	,147	,122	,305	,216	,308	,385	,292	,358	,339	,235	,396	,447	1,000	,547
17	,288	,267	,335	,452	,295	,212	,161	,162	,436	,356	,308	,148	,378	,206	,305	,361	1,000	,447	,590
16	,461	,315	,460	,366	,244	,289	,181	,341	,264	,242	,370	,382	,287	,525	,323	1,000	,361	,396	,409
15	,250	,220	,277	,205	,210	,261	,126	,209	,239	,215	,215	,096	,276	,211	1,000	,323	,305	,235	,320
14	,487	,429	,501	,285	,119	,246	,169	,434	,073	,131	,372	,433	,170	1,000	,211	,525	,206	,339	,261
13	,303	,295	,358	,385	,394	,250	,320	,152	,413	,335	,355	,361	1,000	,170	,276	,287	,378	,358	,462
12	,404	,417	,431	,265	,242	,249	,381	,419	,143	,234	,437	1,000	,361	,433	,096	,382	,148	,292	,276
11	,398	,377	,529	,351	,323	,211	,262	,383	,296	,386	1,000	,437	,355	,372	,215	,370	,308	,385	,352
10	,276	,314	,344	,422	,251	,173	,168	,183	,382	1,000	,386	,234	,335	,131	,215	,242	,356	,308	,343
9	,145	,218	,253	,411	,462	,296	,248	,077	1,000	,382	,296	,143	,413	,073	,239	,264	,436	,216	,410
8	,510	,439	,442	,253	,112	,265	,280	1,000	,077	,183	,383	,419	,152	,434	,209	,341	,162	,305	,206
7	,212	,261	,250	,222	,250	,237	1,000	,280	,248	,168	,262	,381	,320	,169	,126	,181	,161	,122	,319
6	,232	,193	,273	,158	,273	1,000	,237	,265	,296	,173	,211	,249	,250	,246	,261	,289	,212	,147	,197
5	,260	,321	,354	,375	1,000	,273	,250	,112	,462	,251	,323	,242	,394	,119	,210	,244	,295	,195	,300
4	,449	,385	,496	1,000	,375	,158	,222	,253	,411	,422	,351	,265	,385	,285	,205	,366	,452	,278	,406
3	,732	,589	1,000	,496	,354	,273	,250	,442	,253	,344	,529	,431	,358	,501	,277	,460	,335	,442	,373
2	,557	1,000	,589	,385	,321	,193	,261	,439	,218	,314	,377	,417	,295	,429	,220	,315	,267	,248	,236
1	1,000	,557	,732	,449	,260	,232	,212	,510	,145	,276	,398	,404	,303	,487	,250	,461	,288	,345	,258

,405	,429	,312	,274	,322	,152	,341	,310	,335	,319	,310	,352	,341	,450	,431	,403	,411	,351	,052	,314	,344
,439	,429	,510	,246	,212	,300	,344	,312	,281	,347	,449	,296	,454	,367	,323	,354	,470	,410	,059	,480	,432
,383	,431	,483	,203	,254	,344	,302	,366	,250	,460	,487	,298	,409	,348	,302	,274	,475	,406	,144	,548	,379
,398	,489	,406	,304	,292	,283	,247	,506	,262	,331	,416	,381	,449	,377	,355	,298	,382	,448	,171	,398	,348
,429	,208	,191	,508	,465	,008	,387	,230	,492	,251	,208	,376	,170	,351	,401	,367	,261	,275	,063	,191	,404
,344	,358	,326	,296	,287	,250	,279	,342	,332	,339	,473	,380	,533	,383	,381	,349	,368	,446	,139	,420	,378
,391	,211	,173	,427	,437	,030	,364	,183	,456	,274	,269	,385	,286	,392	,463	,329	,295	,312	,063	,191	,338
,451	,294	,240	,411	,451	,165	,367	,315	,509	,245	,358	,389	,393	,368	,379	,381	,336	,329	,127	,310	,420
,359	,580	,504	,179	,178	,347	,302	,445	,208	,364	,504	,312	,471	,354	,352	,326	,434	,515	,205	,507	,382
,381	,459	,396	,245	,301	,308	,311	,450	,295	,307	,442	,299	,374	,347	,282	,272	,322	,379	,126	,428	,496
,403	,272	,376	,332	,380	,177	,406	,386	,396	,351	,459	,425	,299	,406	,424	,356	,397	,437	,085	,424	1,000
,307	,420	,563	,144	,254	,342	,284	,357	,169	,391	,500	,276	,459	,339	,307	,213	,363	,527	,273	1,000	,424
,123	,229	,188	,044	,034	,219	,002	,124	,082	,221	,169	,085	,176	,100	,140	,037	,147	,219	1,000	,273	,085
,436	,493	,444	,291	,312	,234	,330	,370	,351	,349	,511	,399	,487	,422	,418	,377	,462	1,000	,219	,527	,437
,466	,416	,387	,268	,263	,241	,339	,358	,341	,411	,426	,415	,364	,420	,480	,543	1,000	,462	,147	,363	,397
,409	,392	,336	,391	,345	,127	,354	,347	,481	,319	,279	,432	,350	,467	,508	1,000	,543	,377	,037	,213	,356
,426	,385	,366	,330	,385	,140	,412	,241	,420	,388	,372	,485	,424	,741	1,000	,508	,480	,418	,140	,307	,424
,381	,390	,375	,305	,388	,158	,385	,267	,349	,346	,424	,464	,528	1,000	,741	,467	,420	,422	,100	,339	,406
,336	,423	,379	,230	,301	,196	,240	,351	,277	,274	,510	,420	1,000	,528	,424	,350	,364	,487	,176	,459	,299
,425	,276	,280	,465	,427	,116	,452	,376	,491	,370	,416	1,000	,420	,464	,485	,432	,415	,399	,085	,276	,425
,364	,338	,428	,243	,303	,268	,394	,402	,248	,491	1,000	,416	,510	,424	,372	,279	,426	,511	,169	,500	,459
,314	,273	,363	,262	,295	,226	,321	,312	,295	1,000	,491	,370	,274	,346	,388	,319	,411	,349	,221	,391	,351
,503	,242	,169	,591	,527	,015	,515	,372	1,000	,295	,248	,491	,277	,349	,420	,481	,341	,351	,082	,169	,396
,356	,443	,447	,289	,271	,300	,431	1,000	,372	,312	,402	,376	,351	,267	,241	,347	,358	,370	,124	,357	,386
,399	,249	,317	,386	,397	,115	1,000	,431	,515	,321	,394	,452	,240	,385	,412	,354	,339	,330	,002	,284	,406
,146	,370	,469	,022	,051	1,000	,115	,300	,015	,226	,268	,116	,196	,158	,140	,127	,241	,234	,219	,342	,177
,439	,173	,162	,666	1,000	,051	,397	,271	,527	,295	,303	,427	,301	,388	,385	,345	,263	,312	,034	,254	,380
,490	,194	,121	1,000	,666	,022	,386	,289	,591	,262	,243	,465	,230	,305	,330	,391	,268	,291	,044	,144	,332
,320	,516	1,000	,121	,162	,469	,317	,447	,169	,363	,428	,280	,379	,375	,366	,336	,387	,444	,188	,563	,376
,385	1,000	,516	,194	,173	,370	,249	,443	,242	,273	,338	,276	,423	,390	,385	,392	,416	,493	,229	,420	,272
1,000	,385	,320	,490	,439	,146	,399	,356	,503	,314	,364	,425	,336	,381	,426	,409	,466	,436	,123	,307	,403
,372	,440	,684	,209	,252	,364	,295	,450	,243	,387	,470	,329	,451	,424	,404	,294	,381	,450	,152	,552	,381
,368	,347	,516	,280	,354	,187	,430	,370	,314	,341	,259	,373	,247	,426	,468	,295	,369	,370	,025	,358	,428
,339	,405	,601	,179	,227	,403	,325	,429	,164	,410	,449	,312	,323	,322	,304	,254	,396	,417	,132	,527	,427
,450	,284	,353	,369	,371	,127	,443	,360	,443	,431	,412	,458	,335	,374	,472	,407	,429	,367	,062	,317	,348
,237	,264	,299	,144	,208	,240	,139	,248	,112	,348	,312	,185	,308	,216	,178	,190	,247	,330	,039	,298	,175
,463	,243	,140	,501	,510	,024	,410	,265	,446	,264	,339	,361	,235	,379	,407	,327	,272	,300	,131	,196	,383
,337	,551	,501	,139	,185	,340	,186	,389	,227	,272	,371	,348	,456	,370	,330	,305	,347	,435	,166	,382	,282
,419	,318	,200	,462	,422	,052	,319	,356	,484	,218	,273	,416	,358	,359	,365	,348	,318	,341	,037	,244	,326
,343	,289	,279	,294	,298	,190	,267	,309	,298	,355	,330	,309	,293	,386	,353	,228	,240	,348	,005	,219	,324
,277	,284	,333	,238	,215	,228	,243	,202	,184	,365	,318	,308	,315	,320	,360	,333	,337	,340	,236	,285	,336
,333	,353	,471	,115	,081	,453	,194	,349	,097	,283	,427	,314	,325	,256	,232	,208	,387	,415	,206	,406	,259
,360	,195	,069	,526	,463	,087	,334	,232	,468	,188	,236	,354	,316	,340	,374	,263	,285	,254	,004	,081	,326
,194	,143	,198	,162	,169	,091	,208	,195	,226	,104	,193	,263	,244	,302	,180	,255	,206	,242	,006	,256	,216
,292	,252	,250	,196	,204	,052	,105	,246	,202	,207	,228	,240	,214	,192	,172	,222	,222	,287	,026	,177	,149
,266	,401	,406	,167	,153	,304	,191	,399	,100	,178	,239	,237	,288	,239	,172	,197	,193	,368	,199	,290	,156
,322	,416	,381	,255	,233	,280	,283	,417	,181	,366	,466	,379	,320	,318	,329	,364	,406	,428	,133	,356	,401
,459	,327	,294	,422	,466	,119	,364	,276	,342	,311	,352	,403	,308	,404	,418	,332	,286	,401	,076	,254	,358
,415	,235	,195	,407	,439	,110	,292	,264	,395	,213	,315	,314	,287	,324	,267	,246	,256	,381	,090	,164	,445
,448	,273	,233	,475	,474	,044	,416	,248	,372	,273	,331	,441	,310	,358	,389	,277	,289	,395	,130	,225	,402
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

,266	,402	,265	,349	,413	,383	,458	,454	,546	1,000
,396	,541	,345	,297	,377	,254	,453	,669	1,000	,546
,463	,570	,321	,298	,423	,258	,588	1,000	,669	,454
,509	,483	,334	,291	,491	,359	1,000	,588	,453	,458
,253	,104	,370	,494	,306	1,000	,359	,258	,254	,383
,345	,413	,461	,377	1,000	,306	,491	,423	,377	,413
,251	,200	,532	1,000	,377	,494	,291	,298	,297	,349
,395	,277	1,000	,532	,461	,370	,334	,321	,345	,265
,611	1,000	,277	,200	,413	,104	,483	,570	,541	,402
1,000	,611	,395	,251	,345	,253	,509	,463	,396	,266
,496	,382	,420	,338	,378	,404	,348	,379	,432	,344
,428	,507	,310	,191	,420	,191	,398	,548	,480	,314
,126	,205	,127	,063	,139	,063	,171	,144	,059	,052
,379	,515	,329	,312	,446	,275	,448	,406	,410	,351
,322	,434	,336	,295	,368	,261	,382	,475	,470	,411
,272	,326	,381	,329	,349	,367	,298	,274	,354	,403
,282	,352	,379	,463	,381	,401	,355	,302	,323	,431
,347	,354	,368	,392	,383	,351	,377	,348	,367	,450
,374	,471	,393	,286	,533	,170	,449	,409	,454	,341
,299	,312	,389	,385	,380	,376	,381	,298	,296	,352
,442	,504	,358	,269	,473	,208	,416	,487	,449	,310
,307	,364	,245	,274	,339	,251	,331	,460	,347	,319
,295	,208	,509	,456	,332	,492	,262	,250	,281	,335
,450	,445	,315	,183	,342	,230	,506	,366	,312	,310
,311	,302	,367	,364	,279	,387	,247	,302	,344	,341
,308	,347	,165	,030	,250	,008	,283	,344	,300	,152
,301	,178	,451	,437	,287	,465	,292	,254	,212	,322
,245	,179	,411	,427	,296	,508	,304	,203	,246	,274
,396	,504	,240	,173	,326	,191	,406	,483	,510	,312
,459	,580	,294	,211	,358	,208	,489	,431	,429	,429
,381	,359	,451	,391	,344	,429	,398	,383	,439	,405
,404	,514	,279	,175	,349	,235	,433	,462	,488	,391
,316	,410	,261	,326	,276	,334	,380	,371	,434	,417
,379	,430	,273	,188	,329	,220	,372	,474	,442	,364
,241	,345	,323	,443	,394	,402	,309	,438	,350	,375
,118	,294	,220	,173	,280	,179	,277	,311	,310	,190
,288	,216	,335	,422	,327	,442	,281	,310	,244	,334
,440	,540	,369	,231	,343	,181	,442	,369	,365	,329
,329	,251	,595	,383	,354	,320	,371	,338	,260	,272
,309	,283	,272	,290	,304	,260	,403	,336	,293	,348
,266	,357	,258	,170	,339	,215	,300	,307	,332	,305
,320	,444	,151	,118	,266	,100	,292	,376	,344	,197
,201	,166	,340	,428	,316	,371	,306	,219	,247	,304
,214	,167	,397	,190	,177	,185	,121	,160	,211	,197
,167	,148	,211	,201	,243	,135	,213	,212	,237	,181
,316	,369	,193	,092	,230	,096	,385	,331	,256	,182
,351	,414	,228	,205	,340	,227	,398	,436	,349	,321
,264	,289	,315	,294	,249	,331	,339	,332	,267	,330
,292	,246	,372	,277	,268	,374	,358	,272	,231	,232
,261	,241	,382	,410	,294	,389	,314	,295	,246	,307
41	42	43	44	45	46	47	48	49	50