AN INVESTIGATION OF FIFTH GRADE STUDENTS' BEHAVIORS AND DIFFICULTIES THROUGH MULTIPLE IMPLEMENTATION OF MODEL ELICITING ACTIVITIES

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

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The aim of this study was to investigate 5th grade students' behaviors which emerge during the Model Eliciting Activities (MEAs) and how students' behaviors change from the implementation of MEA-1 to MEA-3. This study also aimed to determine difficulties that 5th grade students encounter during the implementation of MEAs in the classroom. Researcher conducted a case study research method to answer the three research questions of the study.

The study was conducted in a public religious middle school in Yenimahalle, Ankara. Three different MEAs were implemented to 31 fifth grade students in alternating weeks during 5 weeks in Fall semester of 2016-2017 school year.

Video and audio data, written works and fields notes were used as main data sources to determine critical behaviors and difficulties students encounter and how these behaviors change during MEA-1, MEA-2 and MEA-3. Findings were coded under three main categories as *(i) supportive behaviors, (ii) interfering behaviors, and (iii) difficulties.* Additionally, these categories were divided into sub-categories with the help of collected data. Supportive behaviors were determined as *generating solution together* and *sharing the work load* while interfering behaviors were determined as *need for approval*, *need for explanation*, and *working alone*. Accordingly, difficulties were named as *understanding the issue* and *time management*.

In general, this study showed that difficulties that students encountered dwindled when MEAs implemented over time. Furthermore, supportive behaviors increased while interfering behaviors decreased. By this way, it can be concluded that multiple and sustained experience of MEA is vital for teachers who want to integrate MEAs into their own classroom.

Keywords: Model Eliciting Activity, Elementary Students, Mathematical Modeling

ÖZ

5. SINIF ÖĞRENCİLERİNİN MODEL OLUŞTURMA ETKİNLİKLERİNİN ÇOKLU UYGULAMALARI ESNASINDA ORTAYA ÇIKAN DAVRANIŞLARININ VE GÜÇLÜKLERİNİN İNCELENMESİ

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Bu çalışmanın amacı 5. Sınıf öğrencilerinin Model Oluşturma Etkinlikleri esnasında ortaya çıkan davranışlarını ve bu davranışların nasıl değiştiğini incelemektir. Bu çalışma ayrıca öğrencilerin bu etkinlikler sırasında yaşadıkları güçlükleri belirlemeyi de amaçlamaktadır. Araştırma sorularına yanıt aramak için durum (örnek olay) çalışması yöntemi kullanılmıştır. 31 5. Sınıf öğrencisine 3 farklı Model Oluşturma Etkinliği 2016-2017 Güz döneminde 5 hafta boyunca birer hafta arayla uygulanmıştır. Öğrenci davranışlarını, öğrencilerin yaşadıkları güçlükleri ve bunların nasıl değiştiğini belirlemek için video ve ses kayıtları, öğrencilerin yazılı çalışmaları ve alan notları veri toplama aracı olarak kullanılmıştır. Bulgular, destekleyici davranışlar, engelleyici davranışlar ve güçlükler olmak üzere 3 ana tema şeklinde kodlanmıştır. Ayrıca bu ana temalar eldeki veriler yardımıyla alt temalara ayrılmıştır. Bu bağlamda, destekleyici davranışlar birlikte çözüm üretme ve iş yükünü bölüşme olarak; engelleyici davranışlar onay isteme ihtiyacı, açıklama isteme ihtiyacı ve yalnız başına çalışma isteği olarak alt temalara bölünmüştür. Güçlükler ise anlama güçlüğü ve zamanı yönetememe güçlüğü olarak bölünmüştür.

Çalışmanın bulguları, Model Oluşturma Etkinliklerinin sürekli uygulanmasıyla öğrencilerin yaşadıkları güçlüklerin giderek azaldığını ortaya koymuştur. Ayrıca Model Oluşturma Etkinliklerinin sürekli tekrarıyla destekleyici öğrenci davranışlarının arttığı, engelleyici öğrenci davranışlarının azaldığı görülmüştür. Bu çalışma sayesinde, Model Oluşturma Etkinliklerini kendi sınıflarında kullanmak isteyen öğretmenler için bu etkinliklerin sürekli uygulanmasının son derece önemli olduğu sonucuna varılabilir.

Anahtar Kelimeler: Model Oluşturma Etkinliği, Ortaokul Öğrencileri, Matematiksel Modelleme

To my family

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MoNE	Ministry of National Education
MMP	Models and Modeling Perspective
MEA	Model Eliciting Activity

CHAPTER 1

INTRODUCTION

Over the last few years, there has been a growing demand for new methods of teaching mathematics (Gilat & Amit, 2013). The reason for this is that existing trends and applications are not enough to grow a new generation who is talented in the fields of Science, Technology, Engineering and Mathematics (known as the STEM field) (Bulgar, 2008). At this point, countries need STEM education to raise the current generation with innovative skills and beliefs in the STEM fields. STEM education is mainly based on curriculum integration. In this curriculum, the knowledge, skills, and beliefs that are aimed to be taught are constructed with the intersection of STEM subject areas (Corlu, Capraro, & Capraro, 2014). According to Kertil and Gürel (2016), there are two perspectives in STEM education, namely, context integration and content integration. Context integration refers to putting one subject area into the center and teaching it by integrating relevant contexts from other subject areas. On the other hand, content integration refers to setting a flexible or structured curriculum on STEM education that more than one subject area can be covered (English, 2017; Kertil & Gürel, 2016).

Organization for Economic Cooperation and Development (OECD) (2008) reported that mathematics curriculum should be redefined to reflect innovative and creative applications of science and technology in the 21st century. Additionally, new methods should enable to grow creative scientists, high-tech engineers, and mathematicians who will develop a brighter future (Leikin, 2009). To achieve this goal, school curriculum should allow students to develop major skills and abilities such as problem solving, analytical thinking, and creativity by means of effective educational perspectives (Gilat & Amit, 2013).

Models and modeling perspective (MMP) is an effective educational perspective whose theoretical foundation is based on constructivist and socio-cultural theories. In this perspective, students organize, interpret, and make sense of real world situations (problems, experiences, or events) by using their own conceptual systems. Accordingly, mathematical modeling is a process of developing generalizable, sharable, and revisable models for organizing, interpreting, and describing real life situations (Kertil & Gürel, 2016; Lesh & Doerr, 2003). Mathematical modeling application in school mathematics is one of the most convenient alternative for new teaching methods (MoNE, 2013; NCTM, 2000), since it improves students' analytical thinking and problem solving abilities (Lesh & Doerr, 2003). At this point, integrating mathematical modeling to classroom settings will be efficient. NCTM (2000) states that applications of mathematical modeling in classroom settings provide students to experience in using mathematics they know and an appreciation of its usefulness for working on applied problems. In addition, mathematical modeling helps students to analyze and describe their world in a versatile and powerful way. Accordingly, student realize underlying mathematical concepts of problem situation given in the real-life context and feel appreciation of these concepts with the help of modeling (NCTM, 2000).

Model-eliciting activities (MEAs) are instructional tools that are specifically developed for school curriculum within the MMP (Moore, Doerr, Glancy, & Ntow, 2015). In MEAs, students are asked to intuitively explore mathematical ideas embedded in a real-life problem and to develop models for the given real-life problem in a relatively short period of time (Erbaş, et al., 2014) . Accordingly, teachers can easily manage MEAs in the class during one or two lesson hours since they are comparatively narrow and small scale instructional tools (Kertil & Gürel, 2016). Many researches showed that implementations of MEAs in the classroom settings develop students' problem solving skills, analytical thinking, creativity, and conceptual learning of basic mathematical ideas in real world situations (Chamberlin & Moon, 2005; Kertil & Gürel, 2016; Lesh & Zawojewski, 2007; Lesh, Cramer, Doerr, Post, & Zawojewski, 2003; Zawojewski, Lesh, & English, 2003). From this aspect, MEAs have been suggested as the instructional tool in the classroom settings for the context integration of STEM education (English, 2017; Hamilton, Lesh, Lester, & Brilleslyper, 2008; Magiera, 2013). As stated by Kertil and Gürel (2016), integrating well-structured MEAs into the school curriculum will be a smart choice to teach mathematics, physics, and other STEM concepts in an effective way. At this point, teachers should have necessary competencies about how the MEA is implemented best in the classroom. The literature described various competencies that teachers must have to implement MEAs in the classroom effectively. Some of them are; (i) knowing how to regulate and manage the classroom during MEAs, (ii) ability to give useful interventions and responses to students, (iii) ability to develop solutions to cope with unexpected situations (Doerr & English, 2006; Schorr & Richard, 2003).

To regulate the classroom, to give useful intervention to students, and to develop solutions for unexpected situations, teachers should know their own students' behaviors emerged and difficulties encountered during implementation of MEAs. However, there are limited sources in the literature focusing on specifically describing students' behaviors emerged and difficulties encountered during MEAs implementation process. Although behaviors and difficulties are not investigated in detail specifically, some researches on implementations of MEAs in the classroom stated some of them. In the literature, students' behaviors during MEAs are stated as follows; (i) asking feedbacks from teacher, (ii) getting approval for their own strategies (Moore, Doerr, Glancy, & Ntow, 2015), (iii) desire to reach a quick solution without spending time understanding or analyzing (Eraslan & Kant, 2015; Zawojewski, Lesh, & English, 2003), (iv) not working together (Eraslan, 2012; Eraslan & Kant, 2015), (v) asking evaluation for their answers, (vi) asking teacher for help, and (vii) asking clarification about what they do (Zawojewski, Lesh, & English, 2003). Accordingly, in the literature, students' difficulties are stated as follows; (i) not understanding the problem, (ii) not developing an adequate model (Eraslan & Kant, 2015; Şahin & Eraslan, 2016). Although literature specifies students' behaviors and difficulties during MEAs implementation, there are not enough source that focus on how these behaviors and difficulties change with sustained implementation of MEAs in the classroom.

Researcher works as a mathematics teacher at a public school in Ankara. The researcher has opportunity to observe students during mathematics lessons. According to her observations, students generally thought that mathematics is a boring lesson consisting of memorizing rules and procedures. In addition, students do not realize the connection between mathematics and real-life due to traditional methods for mathematics teaching. Therefore, they do not feel necessity to learn mathematics. As it can be seen, alternative teaching methods are essential for school curriculum. The teacher (researcher in this study) thought that integrating MEAs into the classroom could solve this situation. As a result, the researcher should implement MEAs that require essential skills and abilities such as group-work, creativity, problem solving, and analytic thinking in an effective and right way. In order to determine steps that teachers need to follow for an effective implementation of MEA, the researcher needed to know difficulties that students could encounter and their behaviors that could emerge during the implementation of MEA at first. Furthermore, the researcher needed to know to how these behaviors change with multiple MEA implementation in the classroom.

When the literature was reviewed, although there are various researches related to MEAs, most of them focusing on theoretical frame of MEAs, limited number of researches applied MEAs in the classroom setting to describe students' behaviors emerged and difficulties encountered and how these behaviors and difficulties change during the implementation of MEAs.

1.1 Purpose of the Study

The purpose of this study was to investigate 5th grade students' behaviors emerged during the Model Eliciting Activities (MEAs) and how students' behaviors change from the implementation of MEA-1 to MEA-3. This study also aimed to determine difficulties that 5th grade students encounter during the implementation of MEAs in the classroom.

1.2 Research Questions of the Study

The research questions of the study were as follows.

a) What are the behaviors of 5th grade students that emerge during the implementation of MEAs in the classroom?

b) What are the difficulties that 5th grade students encounter during the implementation of MEAs in the classroom?

c) To what extent do 5th grade students' behaviors in activities change from the implementation of MEA-1 to MEA-3 in the classroom?

1.3 Significance of the Study

This study is significant for stakeholders such as teachers and Ministry of National Education (MoNE). The literature stated that there are limited studies on the usage of MEAs in mathematics classrooms (Kertil & Gürel, 2016). Therefore, this study will fill an existing gap in the literature. As a result, stakeholders will gain awareness about the importance of MEAs integration to school setting.

Firstly, teachers will benefit from this study. Teachers will gain insight about students' behaviors emerged and difficulties encountered during MEAs. These findings will guide teachers who want to integrate MEAs into their own classroom. Accordingly, teachers can easily determine the steps of MEAs that are necessary to follow in their own classes to implement MEAs successfully to the regular elementary classes. In addition, MEAs used in this study may be resources for other teachers who want to integrate MEAs in their own classes since existing sources of MEAs in Turkey are not sufficient (Erbaş, et al., 2014). By using these sources, teachers can replace their own traditional method with models and modeling approach to promote essential skills and beliefs like problem solving, analytical thinking, communication skills, and necessity of learning mathematics.

Secondly, this study might offer good practices for mathematics curriculum in Turkey. New methods and alternative applications on mathematics education based on student-centered and constructivist approach are welcomed in the mathematics curriculum (MoNE, 2013). Therefore, in the light of this study, MoNE can integrate MEAs into school curriculum with the purpose of developing students' problem solving and analytical thinking abilities. MoNE can use the findings of this study on the behaviors emerged and difficulties encountered when MEAs are integrated into school curriculum so that MEAs can be applied in classroom settings better and more efficiently.

1.4 My Motivation for the Study

"The way of loving something goes through understanding it as it does for everything. We can only love what we understand."

(Sertöz, 1996)

I always remember this sentence myself while teaching mathematics to my lovely students. I know if I want my students to love mathematics, I must make sure that every one of them understands completely the concepts I taught. Actually, this statement also became my starting point for this study. I needed to use effective and appropriate methods and applications to provide students the desire of learning mathematics.

As I previously stated, I am a mathematics teacher. I have been working as a teacher for three years at public schools in Ankara, Turkey. I have the opportunity to observe and criticize stakeholders of education in the school including students, teachers, school environments, and curriculum. The main issue that disturbs me so far is students' negative perception towards mathematics lessons. Most of my students say to me "teacher, where do we use these (mathematics concepts taught in the class) in our daily-life?" They thought that school mathematics and mathematics in daily life have no crosssection. Therefore, they are not motivated to learn mathematics. To overcome this problem, I needed to apply new methods and innovative applications for teaching mathematics to show my students that school mathematics actually takes root from our daily life.

MEAs would be the best answer to accomplish my goal. I was familiar with mathematical modeling and applications of it since I have participated an elective course about mathematical modeling at my undergraduate education. To integrate MEAs into the classroom effectively, I strongly believed that I should know how students behave, to what extend these behaviors change, and which difficulties students encounter during MEAs in the classroom. As a result, I conducted this study to guide me and other teachers who want to integrate MEAs into their own classroom.

1.5 Definitions of Terms

Model is defined as the conceptual systems consisting of elements, operations, relations, and rules governing interactions, that are expressed with external notation systems and that are used to construct, describe, explain, or predict the behaviors of other systems. (Lesh & Doerr, 2003)

Mathematical Model is defined as the conceptual system that focuses on structural characteristics of the relevant systems. (Erbaş, et al., 2014; Lesh & Doerr, 2003)

Mathematical Modeling is defined as a process in which powerful mathematical models which can be generalized to other contexts are developed and created by using existing conceptual systems and models (Erbaş, et al., 2014; Lesh & Doerr, 2003)

Models and Modeling Perspective is defined as the educational perspective which requires developing conceptual systems (models) to make sense of real life situations, and where it is necessary to create, revise, or adapt a mathematical way of thinking (mathematical model) (Lesh & Zawojewski, 2007).

Model Eliciting Activities are defined as special tools used at school curriculum within the models and modeling perspective (Moore, Doerr, Glancy, & Ntow, 2015). They refer to complex, open, and non-routine problems with different entry levels in real-world contexts (Wessels, 2014).

Behavior is defined in this study as the way in which student acts oneself and towards group members or teacher during MEA process.

Supportive behavior is defined in this study as the behaviors which support the MEA process and help students to construct powerful and desired models.

Interfering behavior is defined in this study as the behaviors that interfere the MEA process and prevent students to construct powerful and desired models.

Difficulty is defined in this study as difficult situation that students need to overcome during MEA implementation process.

CHAPTER 2

LITERATURE REVIEW

The purpose of this chapter is to present related literature on the objectives and content of the study. The chapter is divided into two parts. In the first part, theoretical framework of MEA is described. In the second part, previous studies on MEA are discussed.

2.1 Theoretical Framework

In this section, the concepts of models and modeling perspective are presented. Then, MEA is described in detail.

2.1.1 Models and Modeling Perspective

In the literature, there are two different views on problem solving and learning, namely, *traditional perspective* and *models and modeling perspective* (Lesh & Doerr, 2003).

According to traditional perspective, after students learn prerequisite ideas and computational procedures in context, the procedures are applied to sets of story problems that require problem-solving strategies (if time permits). Therefore, students can engage in solving complex and realistic applied problems only in the last part of the instruction. As a result, at the traditional perspective, applied problem solving (i.e., mathematical modeling) is a small sub-category of the traditional problem solving

(Lesh & Zawojewski, 2007). On the other hand, according to models and modeling perspective, students learn mathematical procedures in context and problem-solving strategies by creating their own conceptual system. In the models and modeling perspective, students are expected to develop a mathematical way of thinking by adapting, revising, or creating a mathematical model from a given problem situation in real-life context. Therefore, students learn both problem-solving and mathematization of the problem during the entire modeling process. As a result, at the models and modeling perspective, traditional problem solving become a sub-category of the applied problem solving (Lesh & Zawojewski, 2007). The Figure 2.1, adapted from Lesh & Doerr (2003) summarizes the two perspectives stated above.

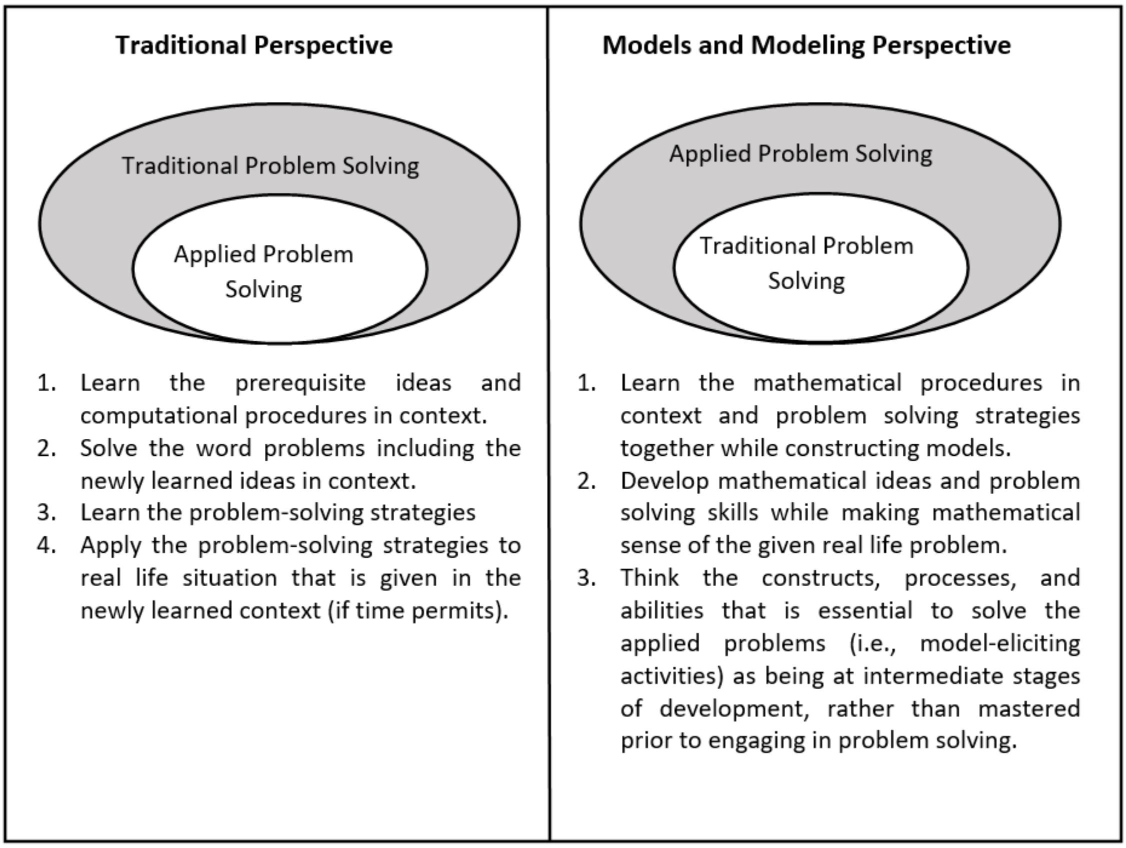

Figure 2.1 Traditional Perspective versus Models and Modeling Perspective (Adapted from Lesh & Doerr, 2003)

Models and modeling perspective is an educational perspective which requires developing conceptual systems (models) to make sense of real life situations, and where it is necessary to create, revise, or adapt a mathematical way of thinking (mathematical model) (Lesh & Zawojewski, 2007). Modeling is considered as a means of teaching mathematics in models and modeling perspective. This approach supports students to create and develop their primitive mathematical knowledge and models (Erbaş, et al., 2014). Moreover, models and modeling perspective encourages students to think mathematically creative and view mathematics in an applicable and useful way.

Lesh and Doerr (2003) describe *models* as the conceptual systems consisting of elements, operations, relations, and rules governing interactions, that are expressed with external notation systems and that are used to construct, describe, explain, or predict the behaviors of other systems. Accordingly, *mathematical model* is defined as the conceptual system that focuses on structural characteristics of the relevant systems. *Mathematical modeling* refers to a process in which powerful mathematical models which can be generalized to other contexts are developed and created by using existing conceptual systems and models (Erbaş, et al., 2014; Lesh & Doerr, 2003).

According to Lesh, Cramer, Doerr, Post, and Zawojewski (2003), models and modeling perspective has three instructional modules that were designed to engage students in sequence of structurally related and situated modeling activities. These modules are model-eliciting activity, model-exploration activity, and model-adaptation activity. They also argue that these modules were designed to meet two specific purposes. Firstly, these instructional modules provide researchers large research sites to investigate the development of interaction between students and teachers. Secondly, since instructional modules are thought-revealing, they allow observing modeling process that influences the development of students' ways of thinking (Lesh, Cramer, Doerr, Post, & Zawojewski, 2003).

Lesh and Zawojewski (2007) stated that model-eliciting activity is the first step of the modeling sequences. In model-eliciting activities, groups of students develop their own mathematical models to provide a client's needs for a specified aim. They also stated that modeling sequences continue with a model-exploration activity as the second step. In model-exploration activities, students are asked to think *about* the model they have developed and other groups' models. In the last step of the modeling sequences, model-adaptation activity, students adapt the model they have produced or another model recently developed by other groups, to a new situation (Lesh & Zawojewski, 2007).

Lesh, Cramer, Doerr, Post, and Zawojewski (2003) explained modeling sequences that include model-eliciting activities, model-exploration activities, and model-adaptation activities in detail. According to them, in model-eliciting activities, students are asked to develop the conceptual tools for the specified purposes. To make students familiar to upcoming model-eliciting activity, they start with warm-up activities that are based on a math-rich newspaper article, or on a math-rich web site. After the modeling process, follow-up activities, presentations, and discussions can be applied. If students explore the similarities and differences between their own models and structurally related conceptual systems, the process continues with the model-exploration activity. In model-exploration activities, students are asked to develop powerful representation systems and language which are essential to comprehend the conceptual system (model) that they have developed by thinking about it. This representational systems or language will be the guide during the model-adaptation activity that is the final step of the modeling sequences. In model-adaptation activities, unlike other two activities, students work alone to adapt and generalize the existing models recently developed to the new situations (Lesh, Cramer, Doerr, Post, & Zawojewski, 2003). At Figure 2.2 given below, the modeling sequence is summarized.

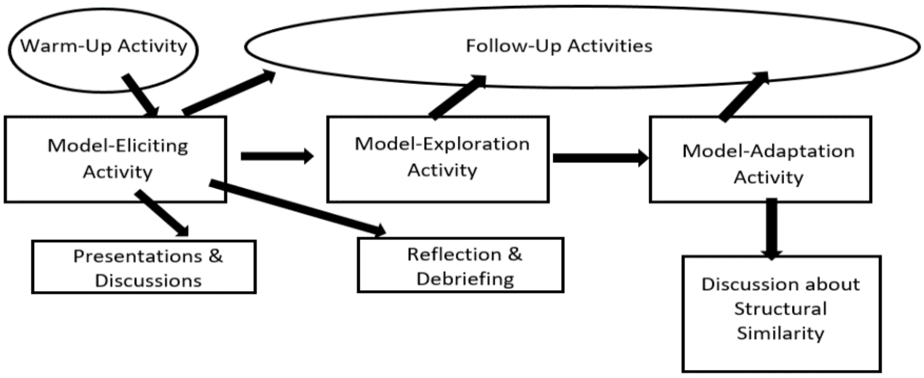

Figure 2.2 A scheme for modeling sequences (Lesh, Cramer, Doerr, Post, & Zawojewski, 2003, p. 45)

Modeling sequences have been developed as modular sequences since it was aimed to enable teachers use any part of them with different purposes like assessment and instruction in the class. Teachers can adapt any part of the modeling sequence to their own instruction by adding, deleting, modifying, or re-sequencing the parts of modeling sequences (Lesh, Cramer, Doerr, Post, & Zawojewski, 2003).

2.1.2 Model-Eliciting Activities (MEAs)

Model-eliciting activities (MEAs) are special tools used at school curriculum within the models and modeling perspective (Moore, Doerr, Glancy, & Ntow, 2015). They are complex, open, and non-routine problems with different entry levels in real-world contexts (Wessels, 2014). MEAs are designed for students to work together in teams to emphasize deeper and conceptual understanding while creating models (Lesh & Doerr, 2003). Students are asked to develop higher conceptual systems (models) by modifying or extending existing conceptual systems and constructs. To accomplish this, students need to integrate, revise, re-organize, or differentiate their initial mathematical interpretations (Lesh & Yoon, 2004). Unlike traditional story problems which require students to give short and only one exact answers on recently learned mathematical concepts, students' models (solutions) are complex tools that meet the given clients' needs in given real life situations. Tools can be expressed, tested, and revised easily since these tools must be reusable and sharable in other situations (Lesh & Zawojewski, 2007).

There are two important reasons why MEAs have been developed and used. Firstly, students find an opportunity to consolidate their existing mathematical knowledge and build new knowledge while they are developing models for the complex mathematical problem given in the real-life context. Secondly, teachers find an opportunity to observe and examine students' mathematical thinking (Chamberlin & Moon, 2005; Lesh & Doerr, 2003; Wessels, 2014).

Lesh, Hoover, Hole, Kelly, and Post (2000) have described six principles for designing productive MEAs. Following these principles during designing or modifying MEAs provides that all MEAs meet the desired standards and stimulate model-eliciting behaviors. To ensure if designed or modified MEAs meet all the standards, researcher can conduct field tests, pilot studies, or interviews with students (Chamberlin & Moon, 2005). These six principles were summarized below (Chamberlin & Moon, 2005; Lesh, Hoover, Hole, Kelly, & Post, 2000; Zawojewski, Lesh, & English, 2003).

1. Model Construction Principle: This principle states that all MEAs require the development of a mathematical model at the end of the process. According to Model Construction Principle, students need to construct a model which consist of concrete, graphic, symbolic, or language-based representational systems. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask *"Does the task put students in a situation where they recognize the need to develop a model for interpreting the givens, goals, and possible solution processes in a complex, problem solving situation? Or, does it ask them to produce only an answer to a question that was formulated by others?"*

2. Reality Principle (Personal Meaningfulness Principle): This principle states that MEAs are “real” questions rather than a “mathematics class” questions. In this sentence, “real” means that the context of MEAs should touch the life of target students. In other words, personal cultures, experiences, and interests of students need to be considered while designing the MEAs. According to Reality Principle, students understand the MEAs in realistic contexts based on their past experiences. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask *"Could this really happen in a real-life situation?"*

3. Self- Assessment Principle: This principle states that MEAs need to have appropriate criteria for evaluating the usefulness of alternative solutions. Accordingly, students should be able to evaluate the usefulness and appropriateness of their own models without feedbacks from the teacher. Moreover, during modeling process, students should be able to decide changes they should make, whether developed models need to be revised, or which of different models is most efficient for the given problem. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask “*Does the problem statement strongly suggest appropriate criteria for assessing the usefulness of alternative solutions? Is the purpose clear (what, when, why, where, and for whom)? Are students able to judge for themselves when their responses need to be improved, or when they need to be refined or extended for a given purpose? Will students know when they have finished?”*

4. Construct Documentation Principle: This principle states that MEAs require students to document their responses in a written form, specifically as a letter written for client. To explain their own solutions (model), students need to document their thinking during the modeling process. This principle enables teachers to see thinking ways of the students, as well as the final solutions (models) of students. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask *“Will responding to the*

question require students to reveal explicitly how they are thinking about the situation by revealing the givens, goals, and possible solution paths that they took into account? In particular, will it provide an "audit trail" that can be examined to determine what kinds of systems (objects, relations, operations, patterns, and regularities) the students were thinking with and about?"

5. Model Generalizability Principle: This principle states that MEAs require the development of models that are used in other similar situations. According to this principle, students must be able to develop the models that are shared and reused in parallel situations. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask *"Is the model that is developed useful only to the person who developed it and applicable only to the particular situation presented in the problem, or does it provide a way of thinking that is shareable, transportable, easily modifiable, and reusable?"*

6. Effective Prototype Principle: This principle states that MEAs require the development of models that are easily understandable by others. According to this principle, students need to develop mathematically rich and significant models for the complex problems in a simple way. To check if the developed or adapted MEAs fulfill this principle, Lesh, Hoover, Hole, Kelly, and Post (2000) suggest to ask *"Does the solution provide a useful prototype, or metaphor, for interpreting other situations? Long after the problem has been solved, will students think back on it when they encounter other structurally similar situations?"*

The MEAs have a traditional format for the teachers who want to use them in the class (Zawojewski, Lesh, & English, 2003; Chamberlin & Moon, 2005). Each MEA includes four parts. The first part is a reading passage. Reading passages are the mathematically rich newspaper articles whose contexts are relevant with the upcoming MEAs. These passages enable students to understand the context of MEA and realize the real-world applications of the upcoming MEA. With the help of reading passages, students get familiar to the upcoming MEAs and spend less time to understand the problem situation (Chamberlin & Moon, 2005). Besides, parents realized the significance of working on MEAs thanks to reading passages (Lesh, Hoover, Hole, Kelly, & Post, 2000). In the second part, students answer readiness questions about the reading passages. Several types of questions can be asked such as basic comprehension questions, inference questions, or questions requiring the interpretation of data given in the problem. The aim of this part is to provide that students understand the context of the upcoming MEA accurately. In addition, if teachers answer these questions with students in the class outloud before modeling process, teachers can determine their students' readiness about the problem situations (Chamberlin & Moon, 2005). The third part is the data part. This part includes data which are used by students while developing models. Data can be a chart, diagram, map, table of times, performance, and price etc. The fourth part is the problem statement. The statement is generally one paragraph long. Solution of the problem statement asks students to develop models for an imaginary client (Chamberlin & Moon, 2005).

The implementation procedure of MEAs can be regulated by teacher. However, there are some principles and traditional formats about it needed to be followed (Coxbill, Chamberlin, & Weatherford, 2013; Zawojewski, Lesh, & English, 2003). Lesh, Cramer, Doerr, Post, and Zawojewski (2003) stated that MEAs mainly include three parts which are warm-up, modeling process, and follow-up. Literature gives some suggestions about planning and managing the implementation of MEAs on the basis of researchers' own experiences (Coxbill, Chamberlin, & Weatherford, 2013; Zawojewski, Lesh, & English, 2003).

At warm-up part, readiness activities are implemented before the actual modeling process. Readiness activities consist of a reading passage related to context of upcoming MEA and five to six readiness questions which review the content of the passage. This part allows students and teachers to feel more comfortable when students start to work the challenging MEAs. There are various ways to implement readiness activities. They can be given as homework, and then can be examined with students in the class before starting the modeling process. Or one student can be asked to read the reading passage loudly in the class and other students listen. Then, readiness questions are answered together (Coxbill, Chamberlin, & Weatherford, 2013). Zawojewski, Lesh, and English (2003) suggested that teachers had better prefer doing readiness activities in the class when MEAs are used at the first time, and then they can give readiness activities as homework for the other MEAs.

At modeling part, students start to develop their own mathematical models by expressing, testing, and revising them (Coxbill, Chamberlin, & Weatherford, 2013). Firstly, cooperative groups are formed by teacher. Zawojewski, Lesh, and English (2003) recommend dividing students into groups of three or four. Teacher should consider students' skills, personalities, and thinking ways. Each group consists of students who have different ways of thinking and different types of skills and personalities. This results that students look from different perspectives while developing models. Secondly, copies of MEA are distributed as one copy per group or each student a copy. It is up to teacher's preference. Then, enough time (5 minutes) is given to read. Zawojewski, Lesh, and English (2003) suggested that after each student read the problem situation, teacher conducts the brief class discussion to ensure that the problem statement (mathematical mission, client etc.) is clearly understood. Thirdly, one or two lesson hours (approx. 50 min) is given to students for working on their models. At the end of the process, students are expected to record their thinking ways, and ideas in a letter format for the imaginary client (Coxbill, Chamberlin, & Weatherford, 2013). In this part, teacher's role is significant (Zawojewski, Lesh, & English, 2003). Teacher should not get involved the modeling process actively as much as possible. Teacher must just listen and observe the students not to affect students' thinking way. However, students usually ask teacher for help during modeling process. If students ask questions about what they do, teacher should suggest students to read the problem statement again and try to identify the client and the solution asked. Similarly, Coxbill, Chamberlin, and Weatherford (2013) suggest that teacher can respond students' questions with questioning tactics by asking specific questions:

"What is the mission or problem statement asking you to do? What is your group trying to do? What do you think? Could you expand on that idea? How does this solution address the mission?"

At follow-up part, students present their models briefly. Then, a brief researcher-moderated, student-centered discussion on presented models can be done to motivate students for upcoming MEAs by sharing their own products with class (Coxbill, Chamberlin, & Weatherford, 2013; Lesh, Cramer, Doerr, Post, & Zawojewski, 2003).

2.2. Review of Related Literature

There are many resources in the literature written by experts in this field. Since it is not possible to mention all of them, the presented studies are limited considering the purpose of this study. In this part, previous studies on MEAs that are conducted with elementary school students (from grade 1 to grade 8) are reviewed.

Jung (2015) carried out a study to identify the strategies used by two middle school teachers and their students during MEAs. Two eighth-grade teachers and researcher worked together to co-develop and co-teach modeling lessons with MEAs over a semester. Three MEAs were implemented by two teachers during the eleven weeks at their own classes. Audiotaped interviews and discussions with two teachers and their students' written work were used as the data source. As a result, researcher determined strategies that helped students' development of the modeling process. These strategies were grouped under six principles of MEAs that are necessary to be satisfied for productive models. Jung (2015) concluded that teachers can ask students questions to be sure that they understand the task on the basis of their own real-life experiences for *reality principle*, guide students with questioning to create a productive model for *effective prototype principle*, remind students to develop a generalizable and reusable model for *model generalizability principle*, ask students to document their process in a letter format for *model documentation principle*, provide discussions and presentations that students see the alternative solutions for *model construction principle,* ask students to use peer-review forms to evaluate their own responses for *self-evaluation principle*. Parallel to Jung (2015), Moore, Doerr, Glancy, and Ntow (2015) described strategies that can be helpful for students' conceptual development and ability to connect with other mathematical concepts. The Pelican Colonies MEA was implemented to 6th grade students. At the end of the implementation, researchers suggested helpful strategies for the role of teacher during MEAs. Firstly, teacher should not intervene. Conversely, teacher should give students time to revise their strategies after they receive feedbacks. Secondly, teacher should not direct students to a particular solution. Instead, teacher can ask related questions to students for clarification of solution path and thinking way. Thirdly, teacher should allow whole-class sharing of ideas and strategies. This helps students see other groups' ideas and compare them with their own solutions. Lastly, teacher should prepare follow-up activities that help students generalize the newly-learned concepts to another related situation.

Different from studies mentioned above, Coxbill, Chamberlin, and Weatherford, (2013) carried out a study with elementary students to identify mathematically creative students and to develop creativity by using MEAs as a tool. 3^{th} grade students including 14 boys and 10 girls and 6^{th} grade students including 7 boys and 8 girls from elementary school in USA were used as sample. Three different MEAs were implemented to each class in alternating weeks. Written products were analyzed on a scale by using Quality Assurance Guide and Krutetskii's nine ways of thinking ways. Creativity scores obtained from scale were analyzed using Multifactor ANOVA with and alpha level of .05 to identify mathematically creative students. Additionally, class mean scores were used over the course of the three MEAs to determine development of mathematical creativity during MEAs implementation. As a result, MEAs were determined as a first step tool to develop creativity and identify mathematically creative students. One 6^{th} grade student was identified as mathematically creative and an analysis presented a mean change in 6^{th} grade class scores of 1.41 on a 5-point scale during three MEAs implementation. Another study on the effect of MEAs to students' creativity was conducted by Gilat and Amit in 2013. The purpose of the study was to show how engaging students in MEAs can promote mathematical creativity. 10-year-old and 13-year-old high achiever girls were participants of this case study. Each girl received the same MEA task followed traditional implementation process (warm-up, model development-presentation-discussion). Then, interviews were done with each girl. Qualitative data analysis was used to investigate mathematical creativity with the framework of creativity namely, fluency, flexibility, and novelty. Interviews, written materials, researchers' notes, conversations during activities, and final discussion were data sources. To conclude, participants created various modeling cycles that presented their thinking process that may serve as the foundation for a methodology that uses MEAs to stimulate mathematical creativity.

Eraslan and Kant (2015) conducted a study to identify the modeling process of 4th-year-middle-school students during MEAs and to determine the difficulties encountered during MEAs. Three students from a public school in Turkey were chosen as a focus group. Volleyball Problem MEA was implemented. Video recording was used as the data source and qualitative analysis was done. As a result, researchers concluded that students produced different ideas, discussed various assumptions while developing models. In addition, MEA enabled students to develop their ways of thinking. However, the study showed that students encountered some difficulties during MEA process in connection with understanding, developing, and constructing an adequate model. Similarly, Celik and Eraslan (2015) carried out a qualitative study with 4th grade students in a public school to determine difficulties encountered during MEAs. Three students were determined as the focus group by using criterion sampling. Focus group worked on the Crime Problem MEA. Video-recordings and written works of students were used as main data sources. Data were analyzed according to Blum and Ferri's modeling processing cycle. The results showed that 4th grade students successfully developed various models, determined the patterns among variables, created and discussed different ideas and assumptions. However, students had difficulty to focus on the problem and they needed to have breaks during MEA implementation process. Another research on students' modeling process and difficulties encountered during MEAs was conducted by Şahin and Eraslan in 2016. Participants were 7th grade students in a public school in the Black Sea Region of Turkey. The Paper Plane Contest MEA was implemented with three students that were determined as the focus group by using criterion sampling technique. Video-recordings and written responses were used as main data sources. Data was analyzed by using descriptive analysis. The results showed that students created different strategies for the given situation and considered each variable while developing models. On the other hand, students had difficulty to understand the problem situation and make mathematical operations. However, they overcame the difficulty of making mathematical operations with the help of group working.

To conclude, there are various studies on implementation of MEAs in the elementary classroom with different purposes. First of all, Jung (2015) and Moore, Doerr, Glancy, and Ntow (2015) focused their studies on describing strategies that guide teachers during the implementation of MEAs in the classroom. These studies also revealed that these strategies can be useful for students' conceptual development and ability to connect with other mathematical concepts.

Secondly, Coxbill, Chamberlin and Weatherford (2013) and Gilat and Amit (2013) integrated MEAs into instruction in elementary schools to stimulate and develop mathematical creativity in school setting and identify mathematically creative students. Thought-revealing activities (Problem posing, problem solving, MEAs) have been successfully integrated into mathematics classes as an effective instructional tool with the aim of developing mathematical creativity. Furthermore, in the light of these studies, it can be concluded that thought-revealing activities, especially MEAs, can be used as performance assessment tools to measure creativity in elementary schools.

Thirdly, Eraslan and Kant (2015), Celik and Eraslan (2015), and Şahin and Eraslan (2016) carried out studies on the modeling process of elementary students during implementation of MEAs in the classroom and the difficulties confronted during MEAs. Studies revealed that although students were able to develop desired models in the given real life situation, they had some difficulties while developing them.

In the light of studies summarized above, although there have been various researches on implementation of MEAs in elementary class, none of them has addressed how students behave during MEAs. Therefore, further researches have to be conducted to enlighten students' behaviors which emerge during MEAs and how students' behaviors change during the implementation of MEAs in the classroom. Moreover, there have still been few studies on difficulties that students encounter during the implementation of MEAs in the classroom.

CHAPTER 3

METHODOLOGY

The aim of this study was to reveal 5th grade students' behaviors which emerge during the Model Eliciting Activities (MEAs) and how students' behaviors change from the implementation of MEA-1 to MEA-3. This study also aimed to determine difficulties that 5th grade students encounter during the implementation of MEAs in the classroom.

In this chapter, methodology of the study will be presented in detail. First, design of the study, context, participants, and data collection tools will be introduced. After that, procedures, and data analysis will be explained. Finally, the quality of the study, and limitations of the study will be addressed.

3.1 Design of the Study

In this study, researcher conducted a case study research method to obtain detailed information in a situation. Case study is a qualitative research method that focuses on developing an in depth understanding of a specific case like an event, activity, or process (Creswell, 2012). In case studies, case refers to an individual, a classroom, a program, or a school, as well as it can be a particular event, an activity, or an ongoing process (Fraenkel, Wallen, & Hyun, 2011).The goal of case studies is to gain insights through the study of a unique case to suggest ways to help similar cases in the future (Fraenkel, Wallen, & Hyun, 2011).

To answer the three research questions of the study, the researcher needed to gather in depth understanding of 5th grade students' behaviors and difficulties during implementation of MEAs. In this study, the researcher investigated 5th grade students' behaviors which emerge during the MEAs and how students' behaviors change from the implementation of MEA-1 to MEA-3. Additionally, the researcher determined difficulties that 5th grade students encounter during the implementation of MEAs in the classroom. As a result, the case was determined as *the implementation of MEA in the classroom setting.*

3.2 Context

The context of the study was a public religious (İmam Hatip in Turkish) middle school in Yenimahalle, Ankara. The school was specified as a "project school" in 2016 by the Ministry of National Education (MoNE). Project school is a special school that applies innovative instructional methods, and national or international projects. According to project school regulation, these schools can admit students with a special entrance exam. There were approximately 1000 students from 5th grade to 8th grade. The school is located at the central part of the Ankara. Hence, almost all students had high socio-economic standards. The school admitted 5th grade students with an entrance exam including participants of the study. Therefore, all 5th grade students had at least average mathematical achievement. There were 12 mathematics teachers out of 72 teachers. Standard middle school curriculum specified by MoNE was used in the school at the time of data collection. None of mathematics teachers used innovative instructional methods. They preferred to teach mathematics by using direct instruction instead of using student-centered approaches. Therefore, students were not familiar to MEAs which was one of the student-centered approaches. Besides, although various mathematics manipulatives were available in the school, none of mathematics teachers used them in their classes. The researcher started to work as a mathematics teacher in this school at the beginning of 2016-2017 school year. Accordingly, the researcher wore two hats as a researcher and a mathematics teacher in the class while conducting the study.

3.3 Participants

In this study, participants were 31 fifth grade students in a public religious middle school in Yenimahalle, Ankara. In other words, class A which had 31 female students constituted the participants of the study. Participants were divided into groups during MEA process. One focus group was determined by researcher. Then, findings were obtained from the focus group data. All participants were females, since classes for females and males were separated at the school because of being a religious school. Students took an entrance exam to enroll to this school. 300 5th grade students including participants in this study were chosen out of 1000 students taking the entrance exam before 2016-2017 school year. Therefore, each student has at least average mathematical achievement.

Non-random sampling is feasible, since generalizability is not a concern in qualitative studies (Merriam, 2009). Convenience sampling and purposive sampling were used in this study. In purposive sampling, researcher selects the sample based on prior knowledge and the specific intent of the research (Fraenkel, Wallen, & Hyun, 2011). The researcher wanted to obtain desired information which was suitable to the specific aim of the study. Therefore, researcher considered the aim of the study while determining participants of the study. Additionally, convenience sampling is a sampling method that participants are selected according to availability for a study (Fraenkel, Wallen, & Hyun, 2011). Convenience sampling saves time, money, and energy. Also, it provides convenience to researcher in terms of location, and availability of individuals (Merriam, 2009). The participants mentioned above were selected by using purposive and convenience sampling method due to two reasons. Firstly, the researcher is the math teacher of class A. Participants were familiar to the researcher and the researcher knows participants' backgrounds, achievement levels, abilities, and personalities. Therefore, collecting data were easy and reliable for the current study. In addition, the researcher was able to interpret the data more accurately. Secondly, class A has average and above-average mathematics achievement based on the score of school entrance exam. In this study, students needed to have at least average mathematical achievement and know basic mathematics knowledge and skills. Since students has average and above mathematics achievement, they did not have difficulty to use necessary mathematics knowledge and skills while they were developing models. This provided to get useful and adequate information which was essential to answer the research questions properly.

3.4 Data Collection Tools

In this study, video recordings of each MEA implementation process, audio recording of focus group, written works of participants, and field notes were used as the main data sources.

3.4.1 Video and Audio Recordings

Each MEA was recorded by two cameras in the class. One of them recorded the whole class during MEAs while other was recording the focus group. In addition, data was obtained from focus group with the audio recording. The researcher chose to use video and audio recording as the data source since it would be difficult without video and audio recordings to follow the essential data for determining the difficulties and significant behaviors. Audio and video recordings captured the participants' gestures, movements, conversations, and intonations that helped to determine findings of the research accurately. In addition, audio and video recordings enabled researcher to reexamine data over and over again after implementation process for coding critical behaviors and difficulties.

3.4.2 Written Works and Field Notes

Findings were supported with written works of participants and field notes. The researcher gathered written works of the groups at the end of each MEA. Moreover, the researcher took field notes about students' behaviors and difficulties during MEAs when the researcher got the chance. The written works and the field notes enriched the data and helped recordings to complete the big picture. As a result, various data sources empowered the findings of the study.

3.5 Instructional Tool: MEAs

3.5.1 MEAs

MEAs were used as an instructional tool in the study. Three different MEAs were chosen and adapted to observe participants' behaviors and difficulties during MEAs. The names, objectives and mathematics content of the MEAs are listed in Table 3.1 The activities are presented in Appendix A. All MEAs were open-ended and have various solutions which allow observing students' creativity and diversity in thinking. The researcher considered the participants grade level while choosing the mathematics content of the MEAs, which were chosen among the mathematics contents that had been covered by 5th grade students so far. Activities were chosen from three different mathematics contents purposefully to authenticate the findings. This situation gave the teacher a new chance with each activity to observe different behaviors and difficulties.

Table 3.1 Summary of the MEAs used in the study

Name	Objective	Mathematics Content
Summer Reading	Create a system for assigning points in a summer reading program based on three separate factors to identify the winner	Developing and weighing variables
Big Lawn Pays Off	Design a lawn as parking space which can take as many cars as possible based on determined factors.	Measuring area
Snowflake	Form 8-sided snowflake by using a given paper folding model, and develop a 6-sided snowflake by revising the given model	Symmetry

All MEAs were taken from the Purdue University College of Engineering website (Purdue University, 2016). They were open sources. All MEAs had been field tested and piloted in a classroom. The MEAs were in English. Therefore, the researcher translated them from English to Turkish considering the traditional format of the MEAs. Yet, the MEAs were revised in regard to students' grade level, developmental level and socio-cultural status.

Since MEAs were adapted by the researcher, reliability and validity issues of them needed to be addressed. To address these issues, an English translator, a faculty member who was interested in Mathematical Modeling and a mathematics teacher who was experienced with MEAs were determined as experts. Firstly, these experts in the field checked the format and content of the MEAs for validity issue. According to feedbacks taken from them, MEAs were updated so that they were consistent with the aim of the study and the participants. Secondly, MEAs were piloted before the actual study. According to the results of the pilot study, necessary revisions were made on MEAs activities.

3.5.2 Pilot Study

The pilot study was conducted in a public school in Mamak, Ankara. It was conducted in the first week of May, 2016. The aims of the pilot study were to determine the most effective implementation procedures of MEA in the classroom and to check appropriateness of MEAs to 5th grade students. Moreover, researcher tested the comprehensibility and clarity of MEAs and average implementation time. Three MEAs were implemented with nine 5th grade students during a week. Participants were separated into the groups of three by the researcher. Participants were selected according to availability and convenience. Since, the researcher was a mathematics teacher in this school at the 2015-2016 school year.

In May 4, 2016, Summer Reading was implemented as the MEA-1. Traditional format of MEA was followed in the first implementation as warm-up, modelling process and discussion. However, discussion part took a lot of time so that researcher decided to remove it. Consequently, warm-up and modelling process were implemented at MEA-2 and MEA-3.

Readiness passage had been distributed to the participants one day before the implementation. Participants were asked to read the passage and answer the readiness questions in advance. Participants complained about reading passage complexity and lengthiness. In addition, participants had difficulty to read and understand the problem statement due to its lengthiness. Therefore, the researcher simplified the reading passage and problem statement for the actual study.

Participants did not understand some words at the activity sheet and asked the meaning of them. For example, the researcher translated ‘’grade level’’ as ‘’düzey’’. However, students did not understand what it meant and asked for explanation. Therefore, researcher revised ‘’düzey’’ as ‘’sınıf seviyesi’’ at the last version of the MEA-1. Like the example, necessary wording revisions were made based on feedbacks given from participants.

At MEA-1 implementation, placement of groups in the classroom was not arranged in a right way and participants were sometimes affected from other groups’ talking, ideas etc. Therefore, the researcher paid attention to placement of the groups in the classroom before starting the following studies.

In May 6, 2016, Snowflake was implemented as the MEA-2. Like MEA-1, traditional format of MEA was followed at MEA-2. However, discussion part was removed at MEA-2. Participants did not understand reading passage very well at MEA-2. Therefore, reading passage was simplified. Problem statement was clear. Hence, no change was made on it.

This activity required scissors and papers. Researcher asked participants to bring scissors and paper with them to the class in the activity. Yet, some of them forgot. In the actual study, the researcher provided scissors and paper to prevent this problem.
In May 10, 2016, Big Lawn Pays Off was implemented as the MEA-3. Like MEA-2, warm-up and modelling process were applied at MEA-3. Reading passage was well-understood. The MEA-3 had a more familiar content to students. Therefore, students adapted the problem situation easier than MEA-2. No major changes were made on MEA-3. Just some wordings and sentences were revised by the researcher for actual study. In addition, researcher decided to implement Big Lawn Pays Off activity as MEA-2 for the actual study. Snowflake was implemented as MEA-3 since students had the most difficulty to adapt it. In the actual study, researcher provided rulers for this MEA since they needed a ruler to measure the dimensions of Lawn and the vehicles.

According to results of the pilot study, implementation time was determined as two lessons without break for the actual study. In other words, each MEA implementation took 90 minutes i.e. 2 lessons and a 10-minute break.

As a result, reading passages and problem statements of MEAs were revised and simplified with the help of feedbacks from participants. Furthermore, the most applicable procedure for in-class implementation of MEA was determined for the actual study according to field notes and observations of the researcher. Implementation order of the MEAs was determined as Summer Reading, Big Lawn Pays Off and Snowflake. The procedure was mentioned in detail at procedure part. In addition, the researcher adjusted minor details like good placement and supplying necessary tools during the pilot study.

3.6 Procedure

Before the implementation, necessary permissions were taken from Middle East Technical University Human Subjects Ethics Committee and the school administration (Appendix B). After getting necessary permissions, pilot study and actual study were implemented. Firstly, pilot study was conducted during a week towards the end of Spring semester of 2015-2016 school year. Based on pilot study, necessary revisions and refinements were done on the MEAs and procedures of the study. Then, 31 participants engaged in three MEAs in Fall semester of 2016-2017 school year. Each activity was implemented in alternating weeks during 5 weeks. The detailed time schedule was presented in the Table 3.2 below.

Table 3.2 Time schedule of the study

Date	Event
February 2016-April 2016	Selection and adaptation of MEAs
May 4, 2016	Pilot study Implementation of MEA-1 (Summer Reading)
May 6, 2016	Pilot study Implementation of MEA-2 (Snowflake)
May 10, 2016	Pilot study Implementation of MEA-3 (Big Lawn Pays Off)
May 2016-September 2016	Revisions and refinements on the MEAs and procedures of the study
November 15, 2016	Implementation of MEA-1 (Summer Reading)
November 29, 2016	Implementation of MEA-2 (Big Lawn Pays Off)
December 15, 2016	Implementation of MEA-3 (Snowflake)
January 2017- April 2017	Data Analysis

Traditional format of MEAs was followed at each activity. Researcher followed the same procedure during all activities as consistent as possible. Procedures were determined considering the results of pilot study. Each MEA consisted of two parts, namely, warm-up and modelling process.

At the warm-up part, take-home assignments were given to students to introduce the problem before in-class activity. These assignments included reading an article and answering readiness questions about the topic. These assignments provided students to comprehend the content of MEA and make meaningful connections to real world applications of the upcoming MEA. In class, the researcher asked what students understood about the reading passage and got answers from some students. Then, readiness questions were answered together in the class. After that, the researcher distributed the problem statement to each student and asked them to read silently. After 5 minutes, one student read the problem statement loudly. Researcher initiated a class discussion about what the activity asked. Discussions about readiness questions and groups' mathematical mission enabled the researcher to be sure that the context and problem situation were understood before students started to work.

After warm-up, students were divided into cooperative groups of four according to the list prepared by the researcher. Groups were formed by researcher before the actual study in terms of personal characteristics of students. Students who could work in harmony were put in the same group since researcher knew all students very well. At modeling part, each group started to create their own model by expressing, testing, and revising the ideas. Two lessons without break were provided for modelling process. At the end of the lesson, as directed in the problem statement, recording their own model in a letter format was expected from each group. Students were warned when 5-min and 10-min is left. To prevent possible effects of teacher-researcher on students which decrease the creativity of students, teacher's mission was just facilitator. Teacher could only ask specific questions given as follows that did not direct students suggested by Coxbill, Chamberlin & Weatherford (2013): "What is the mission or problem statement asking you to do?", "What is your group trying to do?", "What do you think?", "Could you expand on that idea?", "How does this solution address the mission?" Discussion part was removed since pilot study showed that time would not be enough.

3.7 Data Analysis

The process of making sense out of the data is called data analysis (Merriam, 2009). Collected data is analyzed considering the purpose of study to answer the research questions. In qualitative researches, “coding” is a data analysis technique that includes determining the categories from raw data, naming the categories, and finding out the systems for placing data into categories (Merriam, 2009).

The researcher watched carefully the entire video and audio data to examine the overall flow while keeping in mind the aim of the research. The researcher determined critical behaviors and difficulties students encounter and how these behaviors change during MEA-1, MEA-2 and MEA-3. Findings were also supported by written works and fields notes. Intensive information had to be organized considering the purpose of the research. Time interval for the difficulties and critical behaviors were noted at each video and audio data. Then, significant moments were transcribed. Audio and video transcriptions were viewed iteratively to find patterns of significant behaviors and difficulties. When it was necessary, the researcher watched video and audio again to support the determined patterns. These patterns from critical behaviors and difficulties were coded. At the end of the iteration procedure, certain coding schema was developed by the researcher.

At the end of the analysis process, findings were coded under three main categories as (i) *supportive behaviors, (ii) interfering behaviors, and (iii) difficulties.* Additionally, these categories were divided into sub-categories with the help of collected data. These categories were presented at findings chapter in detail.

3.8 The Quality of the Study

In both qualitative and quantitative research, validity and reliability are indispensable issues that are necessary to be given due importance in each step of the study, specifically collecting, analyzing, and interpreting data and presenting findings (Merriam, 2009). Internal validity, external validity and reliability are discussed in quantitative researches. Differently, in qualitative researches, credibility, transferability, and consistency (dependability) substitute for internal validity, external validity and reliability respectively (Lincoln & Guba, 1985).

Triangulation is a method, that requires to use multiple investigators, multiple methods, multiple data source, or multiple theories (Creswell, 2007). In this study, triangulation was used to provide credibility and consistency. Video recordings, audio recording, field notes and written products of participants were used as multiple data source. Analysis process of findings were supported with these multiple data source. Then, findings from these different sources were compared to make sure that they were consistent with each other.

Persistent observation and adequate engagement are other signs of validity and reliability in the study (Creswell, 2007; Merriam, 2009). Within this frame, the main study was applied in 5 weeks. This period of time was enough to know participant and learning culture. And also, it provided researcher to collect more detailed and accurate data of the desired phenomenon under investigation.

At the qualitative methodologies, researcher position is a significant factor for unprejudiced interpretation of investigated phenomenon (Creswell, 2007). Therefore, to provide credibility and consistency, researcher should mention her assumptions, biases and dispositions toward the study so that readers understand better how the researcher arrives at the interpretation of the findings (Merriam, 2009). In this study, the researcher was the actual teacher of the participants. Hence, the nature of lesson flow was not affected. Students shared own opinions and works freely since they were familiar to the researcher. Furthermore, the researcher knew each participant in person. Thanks to this, researcher knew how to behave each participant in a particular situation. Also, this enabled the researcher to make more accurate observations. However, there were certain disadvantages to be a teacher-researcher. For example, participants were so comfortable in the class so this caused distractions during implementation such as chatting among participants. In addition, participants could consider the researcher as an authority and they could feel restricted. In order to avoid these undesired conditions, researcher took necessary precautions in advance. To illustrate, researcher walked around the desk during implementations of MEAs and warned the participants who were distracted.

3.9 Limitations of the Study

The study had four significant limitations. First limitation was about participants and selection of them. Participants were not selected randomly. Researcher was a mathematics teacher at a public school. Hence, purposive and convenient sampling procedure were used. Classes of boys and girls were separated in this school. Researcher taught only one 5th grade girl class. Therefore, the study was conducted at this school with researcher's 5th grade class including 31 girls. However, the schools are mostly coeducational. This may be a limitation since the sample of the study was not representative of all 5th grade class in Turkey. It should be stated that non-random sampling is feasible, since generalizability is not a concern in qualitative studies (Merriam, 2009).

Second limitation was about the physical attributes of the class. The class conducting the study was small and inappropriate to group work. Researcher had difficulty to arrange the placements of groups to avoid possible interactions between groups. In addition, it was difficult to place cameras to suitable place in the class. Accordingly, cameras were big and narrowed the area that researcher walked around during the process. Researcher tried to eliminate this limitation as much as possible by arranging placement of groups and cameras in advance.

Time was the third limitation of the study. 2 lessons without break were separated for the each MEA. But, time was not enough to complete all steps of MEAs in time. For example, researcher wanted to add discussion part at the end of the MEA but, time did not permit. Researcher could not extend the time to 3 lessons so that other teacher had a lesson with participants. At this point, if a teacher wants to implement MEA at mathematics lesson, implementation time will be restricted with maximum 2 lessons without break (approximately 90 minutes). Time limitation may be eliminated or reduced with well-designed MEA implementation. 90 minutes will be enough for the implementation.

Researcher bias was the fourth limitation of the study. Like almost all qualitative research, in this study, data collection and data analysis based on researcher. Researcher took notes and made observations to determine the behaviors and difficulties of participants. In addition, researcher was active during analysis of data. Researcher spread on effort to be objective while taking notes, making observations, and interpreting the audio and video recordings. Furthermore, researcher position was a significant evidence to eliminate the researcher bias. Researcher position was explained in detail at quality of the study part above.

CHAPTER 4

FINDINGS

The aim of this study was to investigate 5th grade students' behaviors emerged during the Model Eliciting Activities (MEAs) and how students' behaviors change from the implementation of MEA-1 to MEA-3. This study also aimed to determine difficulties that 5th grade students encounter during the implementation of MEAs in the classroom. To obtain adequate and desired information, classroom video data, focus group audio data, written works of MEAs, and field notes were used as the main source of the data collection in this study. In this chapter, descriptive analysis of collected data will be disseminated in detail. The research questions of the study were as follows.

a) What are the behaviors of 5th grade students that emerge during the implementation of MEAs in the classroom?
b) What are the difficulties that 5th grade students encounter during the implementation of MEAs in the classroom?
c) To what extent do 5th grade students' behaviors in activities change from the implementation of MEA-1 to MEA-3 in the classroom?

At the end of the analysis process, findings were coded under three main categories as (i) *supportive behaviors, (ii) interfering behaviors, and (iii) difficulties* (Table 4.1). Additionally, these categories were divided into sub-categories with the help of data collected. Table 4.1 indicates codes emerged in the study under three main categories.

How these codes emerged was presented in the next section in detail with the evidences of classroom records and written works. Findings related to each category with sub-categories were presented starting from the MEA-1 with the logical flow of the instruction.

Table 4.1 Summary of the Codes

Main category	**Sub-category**	**Description**
Supportive behaviors	Generating solution together	Students listen to each other's ideas, make discussions, and decide together.
	Sharing the workload	After deciding the solution together, students share tasks which are necessary to be done during the model-eliciting process.
İnterfering behaviors	Need for approval	Students wait for approval from the teacher whether they are on the right track.
	Need for explanation	Students' requests for explanations were mainly regarding the two aspects of the activities, that were (i) process the implementation and (ii) the activity itself.
	Working alone	Students want to work alone instead of working in a group.
Difficulties	Understanding the issue	Students do not understand what is asked in the activity or students get the activity wrong.
	Time management	Students do not use time wisely and they are worried about not finishing the activity on time.

4.1 Supportive behaviors

Supportive behaviors were defined in this study as the behaviors which support the MEA process and help students to construct powerful and desired models. Supportive behaviors were grouped into two sub-categories: *(a) generating solution together* and *(b) sharing the workload.*

4.1.1. Generating solution together

During implementation process, one of the typical behaviors observed was about group work process. The researcher coded students' listening to each other's ideas, making discussions, and deciding together as *"generating solution together"* At MEA-1, the researcher asked students to create one common solution (model) together. However, a majority of students started to work alone. For example, when researcher was distributing the paper for solution, Beril said *"teacher, do we take one paper for each of us?"* Moreover, when students were in the modelling process, Defne said *"everybody creates their own rubric first, then we will prepare group's rubric later."* Such statements supported that students did not show "*generating solution together"* behavior at the beginning of the MEA-1. Moreover, students followed wrong solution path at one group member's request. They tried to group books given as examples in the MEA instead of producing solution ideas together. Therefore, at the beginning of the MEA-1, *"generating solution together"* behavior was not observed.

> Beril: Everybody can choose any category desired for their own rubric.
> Ece: No, everybody will put all categories for their own rubric.
> Beril: Teacher, do we prepare one rubric together or does everybody prepare their own rubric?
> T: One rubric for each group.
> Beril: Just one for each group? Ok.

This conversation above indicated that students tended to work alone instead of working in a group. Beril and Ece think that each group member prepares one rubric. After 10 minutes of solution process, students realized that they needed to create a model by working together with the help of the teacher (researcher in this study) directions during modelling process. After this conversation below, group work started.

> T: Do we agree girls? Rubric will be graded to these criteria. Books are not grouped according to types.

Beril: Girls, we must use these criteria. We do not choose from these example books. I am trying to say this. It is not necessary to group books according to types.
Group: Yes, you are right.

After this conversation above, students started to brainstorm to reach the solution. Each group member expressed their own opinion and they made discussions on shared opinions. They evaluated ideas and decided together which solution way to follow. After 15 minutes of modelling process, the conversations between group members can be given as an evidence to behavior *“generating solution together”* For example, the conversation below showed that students planned together about solution which they have followed.

Beril: Listen! We can divide rubric into 5 criteria given in the problem. And we will decide how many points each category is given.
Melike: Yes, Beril’s idea is fine.
Beril: Let’s divide table into 5 rows for each criterion (number of books, types of books, book level, length of books, quality of the summary) and 2 columns for criteria and points given.
Ece: We can add one more column for example books.
Defne: I think, we cannot. Because we will give points to criteria not example books. Yet, we can add one more column for explanation of each criterion.
Ece: Ok, you are right.
Beril: We distribute 100 total points to each criterion. We need to give more points to more important criterion according to us.

In this example, Beril presented a solution. Melike agreed to her idea. Ece and Defne suggested little changes on the solution. These suggestions were discussed between group members. While Defne’s suggestion was accepted, other group members refuted Ece’s suggestion. Hence, this conversation showed that they decided solution together. Additionally, students shared opinions while scoring each criterion. To illustrate, Beril asked to her friends *“do we give 30 points to “number of books” criterion?”* and Ece answered *“I think we give 70.”* Beril did not agree and said *“70 is too much since we distribute 100 to five criteria.”* Then, Defne suggested to give 40 points. All the group members accepted. The points given to each criterion were determined by group members discussing together as in this example.

Also, students convinced each other by presenting ideas and discussing. For example, Ece said that during preparing rubric together *"book level, let's give an example to it!"* Beril objected to this idea and explained why *"Look, stop! We shouldn't give examples to the books. Let's think like this. For example, what happens if a 6th grader reads an 8th grade level book? 6th grader should get more points."* Ece were convinced. Group members agreed on the idea and they continued the modelling process. Therefore, convincing each other also indicates that students generate solutions together. At the end of the MEA-1, students created a model which included all the group members' ideas. Although they were prone to make their own models by themselves at the beginning, they started to exchange ideas after 15 minutes of the modelling process. Then, group members generated the solution together in every step after 15 minutes of the modelling process.

At MEA-2, the researcher observed *"generating solution together"* behavior during the whole MEA-2 process. Different from MEA-1, students did not tend to work alone. Instead, they started to work together immediately. For instance, Defne presented her idea loudly to the group *"trucks must be on the corner, they make trouble."* This expression showed that students realized MEA activities are required creating solution together. Therefore, students started to share their own ideas immediately at the beginning of the MEA-2 to develop a model together. The conversation below showed that students listened to each other, thought about the shared idea, and decided together for every detail during the modelling process.

(Melike measured the vehicles' dimensions. Since it was somewhere in between 1,5-2, she was undecided about the width of the car and asked to group members.)

> Melike: What should the width of the car be? *(asking to group members while measuring it with ruler.)*
> Defne: We can say that the width of the car is 2 cm.
> Melike: No, it is 1,5 cm.
> Ece: Let's say 2 cm.
> Melike: But, I found 1,5 cm.

Ece: How do we calculate the 1,5 cm? No.
Defne: It can be calculated.
Ece: Actually, it can. Let's say 1,5 cm.

As seen, students also rounded other vehicles' dimensions by discussing together. This showed that students made decisions for even the smallest detail of the solution together.

Melike: One minute! Can you listen to me? Look! There are 4 types of vehicles and the width of the ground is 22,5 cm.
Ece: So, we will divide 22 to 4?
Melike: Divide 22,5 to 4?
Defne: Cars come more often than other vehicles.
Ece: From there to here will be separated for trucks. (she points the ground.)
Melike: This area is not enough for trucks.
Defne: I agree. Two trucks go hardly in this area. Besides, buses come more than trucks. We must determine more area for buses than trucks.
Ece: Here, this area is for cars.
Defne: You determined a small area for cars. But, cars come more often so we need a bigger area.
Ece: Then, do we separate the most area for cars?
Group: Yes, of course!
Melike: And, least area for trucks.

This conversation also showed that students determined the area for each vehicle by discussing together.

Given dialogues above showed that students decided together for almost every point about solution (location of each vehicle, rounding of measurement etc.). These conversations were an evidence that students showed *"generating solution together"* behavior at the beginning of the modelling process which is different from MEA-1. At MEA-2, not only at the beginning but also during every step of the process, students asked each other if everybody agreed with what they do or write. For example, Melike realized that Beril did not say anything during a discussion and she asked to Beril *"why aren't you talking? Say your opinion."* Students expressed opinions and objections about group solution more than MEA-1. There were continuous interactions between group members. Moreover, they did not hesitate to refuse or challenge any opinion they did not agree. For instance, when the group decided the place of the Jeep, Beril did not agree and said *"we do not give small place for Jeep. Even Jeeps come often, they will take more place."*

Students had a strong desire to generate solution together at MEA-2. Students made all decisions together during MEA-2. Moreover, they wanted to make last decisions together. Melike's *"let's make **our** last decisions!"* statement was one of the most powerful evidences to this finding. Furthermore, students used ***"we"*** instead of ***"I"*** while expressing their opinions. To illustrate, Beril asked *"how much place do **we** give for buses?"* or Defne said *"how do **we** arrange entrances and exits of buses?"* There were many other examples like *"do **we** do?, how do **we** put?,* or *what do **we** say?"* in which *"we"* were used.

"Generating solution together" behavior was also detected at the end of the modelling activity. The conversation about the price of each vehicle took place as follows.

> Beril: How much is the price of each vehicle?
> Defne: I guess all of them have the same price.
> Ece: No, I think that just trucks and buses are the same.
> Melike: Bus needs to be the most expensive since there are many people in it. Getting on and off can be problematic. Jeep is 7,5 TL and car is 5 TL.
> Defne: I think, it is fine.
> Ece: I think we must give the same price to bus and truck.
> Melike: But, there are more people in bus than truck.
> Ece: OK, you are right.

From the beginning to the end of the MEA-2, students expressed their ideas about solution, discussed them, decided together, and produced solution together. Therefore, a solution which was the product of group work came up. In the light of findings reported above, the researcher concluded that students showed *"generating solution together"* behavior during the entire MEA-2. The nature of MEAs required group work.

At MEA-3, *"generating solution together"* behavior increased distinctly. Students automatically started to work together without asking to teacher if they create their own solution or group solution. They had already known the MEA required group work. Therefore, they continued the process by thinking, listening each other and discussing. At MEA-3, researcher obtained various conversations that students shared opinions about solution and made discussion together on them. They decided each detail of the solution together. For example, Defne expressed her idea at the beginning of the process *"I think we draw a square first."* This showed that each student expressed their own idea without hesitation. In addition, they did not accept any idea immediately. They thought on it. And, if a student did not agree, she objected. To illustrate, the conversation between group members was an indication of this finding.

> Beril: I think, we will probably get more edges than 6 if we fold 3 times.
> Ece: But, number of folding does not affect the number of edges occurred.
> Beril: No, it does. Since edges increase when the paper is folded more.
> Ece: The number of edges won't change if you fold in half or quarter and cut. Just, the patterns of inside will be more detailed when folding in quarter than folding in half.
> Beril: What you said is wrong.

Beril and Ece did not agree on effect of number of folding. Each of them expressed their own idea and discussed. At the end, Beril was persuaded by Ece. Ece showed to Beril the effect of number of folding by folding and then cutting the paper. After everybody agreed on this idea, they started to discuss about how the snowflake in the nature must be.

> Beril: Girls, do you know why this snowflake does not exist in the nature? *(they are trying to decide how the snowflake in the nature must be.)*
> Group: Why?
> Beril: Because this has 8 edges. *(She points to the snowflake which was given at the MEA-3 as an example.)*
> Defne: Then, we will make a snowflake which has 6 edges. 6 edged-snowflakes exist in the nature. *(This information was given in the reading passage.)*
> Melike: Yes, absolutely! Since the problem asks us to create snowflake which exists in the nature.
> Beril: That's it! If the snowflake has 6 edges, it will exist in the nature.

This conversation indicated that they expressed their own ideas to other group members very well. This behavior – expressing their own ideas, discussing together, deciding together- became a habit at MEA-3. They learned that they need to act together at MEAs' implementation process. Students did not tend to work alone. Instead, they created every solution together. In addition, they overcame each difficulty together during MEA-3. To illustrate, this conversation below was an evidence of this finding.

> Beril: Our snowflake has 4 edges.
> Ece: How do we make 2 more edges?
> Defne: I think we should fold 6 times or 3 times.
> Melike: I think we should fold 3 times since we folded 2 times and we got a snowflake with 4 edges at previous one.
> Defne: Let's try. *(They took the paper and tried to fold 3 times.)*

Similar to MEA-2, students used "we" language instead of "I" language at MEA-3. Almost all sentences made by students at MEA-3 were plural form. For instance, Defne asked to friends while folding the paper *"from where do we fold?"* and Ece said *"we will fold 2 times to a get symmetric shape."* Moreover, researcher recorded many expressions like *"we found."*, *"we will write."*, *"do we open?"*, *"we will cut this now."* during the whole MEA-3. These conversations strongly indicated that students created every detail of the model together. Thus, this finding supported that students showed *"generating solution together"* behavior during all of the MEA-3 process.

To conclude, *"generating solution together"* behavior increased significantly from MEA-1 to MEA-3. Although students did not show *"generating solution together"* behavior at first, they started to share opinions and discuss after 15 minutes of the MEA-1 solution process. Unlike MEA-1, students did not tend to work alone at MEA-2 and MEA-3. On the contrary, students created every detail of the solution together.

4.1.2 Sharing the workload

Sharing the workload was the other supportive behavior which helped students to construct powerful models. Students' sharing tasks necessary to be done after deciding the solution together during MEA process were coded by the researcher as *"sharing the workload".* At MEA-1, Ece took the floor and directed the solution process at the beginning of MEA-1. Instead of sharing the workload, Ece wanted to do every task that group members decided to be done like creating rubric, writing letter, grouping books etc. Ece tried to do every task by herself during approximately 15 minutes of the solution process. Then, Defne objected to this situation and said *"let us help. this cannot be with one person."* Ece answered *"Yes, why don't you help me?"* This conversation between Defne and Ece indicated that group members were open to cooperate. After that, the researcher observed "sharing the workload" behavior. Conversation below was an evidence of this behavior.

> Defne: I think we need to do quickly. Everybody do something.
> Group: Yes, come on!
> Ece: How do we share tasks? For example, somebody scores the rubric.
> Melike: I can do.
> Ece: Somebody writes the letter.
> Beril: I can handle it.
> Ece: Ok. Defne is also good at scoring the rubric.
> Melike: Come on! We have 15 minutes left.

This conversation showed that students shared two tasks. Melike would have scored the rubric while Beril was writing the letter. Yet, although students shared the tasks as seen in the conversation above, they did not stick to the shared the workload. They continued to score the rubric together. These evidences showed that students shared tasks, but they could not plan the task sharing in an applicable and effective way. When students realized that they would not finish the model towards the end of the MEA-1 process, they split in half. While Beril and Ece were preparing the rubric, Melike and Defne started to write the letter. Yet, this sharing the workload stemmed from a necessity since they had to complete the model before the deadline. At MEA-1, there was not an effective *"sharing the workload"* behavior instead students tended to do every task together.

At MEA-2, researcher observed sharing the workload behavior during the solution process. For instance, Ece said *"why don't you measure the dimensions of each vehicle and tell me?"* Then, students shared the vehicles and each group member measured one vehicle's dimensions. This finding denoted that students shared measuring task to make the solution process faster. Melike finished to measure first, while Beril and Defne were still measuring and Ece was recording the results of measurements. Then, she said *"you continue to measure, I can start to write the letter."* Accordingly, this statement was the evidence that *"sharing the workload"* behavior still continued. After Melike, Beril finished to measure vehicle. Then, Beril helped Melike to write letter. In the meantime, Defne and Ece continued to measure the vehicle and the parking area together. After measuring the vehicles and the parking area, students discussed where each vehicle should be placed in the parking area together. This conversation below was recorded between students.

> Defne: Here, we can put trucks, here for cars and then here for Jeep.
> Beril: Ok, let's calculate the area which each vehicle covers.
> Ece: Then, I also write the letter about how we arrange the vehicles in the parking space.

This conversation indicated that students shared tasks – writing letter and calculate the parking space area for vehicles- after deciding where each vehicle is located. Like MEA-1, students divided tasks into two pieces as writing letter and implementing the solution that group members decided together. Then, students split in half and shared the two tasks. Different from *''sharing the workload''* behavior at MEA-1, students applied sharing the workload effectively. While Ece and Defne were working on the design of parking space, Beril and Melike were preparing the letter during the last 20 minute of the modelling process.

At MEA-3, students started to work by sharing tasks. Melike said *"why don't you try to draw snowflake which exists in the nature and I write why snowflake in the problem does not exist in the nature?"* Melike's expression showed that students knew what they do and shared tasks in advance. Yet, they did not agree upon how they shared tasks. For example, Melike suggested that Beril, Ece and Defne should draw snowflake, while Melike should write the letter. Differently, Ece suggested that Beril and Melike should write the letter while Ece and Defne should think how they did the snowflake. Yet, Melike objected to Ece. The conversation between them on this issue was as follows.

> Melike: I also want to draw snowflake.
> Ece: Ok. Then you and Melike draw the snowflake. Me and Defne write the letter.
> Defne: No, I will try to draw snowflake. Melike can write.
> Ece: Ok, ok. We will write the letter with Melike.
> Defne: One person can write the letter. Others should try to find snowflake. We run out of time.

This conversation showed that students wanted to share tasks but they could not decide who implemented which task. Although sharing the workload behavior was observed more than MEA-2, students had difficulty to decide who took which task. They decided almost 10 minutes later. Melike wrote the letter while three of them were trying to create snowflake which exists in nature. After they reached the solution, they made new task-sharing. They split in half this time. Accordingly, Defne and Beril were writing how they created their own snowflakes and directions for everybody who wants to create their snowflake, Ece and Melike made a clean copy of the letter.

As a result, students showed "*sharing the workload"* behavior at MEA 3 more frequently than MEA-1 and MEA-2. One student dominated the modelling process at the first 15 minutes of MEA-1. After 15 minutes, students shared tasks but they did not implement decided workload effectively at MEA-1. Unlike MEA-1, students made sharing the workload effectively at MEA-2 and MEA-3. Students generally shared tasks into two as writing letter and creating solution after they decided the solution together.

4.2 Interfering behaviors

Interfering behaviors were defined in this study as the behaviors that interfere the MEA process and prevent students to construct powerful and desired models. İnterfering behaviors were grouped under three sub-categories: *(a) need for approval, (b) need for explanation and (c) working alone.*

4.2.1 Need for Approval

One of the typical behavior was need for approval. The researcher coded students' waiting for approval from teacher whether they are on the right track during solution process as *"need for approval"*. At MEA-1, this behavior emerged too many times during the solution process. Students needed to obtain approval from researcher at each step of their solution so that they wanted to be sure they were on the right track. Moreover, students also told each decision they made to the teacher to get approval. Because, they thought that there was a unique solution and research knew it. Although researcher explained *"there were not a unique solution at MEA and each group needs to create their own specific, generalizable model."*, students tried to reach a specific solution that they believed to exist. The conversation below was taken from the beginning of the solution process.

> Ece: Teacher, we are doing like this. We write here the name of the book, and here we write how many point the books given. Do we need to do anything else?
> Teacher: But, in this way, you can score just these books. What if he reads another book which does not exist in the list?

The question in the conversation above *"do we need to do anything else?"* was a strong evidence that students needed approval from teacher at each step of their decisions about solution. After researcher's reaction in this dialogue, they realized they were on the wrong track so that students started to search for new solutions. At MEA-1, students also wanted to receive approval from the teacher insistently during the modelling process. Students asked *"are we doing right, teacher?"* every time teacher passes by them. For example, this conversation below was recorded when researcher was walking around the class.

(While she was passing by the focus group, Beril asked.)

> Beril: Are we going right, teacher? *(while pointing the solution on the paper.)*
> Teacher: there is not one unique solution. Every group will develop their own scoring rubric.

This conversation indicated that they continuously needed for approval from the researcher during the MEA-1. Students wanted to be sure that they were on the right solution track. Furthermore, students waited for approval when the researcher explained something asked by students. To illustrate, this conversation below could be given as an example of this finding.

(Students asked about criteria including the MEA. Teacher explained.)

> Teacher: People who participate the summer reading program will be scored according to these criteria. So, you should take these criteria into consideration while preparing scoring rubric.
> Ece: And then, is this right? *(by showing their solution)*

According to this conversation, students needed to get approval from teacher instead of deciding by themselves whether their solution was in accordance with teacher's explanations.

Before submitting the solution of MEA-1, students also asked to researcher whether their solution was right.

> Beril: Teacher, is our solution OK? Here we wrote the letter like this, here we wrote how to use the scoring rubric and here we wrote the scoring rubric.
> Ece: Is it correct, teacher?

This conversation strongly indicated that students needed for approval even at the end of the MEA-1. At MEA-1, students showed continuously *"need for approval"* behavior from the beginning to the end of the modelling process.

At MEA-2, need for approval behavior decreased. Unlike MEA-1, students did not need to get approval from the researcher at each step of the modelling process. Differently, students obtained approval just three times during the MEA-2. Students did not need for approval for each decision taken. Conversely, students showed need for approval behavior once at the beginning, middle and end of the MEA-2, respectively. At MEA-1, students asked whether they were on the right track at every time teacher passes by. Different from MEA-1, Beril asked just one time “how do we go, teacher?” by showing the solution to researcher while she was passing at MEA-2. Then, at the end of the process, students told how they developed parking model while submitting the solution to researcher. Researcher just said “Ok” and took the solution. This behavior also denoted that students wanted to get approval for being sure at the end of the MEA-2. Although this finding indicated that students showed need for approval behavior at the end of the modelling process, this behavior decreased at entire MEA-2 in contrast with MEA-1. For example, after discussing solution together and deciding the draft of the parking area, two students of the group wanted to get approval for solution from the researcher. The conversation about this was as follows.

> Beril: I think this draft looks nice.
> Group: Yes! *(everybody approved.)*
> Beril: shall we show the draft to teacher?
> Defne: No! Then, we will have to change the solution according to teacher’s direction.

This conversation indicated that while two students needed to get approval for the solution, other group members did not want to do it. Furthermore, this evidence also showed that need for approval behavior decreased.

At MEA-3, need for approval behavior dramatically changed. Although students needed to obtain approval from teacher during the entire MEA-1, they just requested approval from teacher only at the beginning to be sure they totally understood what the activity asked. Students just mentioned researcher how they came up with a solution path instead of getting approval. For example, students did not ask *“are we going on right way?”* instead, they used *“ we did like this ....”* expression to explain solution ways.

Although the researcher explained in detail what the activity asked, students waited for approval to be totally sure they understood well. To illustrate, this conversation below was an evidence of this finding.
(after readiness questions were answered and researcher explained twice the activity. One students asked to speak in the class before starting the process.)

> Ece: Teacher, you mean that we will write a letter why the Ali’s snowflake does not exist in the nature. Then, we developed a snowflake which exist in the nature and then we will write how we develop it step by step to letter. Right?
> Teacher. Yes, it will be totally like this.

This conversation indicated that students showed need for approval behavior at the beginning of the MEA-3. Students needed to get approval from the teacher before starting the activity to be sure instead of reading it from activity sheet having directions about what is asked in detail. But, after the beginning of the MEA-3, students did not show need for approval behavior at MEA-3.

Different from other two MEA, students communicated to the researcher to share their ideas and solution ways instead of getting approval. Accordingly, students just informed the researcher about their progress during the modelling process.

> Ece: First snowflake that we developed was not accurate.
> Teacher: Why?
> Ece: Because, it had 4 vertices. We thought like this teacher. When we fold two times, snowflake has 4 vertices. When we fold four time, it has 8 vertices. Maybe, if we fold three times, it will have 6 vertices. Now, we will try this.
> Teacher: Try it, then.

This conversation above indicated that students did not wait for approval. Instead, they shared own ideas with researcher just to inform her.

Need for approval behavior significantly decreased from MEA-1 to MEA-3. Yet, it did not completely disappear. At MEA-1, students showed need for approval behavior during the entire implementation process. Similar to MEA-1, although need for approval behavior decreased at MEA-2, students showed this behavior once at the beginning, middle and end of the MEA-2. At MEA-3, students waited for approval just at the beginning of the process to be sure that they totally understood the activity. After that, unlike MEA-1 and MEA-2, students did not show need for approval behavior at MEA-3. Instead, they preferred to inform researcher about their ideas and solutions during the implementation process of MEA-3.

4.2.2 Need for explanation

Other interfering behavior was need for explanation. When students waited for explanation from teacher about what they do and how they do during the modelling process, researcher coded them as *"need for explanation"* behavior. Students needed for explanation about process (e.g. questions about requirements of MEAs) and activity (e.g. questions for clarifying MEAs).

At the beginning of the MEA-1, students were not familiar with open-ended problems requiring inventing and testing models like MEAs. Therefore, they asked many questions to the researcher about both the process and the activity. Firstly, students wanted to be sure that they understood what was asked at the activity. At MEA-1, after readiness questions were answered, the researcher distributed problem situation to students and asked them to read silently. Then, one student read the problem loudly to the class. After that, students did not start to work on the model immediately. Instead, they waited for explanation about what was asked at MEA-1 from the researcher again in detail. After the researcher explained, students continued to ask questions about the activity instead of reading and trying to understand what was asked. Students asked even about the basic information written at the activity sheet clearly. To illustrate, one student asked *"how do we create the scoring rubric, teacher?"* or another said *"to* *whom do we write the letter?"* or another one asked *"what do we write to the letter?"* This indicated that students had low reading and understanding skills. They were unwilling to examine the problem situation. These findings verified that students intensively showed *"need for explanation"* behavior at the beginning of the MEA-1. Researcher had to explain questions asked about both the process and the activity too many times at MEA-1. Since they had difficulty to create generalizable solution, they tended to reach to a single solution. Accordingly, students asked insistently for explanation about this issue. For instance, the evidence of this finding was given in the below conversation.

> Beril: We didn't have to categorize the books according to varieties.
> Ece: Teacher, do we choose sample students? And then, do we score the books which they read?
> Teacher: Go ahead and read what the activity asks from you. You should be able to score every student participating the summer reading program with the scoring rubric.

This conversation showed that students tried to develop a scoring rubric for sample students instead of developing a model valid for every student. Since students had difficulty to develop generalizable model, they needed for explanation from researcher about how they could create a model applicable to every student.

At MEA-1, students asked for explanation from teacher about the conventional procedures of the solution and implementation of MEAs. For example, Ece asked *"do we prepare the rubric together?"*, "*do we write the letter as two pages?"* This also showed that students waited for explanation from researcher about what they do and how they do it. As a result, students showed *"need for explanation"* behavior during the entire MEA-1.

At MEA-2, students did not have difficulty to understand the activity and conventional procedure of MEAs solution path. Similar to MEA-1, after readiness questions were answered, the researcher distributed problem situation to students and asked them to read silently at MEA-2. Then, one student read the problem loudly to the class. But this time teacher asked a student to explain what the activity asked. And, two students added some explanation to fill the missing parts. After that, students started to work on modelling process without any further questions. This evidence clarified that students did not need for explanation for understanding the activity. At MEA-2, they totally understood what the activity asked. Accordingly, they did not need to get explanation from teacher during the activity. They knew what to do and how to do it. Unlike MEA-1, students did not show need for explanation behavior during the entire MEA-2.

At MEA-3, need for explanation behavior considerably decreased. But, it was not completely over. Especially, students needed to get explanation from the researcher about activity at the beginning of the MEA-3. Like MEA-1, students asked specific questions about MEA-3 for understanding like *"teacher, do we create a snowflake by using Ali's method or own method?"* Yet, similar to MEA-2, students did not need to get explanation about conventional procedure of MEAs such as *"how do we work, to whom do we write the letter, do we write the letter?"* This was a strong evidence to show that students internalized the conventional procedure of MEAs. Accordingly, they totally understand which steps they had to follow during the implementation process of MEAs. As a result, students showed need for explanation behavior at the beginning of MEA-3 for understanding the MEA-3 asked while they did not show need for explanation behavior about the process of MEA-3.

4.2.3 Working Alone

Another typical interfering behavior was working alone. When students wanted to work by themselves, the researcher coded them as *"working alone".* At MEA-1, even the researcher said that this activity required group work and all groups would prepare solution together, almost every student tried to create their own rubric. The below conversation between group members was an evidence of this findings.

Beril: Everybody can choose any category desired for their own rubric.
Ece: No, everybody will put all the categories for their own rubric.
Beril: Teacher, do we prepare one rubric together or does everybody prepare their own rubric?
T: One rubric for each group.
Beril: Just one for each group? Ok.

This conversation showed that Ece and Beril wanted to create their own rubrics instead of preparing a rubric together. Beril asked to teacher whether they prepare their own rubric or a group rubric at the conversation above. Although teacher explained that it was necessary to prepare one common rubric, Beril insisted to work individually. To illustrate, Beril said *"Firstly, everybody prepares their own rubric. Then, we will create a common rubric by using categories which everybody wants."* This sentence strongly indicated that Beril showed extensively *"working alone"* behavior. But, other students did not show *"working alone"* behavior after teacher's warning on group work. At MEA-2 and MEA-3, students did not show working alone behavior from the beginning to the end of the modelling process. Conversely, students developed model together by discussing and sharing ideas.

4.3 Difficulties

Difficulties were defined in this study as difficult situations that students need to overcome during MEA implementation process. Difficulties were grouped under two sub-categories: *(a) understanding the issue and (b) time management.*

4.3.1 Understanding the issue

One of the difficulties observed was understanding the issue during MEA process. When students did not understand what was asked at the activity or misunderstood the activity, researcher coded them as "understanding the issue". At MEA-1, students were asked to develop a fair rating system to award points to students participating in a summer reading program. Yet, students did not understand the activity at first although teacher explained what was asked in detail at the beginning. To illustrate, Defne said to group members *“I am indecisive. I do not understand what we will do.”* Then, other students did not say anything on it. Hence, this finding indicated that students were confused and did not understand what the activity asked.

> Ece: We will classify these (example books given at MEA) by varieties.
> Melike: How’s that!? *(she was confused.)*

This conversation showed that Ece misunderstood the activity. Students were asked to create a rating system including 5 criteria: the number of books, the variety of the books, the difficulty of the books, the lengths of the books, and the quality of the written reports. Instead, they started to make groups of example books according to their types like adventure, horror, drama etc. After 10 minutes, the teacher realized that they were on the wrong track while she was walking among the desks. She explained what the students were asked and asked them *“do you understand what is asked?”* Students said yes but they had followed the wrong path again. Researcher came again and saw their work were still inaccurate. The researcher said *“girls, would you like me to explain again?”.* They said *“yes teacher, we are totally lost.”* The researcher explained in more detail this time and asked trigger questions *“Think girls! Consider all the criteria but not just the variety of the books. For example, if a sixth grader and an eighth grader both read Sefiller, will they both earn the same number of points?”* Students thought and discussed about the researcher’s explanations.

> Beril: Girls, we must use these criteria. We do not choose from these example books. I am trying to say this. It is not necessary to group books according to types.
> Group: Yes, you are right.

This conversation above showed that students started to understand the activity. After approximately 20 minutes, they totally explored what the activity asked and how they could develop a solution. The conversation below was an evidence that students completely understood the activity.

> Beril: Listen! We can divide rubric into 5 criteria given in the problem. And we will decide how many points each category is given.
> Melike: Yes, Beril's idea is fine.
> Beril: Let's divide table into 5 rows for each criterion (number of books, types of books, book level, length of books, quality of the summary) and 2 columns for criteria and points given.
> Ece: We can add one more column for example books.
> Defne: I think, we cannot. Because we will give points to criteria not to example books. Yet, we can add one more column for explanation of each criterion.
> Ece: Ok, you are right.
> Beril: We distribute 100 total points to each criterion. We need to give more points to more important criterion according to us.

At MEA-1, students had difficulty to understand the activity. They misunderstood the activity at the beginning. After 20 minutes, students had already started to create model that the MEA asked.

At MEA-2, students completely understood what the activity asked. They did not use the expressions like *"I didn't understand.", "what will we do now?"* Moreover, there was not any misunderstood point or deviation from true path.

At MEA-3, students did not have difficulty to understand the activity. Students immediately started to work on the model after teacher presented the activity. To sum up, students did not understand what they did at the beginning of the MEA-1. Then, they got the activity wrong during the first 20 minutes of the MEA-1. After guidance of researcher, students barely understood the activity and started to create model. Unlike MEA-1, students did not have difficulty to understand what the activity asked at MEA-2 and MEA-3.

4.3.2 Time management

Other difficulty observed was time management during MEA process. When students did not use time wisely and they were worried about not finishing the MEA, the researcher coded them as *"time management"*. Students were given 90 minutes (1 block class) to finish their work. At MEA-1, students did not care about time at first. Then, they realized that they were proceeding slow. And they started to move fast. This situation prevented creative solutions ideas that they wanted to develop. Instead, students preferred to use the solution that they could develop faster. This conversation below was an evidence of findings mentioned above.

(Students were on the wrong track. They were divided books given as examples in the MEA-1 into types instead of preparing a rubric. And, they preferred to choose books whose summaries were short due to time issue.)

> Ece: Let's choose from short books *(short books meant to books whose summaries were shorter.)*
> Defne: Ok, for example, Sefiller.
> Ece: Yes, yes. Hurry, hurry up!

Students lost motivation since they thought they would not finish the activity on time. There were many dialogues between them that can be given as an example of this finding:

> Defne: Off.
> Ece: Don't do this Defne! You get us down. We go bad, anyway.
> Beril: We do not go bad. We have 20 minutes.

At this conversation, some students were worried about not developing rating system on time. Accordingly, this conversation showed that students could not manage the time given effectively.

Towards the end of the activity, concerns of students on not finishing the activity escalated. For example, around 20 minutes before time is up, Melike said *"Girls, I just want to say something. We need to write letter, too."* Ece replied Melike with question *"what will we do if we do not complete on time?"* This conversation also indicated that students could not use time given for the solution process wisely. Accordingly, improper time management resulted developing less powerful and desired models.

Because, students did not find enough time to finish the models entirely. To illustrate, this conversation was an evidence of this finding.

> Melike: Girls! We have 10 minutes left. I think we should write the letter now.
> Ece: The solution hasn't been finished yet but then, let's write the letter.

At MEA-1, there were various statements said by students that indicated that students had difficulty to manage time and did not use it wisely. To illustrate, expressions said by students like *"say quick!, let's write quickly!, faster, faster!, do not write the letter in detail, quick!"* were supports of this finding.

At MEA-2, students managed the time better than MEA-1. But, they still had difficulties related to limited time. To illustrate, students wanted to draw the parking area as a draft at the beginning. However, time limitation prevented them to do it. This conversation below was an evidence of this finding.

> Ece: This is our draft. If we measure each vehicle and places of them in detail at the draft, it will take time.
> Beril: Yes, there is also a letter that we need to write. Time will not be enough.
> Students could not draw parking space draft by measuring each vehicle in detail.

Instead, they created a draft superficially. Then, they started to develop the actual model. This showed that students did not feel free to try everything they desired while creating the model. Since, they were worried about time.

(After they created a parking area by parking vehicles straight. Beril suggested to try parking them at an angle.)

> Beril: Let's try to park vehicles at an angle after finishing to park them straight.
> Ece: We don't park them at an angle. We just park them straight. Straight parking will be easier.
> Melike: But we can fit more cars into a parking area by parking them at an angle.
> Ece: But we don't have enough time. Are you aware?
> Melike: We wrote the letter "parking area takes more vehicles at an angle".
> Ece: Let's change it as straight.
> Melike: But, parking space takes less cars by parking vehicles straight.
> Ece: Time is not enough to try parking them at an angle.

Group: Yes. *(they continued to create parking space by parking them straight.)*

This conversation indicated that students avoided trying different and innovative solutions due to time limitation. In this example, students did not create a parking space with vehicles at angle parking although they found that angle parking could take more vehicles than straight parking. Since they thought that calculations of vehicles at angle parking would be more difficult and take more time.

At MEA-2, even if students were better at time management than MEA-1, they could not do things they desired to do due to not having enough time. Like MEA-1, expressions showed their worries about time said by students as *"how much time do we have left?"*, *"the bell will ring, quick!"*

Compared to MEA-1 and MEA-2, students were less worried about time at MEA-3. Even though developing snowflake having 6 vertices took a long time, students expressed fewer worries about time during implementation process.

CHAPTER 5

DISCUSSIONS

In this chapter, findings presented in Chapter 4 will be discussed. Then, implications of the current study and recommendations for future studies will be given.

5.1 Discussion of Findings

This part is organized based on research questions. In other words, supportive behaviors, interfering behaviors, and difficulties will be discussed in the light of previous studies.

In general, this study showed that difficulties that students encountered dwindled when MEAs implemented over time. Furthermore, supportive behaviors increased while interfering behaviors decreased. Therefore, it can be concluded that multiple and sustained experience of MEA is vital for teachers who want to integrate MEAs into their own classroom. This overall finding is consistent with the study of Zawojewski, Lesh, and English (2003). They stated that sustained experience of MEAs increase satisfaction of students and teachers. In a classroom with students who are inexperienced in student-centered pedagogies, the first implementation of MEA is likely to be unstable in terms of students' behaviors. After multiple implementations, students start to learn and adopt to the MEAs routine. As a result, after multiple implementations, there will be a better learning atmosphere in terms of student behaviors and actions for MEA implementation.

5.1.1 Supportive behaviors

In the current study, supportive behaviors were described as behaviors that support the MEA process and help students to construct powerful and desired models. These behaviors emerged during the implementation of MEAs will be discussed in the light of findings explained in Chapter 4.

5.1.1.1 Generating solution together

"Generating solution together" behavior increased significantly from MEA-1 to MEA-3. At MEA-1, students did not show *"generating solution together"* behavior at first. Although teacher (researcher in this study) asked students to work together for developing one common model (solution), students worked alone during the first 15 minutes of the MEA-1. This might be due to the fact that students were not accustomed to group work. It was possible that students did not engage in activities that require group work in their classroom routine. Students showed *"generating solution together"* behavior after 15 minutes of the MEA-1 solution process. They started to share opinions and discuss. This might stem from teacher's directions. Since, when teacher realized that majority of students tended to work alone, she reminded them one common model must be developed by the group members together. Furthermore, teacher warned groups about this issue by walking around the groups. In fact, group work is commonly preferred pedagogical approach in MEAs. MEAs are complex and non-routine problems that require creating generalizable models by integrating, revising, or re-organizing students' initial mathematical interpretations (Lesh & Yoon, 2004). Therefore, MEAs are more convenient to group work because of these features. (Lesh, Cramer, Doerr, Post, & Zawojewski, 2003). Students could notice that reaching a solution (model) together is easier and more efficient than reaching a solution alone.

Unlike MEA-1, students did not tend to work alone at MEA-2 and MEA-3 and created every detail of the solution together in their groups. According to the study conducted by Eraslan and Kant (2015), students have various difficulties during MEAs process since they are not familiar with working together and participating in activities that require generating ideas together. This finding is partially consistent with current study. In the current study, although students did not prefer to work together at the beginning of MEA-1, "generating solution together" became a habit at MEA-2 and MEA-3. After repeated MEA implementations students learned that they need to act together during MEAs. It can be concluded that students might not prefer to work together at the first implementation of MEAs in the class due to learning experiences (Eraslan & Kant, 2015). However, after second and third MEA implementation, students started listening to each other's ideas, made discussions, and decided together while developing the model.

5.1.1.2 Sharing the workload

"Sharing the workload" behavior was emerged at MEA-3 more frequently than MEA-1 and MEA-2. This increase is partly due to the fact that students noticed that solution process of MEA is long, challenging and takes more time compared to ordinary problems that they solve in the math lessons. In other words, students realized that they would not finish the activity on time if they did not share the necessary workload.

To elaborate on this, at the first 15 minutes of MEA-1, Ece dominated the modelling process. She tried to do every task that groups decided together. After 15 minutes, other groups members objected to this. They wanted to help her. Then, students shared tasks. At this point, it can be concluded that teacher arranged groups properly. Other group members could object to Ece since they were not shy and introvert. Arranging groups according to characteristics of students is crucial for the classroom integration of MEAs (Zawojewski, Lesh, & English, 2003). For example, if teacher did not determine the groups properly considering personal characteristics of her students, the activities could have been dominated by one student. Parallel to this, Zawojewski, Lesh, and English (2003) stated that besides personal characteristics of students, teacher need to take various factors into consideration, namely, students who have different ways of thinking and different types of skills for the effective MEA implementation. After other group members' objection, students decided to share tasks but they were not effective enough in finishing the workload in MEA-1.

Although *"sharing the workload"* behavior was emerged at MEA-2 and MEA-3, students had difficulties in deciding who would take which task. This might result from the lack of students' experience in sharing their workload during a group work. They realized that they needed to share their work to finish the activity on time but they could not know how to share the workload, who distributes the workload, and how much workload each person gets. Therefore, students could not share the workload in an effective way.

5.1.2 Interfering Behaviors

In the current study, interfering behaviors were described as behaviors that interfere the MEA process and prevent students to construct powerful and desired models. These behaviors emerged during the implementation of MEAs will be discussed in the light of findings explained in Chapter 4.

5.1.2.1 Need for Approval

"Need for approval" behavior was significantly decreased from MEA-1 to MEA-3 although it did not completely disappear. At MEA-1, students needed to get approval from teacher about each decision they made during the entire implementation process. This finding is consistent with previous studies in the literature (Moore, Doerr, Glancy, & Ntow, 2015; Zawojewski, Lesh, & English, 2003). Moore, Doerr, Glancy, and Ntow (2015) implemented an MEA (Preserving Pelicans) to 6th grade students in the

classroom. They specified that students asked feedbacks and needed to get approval from teacher during the MEA. Parallel to this, Zawojewski, Lesh, and English (2003) stated that students ask questions to obtain approval like *"are we on the right track?"* or *"Is this what you want?",* especially in the first few MEA implementation. The reason for this might be that students thought that every mathematics problem has only one correct solution and they must find it to solve the problem. Accordingly, based on the previous experiences on mathematical problems, students could think that teacher is the only source that knows the correct answers. Therefore, students might persistently ask whether they were on the right track. In addition, it could be concluded that students were not familiar with mathematics problems that intensely entail reasoning, inquiry, and critical thinking skills in mathematics lessons like MEAs do. To improve these skills, it is necessary that the teacher turns the mathematical authority over to students while they were solving problems. In MEAs, well-designed activities and multiple implementation can achieve this goal. (Zawojewski, Lesh, & English, 2003). The current study supported this statement. *"Need for approval"* behavior dwindled with sustained implementation of MEAs. Students became the mathematical power in the MEAs at the end of the MEA-3.

At MEA-2, students showed need for approval behavior once at the beginning, middle and end of implementation process. Unlike MEA-1, they did not get approval for each decision taken. Firstly, this could be due to the fact that students came to realize that solution requires developing specific and generalizable model. Secondly, maybe, students gave up asking insistently for approval when they noticed that teacher did not respond and guide them.

At MEA-3, students showed *"need for approval"* behavior only at the beginning to ensure they totally understood what the activity asked. One important thing is the way they needed for approval was dramatically changed. Unlike the first two MEAs, students shared their ideas and solution ways instead of getting approval. The reason for this might be that students learn that not every mathematics problem has one correct answer. Conversely, some of them such as MEAs can be totally depend on students' thinking, reasoning, and creativity. Another reason might be that students totally understood the teacher's role as observer and facilitator during MEAs. To sum up, teacher's role should be the listener during MEAs when students come to get approval. Since this behavior emerged more in the first few MEA implementation, teachers had better stay physically away from the groups (Zawojewski, Lesh, & English, 2003). After sustained implementation, students get used to the role of teacher and the nature of MEAs.

5.1.2.2 Need for Explanation

Another finding was that during the implementation of MEAs, students requested explanations about the process of activity (e.g. questions about requirements of MEAs) and the activity itself (e.g. questions for clarifying MEAs). At MEA-1, students frequently showed *"need for explanation"* behaviors about both the process and the activity. At MEA-2, students did not ask any question about the activity and conventional procedure of MEAs. At MEA-3, although, *"need for explanation"* behavior significantly decreased, it was not completely over. Surprisingly, students had difficulty to understand the activity contrary to MEA-2. However, they did not need for explanation about the conventional procedure of MEAs. Parallel to these findings, Zawojewski, Lesh, and English (2003) stated during MEAs students often ask help from their teachers about evaluation of their answers or clarification of what they do. Yet, there is limited information about how these behaviors change with sustained implementation of MEAs.

At MEA-1, students asked even about the basic information written clearly at the activity sheet. This might stem from various reasons. Firstly, it is possible that students had low reading and understanding skills. Although the current study did not control reading-comprehension skills of students, we can argue that any limitation in such skills is a barrier for starting MEAs in the class. This could be a reason why they needed additional explanation to make sense out of the problem statement in MEA. Another reason may be that students might think that understanding the activity will be easy and reliable if the teacher summarizes the problem situation. In this way, they are eliminating the risk of going off track of the problem solution process. It is also possible that the problem statement was not be well structured for the participating students or the real-life context of the problem was unfamiliar to some of the students. We know from the literature that if the MEA does not have appropriate and clear problem statement for the target students, they will ask too many questions to teacher (Zawojewski, Lesh, & English, 2003). At MEA-1, students also waited for explanation about the conventional procedures of the solution and implementation of MEAs. Students usually asked questions like *"do we prepare the rubric together?"*, "*do we write the letter as two pages?"* to get explanation about what they do and how they do it. In fact, when considered this being students' first experience with MEA, this situation might be due to the fact that students were not familiar with the procedure of MEAs that are the open-ended problems requiring inventing and testing models. Hence, they needed to learn which steps they must follow during the solution process. At this point, they would have learned the process from instructions given by teacher and written in the activity.

At MEA-2, students did not have difficulty to understand the activity and conventional procedure of MEAs. This might result from various reasons. The first reason for this could be that context of the MEA was familiar to students. Students might associate easily the context with their own surrounding. In addition, problem statement could be well-structured and clear enough. Therefore, students totally understood without additional explanation what the MEA-2 asked. We can say that student did not have difficulty to follow necessary procedure of the MEAs during MEA-2 since they were familiar with the steps that they had to follow.

At MEA-3, although students did not have any difficulty to follow the conventional procedure of MEAs, they needed explanation about the activity itself. It could be concluded that students internalized the conventional procedure of MEAs. Accordingly, they totally understood which steps they had to follow during the implementation process of MEAs. However, the context of MEA-3 might be complex and unfamiliar to students. Therefore, they could ask additional questions to understand.

In the light of this information, teachers should give necessary importance to choose, modify or develop appropriate MEAs for their own students considering socio-cultural environment, characteristics, and grade level of them. Context of the implemented MEA is also significant since familiarity of students to context promotes the comprehensibility of the problem statement. Consequently, students need less explanation about the activity. Field tests, multiple implementation, and well-designed MEA enable students to understand well to the steps of the MEA implementation process (Zawojewski, Lesh, & English, 2003).

5.1.2.3 Working Alone

"Working alone" behavior emerged only at MEA-1. At MEA-2 and MEA-3, students did not tend to work alone. Instead, students developed model together by discussing and sharing ideas during the entire process. At MEA-1, even the teacher said that this activity required group work and all groups would create one common model together, almost every student tried to develop their own model alone. As I mentioned at *"generating solution together"* part, the reason of this could be that students did not have enough experience with activities requiring working together. They did not manage to cooperate. At MEA-1, students insistently sought a solution by themselves, although the teacher asked them to create models collaboratively in groups. This could stem from the common pedagogical approach in Turkish educational practices that rewards the individual success and creates competition among students through existing teaching methods, curriculum, and high-stakes exams. At MEA-2 and MEA-3, this behavior disappeared. Students might notice that teacher did not care about the

individual success for the solution of MEAs. Conversely, they could see that teacher prized the models that were developed together. As a result, students might internalize the idea of generating model together instead of the idea of reaching the best solution alone.

5.1.3 Difficulties

In the current study, difficulties were described as difficult situations that students need to overcome during MEA implementation process. These difficulties encountered during the implementation of MEAs will be discussed in light of the findings explained in Chapter 4.

5.1.3.1 Understanding the Issue

Students had difficulty to understand the activity in MEA-1. Different from MEA-1, students easily understood what the activity asked at MEA-2 and MEA-3. This finding is partially consistent with the studies conducted by Eraslan and Kant (2015) and Şahin and Eraslan (2016). In both studies, only one MEA was implemented to middle school students in the classroom environment. Similar to the current study, results showed that students had difficulty to understand the problem due to previous thinking habits and experiences at math lessons.

In this study, there might be two reasons that students had difficulty to understand the activity at MEA-1 while they easily understood the activity at MEA-2 and MEA-3. Firstly, it can be argued that students were not familiar with MEAs that are open-ended and require developing generalizable models at MEA-1. Secondly, MEA-1 were mathematically more complex than MEA-2 and MEA-3. Therefore, understanding the MEA-1 might be more challenging than other two. It could be concluded that starting with more complex MEA was not a wise choice. Students might get frustrated when the MEA was too complex and students did not know immediately what to do. To overcome this, teachers should choose MEAs which are appropriate to their students' grade level and backgrounds (Zawojewski, Lesh, & English, 2003). Furthermore, teachers had better to implement MEAs from the less complex to more complex.

5.1.3.2 Time Management

Students got better at time management from MEA-1 to MEA-3. After sustained MEA implementation, students developed experience with the requirements of MEAs such as writing letter to client, explaining steps of model development in this letter. With the experience they gained, they come to understand how long these processes take to prepare. Therefore, students started to use the given time more wisely. However, this study revealed that limited time for MEAs' classroom integration causes some problems; (i) preventing creative and different solution ideas, (ii) losing motivation, (iii) developing less powerful and desired models. If MEAs are integrated to mathematics curriculum, integration of MEAs should be limited under class hours, which are separated for mathematics lesson. Optimal duration for MEAs differs based on the complexity of the activity or the levels of the students. According to researcher experiences in the current study, teacher had better implement MEAs during two class hours without break (approx. 90 min).

5.2 Implications of the Study

The study has some implications for educational practices. Since integration of MEAs to school setting is a relatively new teaching trend, there are many implications that are necessary to be enlightened. Accordingly, in the light of findings of this study, teachers and curriculum developers will gain awareness about the students' behaviors and difficulties that emerge and how these behaviors and difficulties change with multiple implementation of MEAs in the class. In addition, these stakeholders will realize the importance of MEAs integration to school setting.

This study revealed that interfering behaviors and difficulties decreased, supportive behaviors increased after multiple implementations of MEAs. At this point, teachers who want to integrate MEAs into their own classroom should benefit from this finding. They mustn't give up when one implementation has failed. Conversely, teacher can see the progress when they continue to implement MEAs. For example, although *"generating solution together"* behaviors did not appear at first, students started to share opinions and discuss after 15 minutes of the MEA-1 solution process. This result is significant for teachers who want to integrate MEAs to their own classroom. Teachers should not give up if students do not generate one common model together at the first MEA implementation. They should continue to implement MEAs by directing students to work together in the class, as a result *''generating solution together''* behavior is likely to increase at each subsequent MEA implementation progressively.

This study showed that MEAs implemented to elementary classroom successfully and sustained implementation of them enabled that this implementation gets more effective and progressive. Therefore, thanks to this study, curriculum developers should realize that integration of MEAs into the mathematics lessons is feasible. They can give place to MEAs in the mathematics curriculum and textbooks by taking into consideration that MEAs increase working together, sharing, ability of problem solving, and time management.

In addition, this study provided mathematics teachers in Turkey three MEAs that were field tested, well-designed, and appropriate for elementary grade level. Lessons should be enriched with different MEAs that students create their own understanding by developing models for real life situations. Teachers can use MEAs presented in this study directly in their classrooms or modify them for their own students. By this way, students will not be limited with teachers' ordinary mathematics problems used in the class.

This study also presented some suggestions for teachers and curriculum developers on following steps which were necessary to implement effective MEAs in the classroom. These suggestions can be summarized as; (i) implementing multiple MEAs to see the progress, (ii) arranging groups considering personal characteristics of students, (iii) not directing students during MEAs, (iv) choosing appropriate MEA for target students up to socio-cultural environment, characteristics, and grade level, (v) starting MEA implementation from less complex one, and (vi) using two class hours without break to implement activity. In addition, students generally tried to share tasks into two as writing letter and creating solution after they decided the solution together. To make sharing the workload effective, teachers could ask groups to determine each group member's responsibility as writing letter or creating solution in advance. Teachers should take these into consideration while implementing MEAs in the class. Also, curriculum developers can benefit from these suggestions when they integrate MEAs into mathematics curriculum.

5.3 Recommendations for Further Studies

In the light of findings of the current study, some recommendation can be given for further studies. First of all, new studies should be conducted with different grade levels like pre-school, high school, and college to examine students' behaviors and difficulties during MEAs. In addition, this study was conducted in girls only class. In the literature, there are many studies that shows differences in female and male students in terms of behaviors in the school settings (Bugler, McGeown, & Clair-Thompson, 2015; Coates, 2013; Zhang, 2010). Girls and boys could behave differently since both girls and boys have their own rules for behaviors by reason of coming from different subcultures (Thomas, et al., 2004). Therefore, the study can be repeated in the mixed class to compare the results of studies. By this way, structures of MEA integration for mathematics lessons can be determined at each grade level and gender.

Secondly, there are not enough resources for teachers who want to integrate modeling into the class (Erbaş, et al., 2014). Therefore, further studies seem necessary on implementation of MEAs into the classroom. This provides teachers resources and information about effective implementation of MEAs. In addition, further research studies can be conducted to provide various MEAs that cover different mathematical content in the Turkish mathematics curriculum. Like MEAs projects of Purdue University, a website can be prepared including various MEAs to share these with Turkish teacher. Then, they can try these activities in their classrooms and share their opinions about implementations of the activities in the classrooms.

Thirdly, there are limited resources in the literature to examine different aspects of sustained MEAs implementation in the classroom. Further studies can focus more on how MEAs affect thoughts, opinions, and beliefs about mathematics during sustained implementations of them. In addition, it can be interesting to determine which social aspects and skills are developed with multiple implementation of MEA.

Lastly, a longitudinal study on students who participated in sustained MEAs to determine how these students' educational and career choices differ from the peers who did not experience with MEAs can be another strand of research in the future.

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APPENDICES

A: MODEL ELICITING ACTIVITIES

YAZ HEYECANI KÜTÜPHANEYİ SARDI

Yenimahalle İlçe Halk Kütüphanesi, her yaz tatilinde geleneksel olarak ''yaz okuma programı'' düzenliyor. Program, bu yıl ''Kitap, hayatı okumaktır!'' sloganıyla 15 Haziran'da başlıyor. Belediye Başkanı, kütüphanede düzenlenecek törende ortaokul öğrencilerine kitap okuyarak programı tanıtacak.

Program 1970lerde üç öğretmen tarafından başlatıldı. Bu sene 25.si düzenlenen programa bugüne kadar Yenimahalle'den birçok insan dahil oldu. Yaz okuma programı her yaştan öğrencinin katılımına açıktır.

Yenimahalle'de okuyan bütün öğrenciler yaz boyunca sürecek olan bu yarışmaya katılabilirler. Yenimahalle İlçe Halk Kütüphanesi'ne gidip kayıt olduklarında kişiye özel bir kütüphane kartı verilecek. Bu kartla program dahilinde kitap okumak için kütüphaneden kitap alabilecekler. Yarışmaya katılan her öğrenci onaylı kitap listesinden dilediği kitabı seçip okuyabilir. Listedeki kitaplar sınıf seviyesi, kitabın uzunluğu ve türüne göre sınıflandırılmıştır. Her öğrenci istediği seviyede, türde, uzunlukta kitabı seçebilir.

Programın 25. Yılı şerefine Yenimahalle Belediyesi birinci olan öğrenciye 1500 TL ödül verecek. Ayrıca her yaş kategorisinde dereceye giren öğrencilere de bilgisayar, bisiklet, tişört, kitap gibi hediyeler verilecek. Yenimahalle'deki her okul büyük ödülü kazanmak için yarışmaya dahil oluyor.

Yarışma 15 Haziran'da başlayıp 12 Ağustos'da sona erecek. Kalan zamanda da yarışma komitesi öğrencilerin okudukları kitapları belirleyecek. Komite, katılımcıların kazandıkları puanları hesaplayacak ve kazananı açıklayacak. Her öğrencinin toplam puanını hesaplayıp kazananı belirlemek çok zaman alıyor. Bu yüzden de önceki yıllarda kazanan en erken Eylül başında açıklanabildi. Bu durum maalesef son 4 yıldır yarışmaya katılımı ciddi bir oranda düşürdü. Komite, bu yıl kazananı daha çabuk belirleyip erken açıklamaya çalışacak.

Başlamaya hazırız! Yaz okuma programı için seçilen 250 kitap Yenimahalle İlçe Halk kütüphanesinin raflarında yerini aldı. Yarışmaya katılacak öğrenciler gelip onaylı kitap listesinden dilediği kitabı seçebilir.

ONAYLANMIŞ KİTAP LİSTESİNDEN ÖRNEKLER

BAŞLIK	YAZAR	SINIF SEVİYESİ	SAYFA SAYISI
Pollyanna	Eleanor H. Porter	4	64
Alice Harikalar Diyarında	Lewis Carrol	4	149
Nasrettin Hoca Hikayeleri	Orhan Veli	4	134
Dede Korkut Hikayeleri	Anonim	5	268
Ezop Masalları	Anonim	5	152
80 Günde Devr-i Âlem	Jules Verne	5	80
Çalıkuşu	Reşat Nuri Güntekin	6	117
Havaya Uçan At	Peyami Safa	6	256
Gammaz Yürek	Edgar Allan Poe	6	64
Küçük Prens	Antoine de Saint-Exupéry	6	112
Harry Potter ve Ateş Kadehi	J. K. Rowling	7	734
Küçük Kadınlar	Louisa Mae Alcott	7	388
Tom Sawyer	Mark Twain	7	208
Kayıp Aranıyor	Sait Faik Abasıyanık	7	125
Beyaz Zambaklar Ülkesi	Grigory Petrov	7	168
Şeker Portakalı	Jose Mauro De Vasconcelos	8	183
Büyük Umutlar	Charles Dickens	8	656
Yaban	Yakup Kadri Karaosmanoğlu	8	214
Kuyucaklı Yusuf	Sabahattin Ali	8	224
İki Şehrin Hikayesi	Charles Dickens	9	384
Momo	Michael Ende	9	184
Mor Salkımlı Ev	Halide Edip Adıvar	9	273
Mutlu Prens	Oscar Wilde	9	85
Don Kişot	M. Cervantes	10	940
Sefiller	Victor Hugo	10	512
Toprak Ana	Cengiz Aytmatov	10	138
Kuru Gürültü	William Shakespeare	10	75

BAŞLIK	KISA ÖZET
Pollyanna	Pollyanna Whittier, katı yapılı bir teyzesinin yanında yaşayan yetim bir kızdır. Pollyanna, aksi ve mutsuz teyzesiyle birlikte yaşarken babasından öğrendiği "Mutluluk oyunu" sayesinde zor günlerin üstesinden gelmiştir.
Alice Harikalar Diyarında	Her şey elindeki saate bakıp hızlı hızlı yürüyen tuhaf giyimli bir tavşanla başladı. Tavşanın peşine takılan Alice, bir anda kendini fizik kurallarının çok da geçerli olmadığı garip bir dünyada buldu. Yediği ya da içtiği her şey kızcağızı ya küçücük yapıyor ya da dev gibi büyütüyordu. Kendi gözyaşlarından oluşan kocaman bir denizde boğulmaktan güç bela kurtulup, komik bir çay partisine katılan Alice'i daha bir sürü acayip macera bekliyordu.
Nasrettin Hoca Hikayeleri	Orhan Veli'nin kaleminden Nasrettin Hoca hikayeleri
Dede Korkut Hikayeleri	12 tane Dede Korkut hikayesinden oluşur.
Ezop Masalları	10 farklı masaldan oluşan bu kitap insanı ve davranışlarını hayvanları kullanarak betimliyor.
80 Günde Devr-i Âlem	Phileas Fogg, kimsenin hakkında hiçbir şey bilmediği zengin ve kibar bir İngiliz beyefendisidir. Son derece düzenli bir hayat sürmesi, titiz ve dakik yaşayan biri olmasıyla ünlüdür. Bir gün, üyesi olduğu "Londra Bilim Kulübü"nde, gerçekleştirilmesi imkânsız gibi görünen bir konuda, servetini ortaya koyarak iddiaya girer: Dünyanın çevresini 80 günde dolaşacaktır, hem de önceden hiçbir ayarlama ve planlama yapmaksızın.
Çalıkuşu	İstanbul'dan ayrılıp Anadolu'da öğretmenlik yapmaya karar veren Feride'nin burada insanlarla yaşadığı sorunları anlatır.
Havaya Uçan At	Kitapta Binbir Gece Masalları'ndan alınmış 11 tane masal bulunmaktadır.
Gammaz Yürek	Öldürdüğü yaşlı adamın kalp atışlarını duymaya devam eden katil buna dayanamayarak kendini ele verir.
Küçük Prens	Gezegenindeki çiçeğiyle pek anlaşamadığı için biraz uzaklaşmaya karar veren, yolculuğu sırasında Dünya'ya da uğrayan Küçük Prens, Sahra Çölü'nde bir pilotla karşılaşır. İşte olan biteni de bu pilot anlatır bize.
Harry Potter ve Ateş Kadehi	Harry Potter dizisinin 4. Kitabı'nda Harry'nin başından geçenler anlatılmaya devam ediyor.
Küçük Kadınlar	Şanssız bir biçimde anne babalarını kaybeden ve başka kimseleri olmayan kız kardeşlerin hayata tutunma çabalarını anlatır.
Tom Sawyer	Tom'un aldığı cezalardan kurtulmak için herkesi şaşkına çevirecek zeka oyunlarını ve sonunda bunlardan nasıl kurtulduğu anlatılıyor.
Kayıp Aranıyor	Aydın ve kültürlü genç bir kızın mutluluk anlayışını sorguladığı yaşam öyküsünü anlatıyor.
Beyaz Zambaklar Ülkesi	Bir zamanlar yoksulluğun pençesinde bir bataklıklar ülkesi olan Finlandiya'nın bir avuç vatanseverin insanüstü ve destansı mücadelesiyle nasıl Beyaz Zambaklar Ülkesi'ne dönüştüğünün anlatılıyor.
Şeker Portakalı	Yaşamın beklenmedik değişimleri karşısında büyük sarsıntılar yaşayan küçük Zeze'nin başından geçenleri anlatır
Büyük Umutlar	Pip'in hayatı birdenbire nereden geldiğini bilmediği bir yardımla değişir ve bir beyefendiye dönüşür. Hızla sınıf atlayan genç adam bu konumunu çocukluk aşkı Estella'ya yeniden ulaşmak amacıyla kullanır.
Yaban	Kurtuluş Savaşı esnasında Anadolu köyünde, köylüleri, köyün durumunu, Milli Mücadeleye ilişkin tavırlarını bir aydının gözüyle anlatır.
Kuyucaklı Yusuf	Sahipsiz kalan küçük bir çocuğun bir aile tarafından evlatlık edinilmesi, bu çocuğun başından geçen dramatik olaylar anlatılmaktadır.

İki Şehrin Hikayesi	Fransız Devrimi sırasında Londra ve Paris'in yaşadığı açlık,sefalet, hüzün ve kederi tüm açıklığı ve acımasızlığı anlatılıyor.
Momo	İnsanların "vakit nakittir" diyerek, sürekli olarak çalışıp, birbirlerine ve doğadaki güzelliklere zaman ayırmadıkları ve süreç içerisinde nasıl birer makine parçası haline geldikleri akıcı bir tarzda anlatılmaktadır.
Mor Salkımlı Ev	Genç bir kızın küçüklüğünden evliliğine kadar Mor Salkımlı Ev'de yaşadıkları anlatılmaktadır.
Mutlu Prens	İçinde 5 farklı öykü vardır. Kitaba ismini veren Mutlu Prens öyküsü ise şehrin ortasında yüksek bir yerde duran yakut gözlere sahip bir heykeli anlatmaktadır.
Don Kişot	Şövalyeliği, alaylı bir dille eleştiren bir romandır. Don Kişot Dünyayı hayallerine göre kurar; yatıp kalktığı hanlar onun için birer şato, hancılar oraların hakîmi yani derebeyi, oralarda çalışan hizmetçiler prensestirler. Karşılaştıkları olaylara da hayallerinde yer bulur.
Sefiller	Valjean adlı bir köylünün ailesinin karnını doyurmak için çaldığı ekmek sonucu mahkum edildiği kadırgada başından geçenler anlatılmaktadır.
Toprak Ana	İkinci Dünya Savaşı sırasında savaşta üç oğlunu, kocasını ve gelinini kaybeden bir kadının toprakla yaptığı söyleşi anlatılıyor.
Kuru Gürültü	İki genç aşığın, Claudio'yla Hera'nun imkansız aşkını anlatan Shakespeare komedisi

Okuma-Anlama Soruları

Parçayı ve tabloları okuduktan sonra aşağıdaki soruları cevaplayalım.

1. Yarışma programı ne zaman olacak?
2. İlçedeki öğrenciler yarışmaya neden katılıyorlar?
3. Bu yılki yarışmayı öncekilerden farklı kılan nedir?
4. Komite birinciyi nasıl belirleyecektir?
5. Yarışma sonuçları neden geç açıklanıyor?
6. Bir öğrenci **Gammaz Yürek** ve **Havaya Uçan At** için aynı puanı almalı mıdır? Neden?
7. 6. ve 8. Sınıftan iki öğrenci **İki Şehrin Hikayesi**'ni okuduğunda aynı puanı almalı mıdır? Neden?
8. Eğer öğrenci **Büyük Umutlar** ve **Kuru Gürültü**'yü okursa, ikisi için de aynı puanı almalı mıdır? Neden?
9. Elif **Gammaz Yürek** ve **Havaya Uçan At**'ı okudu. Elif her iki kitaptan da aynı puanı almalı mıdır? Neden?
10. Eğer Gülay **Büyük Umutlar** ve **Kuru Gürültü**'yü okursa, her iki kitap için de aynı puanı almalı mıdır?
11. Ömer **Kayıp Aranıyor** ve **Tom Sawyer**'ı okudu. Ömer her iki kitap için de aynı puanı almalı mıdır?

Yaz Okuma Programı

Tevfik İleri İmam Hatip Ortaokulu 5-L sınıfı öğrencileri ''Kitap, hayatı okumaktır!'' isimli kitap okuma yarışmasına katılmaya karar verdi. Yarışmayı kazanmak için en yüksek puana ulaşmak gerekiyor. Puan toplamak için 5-E sınıfı öğrencileri listedeki onaylanmış kitaplardan okumalı ve okudukları her kitap hakkında özet hazırlamalılar. Her sınıf seviyesinde en çok puan toplayan öğrenci birinci seçilecektir. Ve her sınıfın birincileri arasında en çok puana sahip olan öğrenci yarışmanın da birincisi olacaktır. Onaylanmış kitap listesi örneğini yukarıda bulabilirsiniz.

Yarışmaya katılan öğrenciler bütün yaz boyunca genellikle 10-20 arası kitap okumaktadırlar. Yarışma komitesi öğrencilere okudukları kitaplara göre puan verecektir. Komite puanlamanın adil ve en doğru yolunu bulmak istiyor. Komite, öğrencinin toplam puanını hesaplarken aşağıdaki 5 ana başlığı dikkate alıyor.

Öğrencinin okuduğu;

- kitap sayısı
- kitapların çeşitliliği
- kitabın zorluk düzeyi
- kitabın uzunluğu
- her kitap için hazırladığı özetin kalitesi

Not: Öğrenci tarafından hazırlanan kitap özetleri 100lük sisteme göre puanlandırılacaktır.

Sıra Sende…

Senin görevin yukarıdaki 5 ana başlığa göre öğrenciyi puanlayan bir çizelge hazırlamak. Bu çizelge, yarışma komitesinin yarışmaya katılan her öğrenciyi doğru ve hızlı bir şekilde puanlamasına olanak sağlamalıdır. Komite, eski puanlama sisteminin yerine geçecek yeni bir puanlama çizelgesi bulacağına inanıyor.

Puanlama çizelgeni hazırla.

Komiteye çizelgeni nasıl hazırladığını adım adım anlatan bir mektup yaz.

Komiteye puanlama çizelgeni nasıl kullanacaklarını anlatmayı unutma. Eğer puanlama çizelgeni beğenirlerse yarışmanın birincisini belirlerken senin hazırladığın çizelgeyi kullanacaklardır ☺

PARK YERİ PROBLEMİ

Yenimahalle Belediyesi futbol takımının taraftarları, takımlarının kendi sahalarında oynacakları ilk maça geciktiler. Çünkü yeni açılan Yenimahalle Stadının park yeri ilk maç için gelen binlerce taraftara yetecek büyüklükte değildi.

Yenimahalle Belediye Başkanı '' Yenimahalle'de oturan birçok taraftarın takımını desteklemeye geleceğini tahmin ettik. Ancak bu kadar yoğun bir talep olacağını düşünmemiştik. Bu yüzden park yerlerinin yetersiz kalacağını hesaba katamadık.'' diye konuştu.

Park etmek için gelen birçok araç stadyumdaki park yeri görevliler tarafından '' Eğer maç sonrası trafikte sıkışmak istemiyorsanız buraya park etmek yerine çevredeki diğer park yerlerine park etmeyi deneyin.'' diyerek uyarıldı. Park yerleri çabucak doldu. Maç sonrası aynı anda evlerine dönmek isteyen binlerce taraftar yaşanan yoğunluktan dolayı park yerinde sıkıştı. Bulunduğu yerden çıkamadı.

Bu esnada Yenimahalle'deki birçok öğrenci gibi Tevfik İleri İmam Hatip Ortaokulu 5. Sınıf öğrencisi Ayşe'de takımını desteklemeye stadyuma yürüyordu. Yaşanan park yeri problemini gördüğünde aklına bir fikir geldi. Ayşe stadyuma çok yakın oturuyordu ve evlerinin önünde dedesine ait büyük bir arazi vardı. Bu araziyi park yeri olarak kiralamak iyi bir fikir olabilirdi. Ayşe önce dedesinden izin aldı. Sonra arazinin, saati 5 TL'ye park yeri

olarak kiralandığını gösteren tabelayı araziye astı.

Bu haftaki maç öncesi en azından 40 tane araba, kamyon, otobüs ve Jeep arazilerine park etmişti. Ayşe bile bu kadar talep göreceğini tahmin etmemişti. '' Eğer daha fazla park yeri olsa daha fazla araç park edebilir, daha fazla para kazanabilirdik.'' diye düşündü.

Ayşe'nin fikri çok iyiydi. Ancak arazi park yerine uygun olarak daha planlı bir şekilde düzenlenmeliydi. Ayşe hangi tip aracın nereye park edeceğini gösteren park yeri planı oluşturmaya karar verdi. Planda her aracın etrafında maç sonunda rahatça çıkabilecek şekilde yeterli alan olmasına özen gösterdi. Bu sayede her araç için gerekli alanı ayırıp mümkün olduğunca çok aracın park etmesini sağlayacaktı. Ve farklı tip araçlara farklı fiyat tarifeleri koydu çünkü her araç arazide aynı boyutta yer kaplamıyordu. Örneğin, kamyonlar çok yer kaplarken arabalar onlara kıyasla daha az yere ihtiyaç duyuyordu.

OKUMA-ANLAMA SORULARI

1. Geçen haftaki maçta neden park yerinin alamayacağı kadar çok araba vardı?

2. Daha önce park yeri problemi yaşadığınz bir etkinliğe (maç, konser vb.) gittiniz mi? Park yeri bulamayınca nasıl hissettiniz?

3. Neden Ayşe evlerinin önündeki boş araziyi kiralamadan önce dedesini aradı?

4. Sizce park yeri ücretinin saatlik 5 TL olması uygun mu? Neden?

5. Siz olsanız nasıl fiyatlandırırdınız? Farklı türdeki araçlar için farklı fiyatlar verir miydiniz? Araçtaki kişi başına farklı fiyatlandırma uygular mıydınız? Açıklayınız.

6. Neden Ayşe'nin park yeri taslağı oluştururken farklı türdeki araçların olacağını düşünmesi gerekti?

7. Sizce hangi durumlarda daha fazla araç park edebilir? Araçlar düz park ederlerse mi açılı park ederlerse mi?

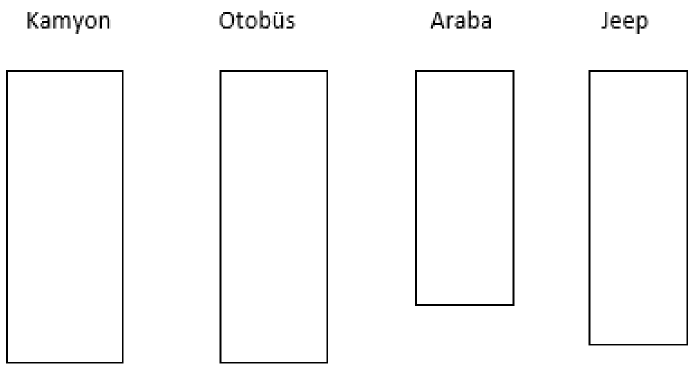
Geçen hafta Yenimahalle Belediyespor'la maça çıkan Sakarya Belediyespor'un taraftarı olan Kerem maçta yaşanan park yeri problemini ve Ayşe'nin aklına gelen fikri gazetelerden okudu. Kerem'de Sakarya'da oynanacak maç günlerinde kendi evlerinin önündeki araziyi park yeri olarak kiralamak istiyor. Ancak dikdörtgen şeklindeki arazisini mümkün olduğunca çok araba park edecek şekilde nasıl düzenlemesi gerektiğini bilmiyor.

Kerem, arazilerine mümkün olduğunca çok araba park etmesini ve aynı zamanda bütün araçların diğerlerini rahatsız etmeden diledikleri zaman çıkabilmelerini istiyor. Ayrıca, her araç için insanların araç kapılarını rahatça açıp dışarı güvenli bir şekilde çıkmaları için de yeterli alan ayrılmış olmalıdır. Kerem'in park yeri planı yaparken farklı tip ve boyuttaki araçları da hesaba katması gerekiyor. Bunun için de park yerine park edebileceğini düşündüğü dört farklı tipte aracın boyutlarını ölçüyor. Kerem'in arazisinin ve ölçtüğü araçların (araba, kamyon, otobüs ve Jeep) boyutları size aşağıda aynı oranda küçültülerek verilmiştir.

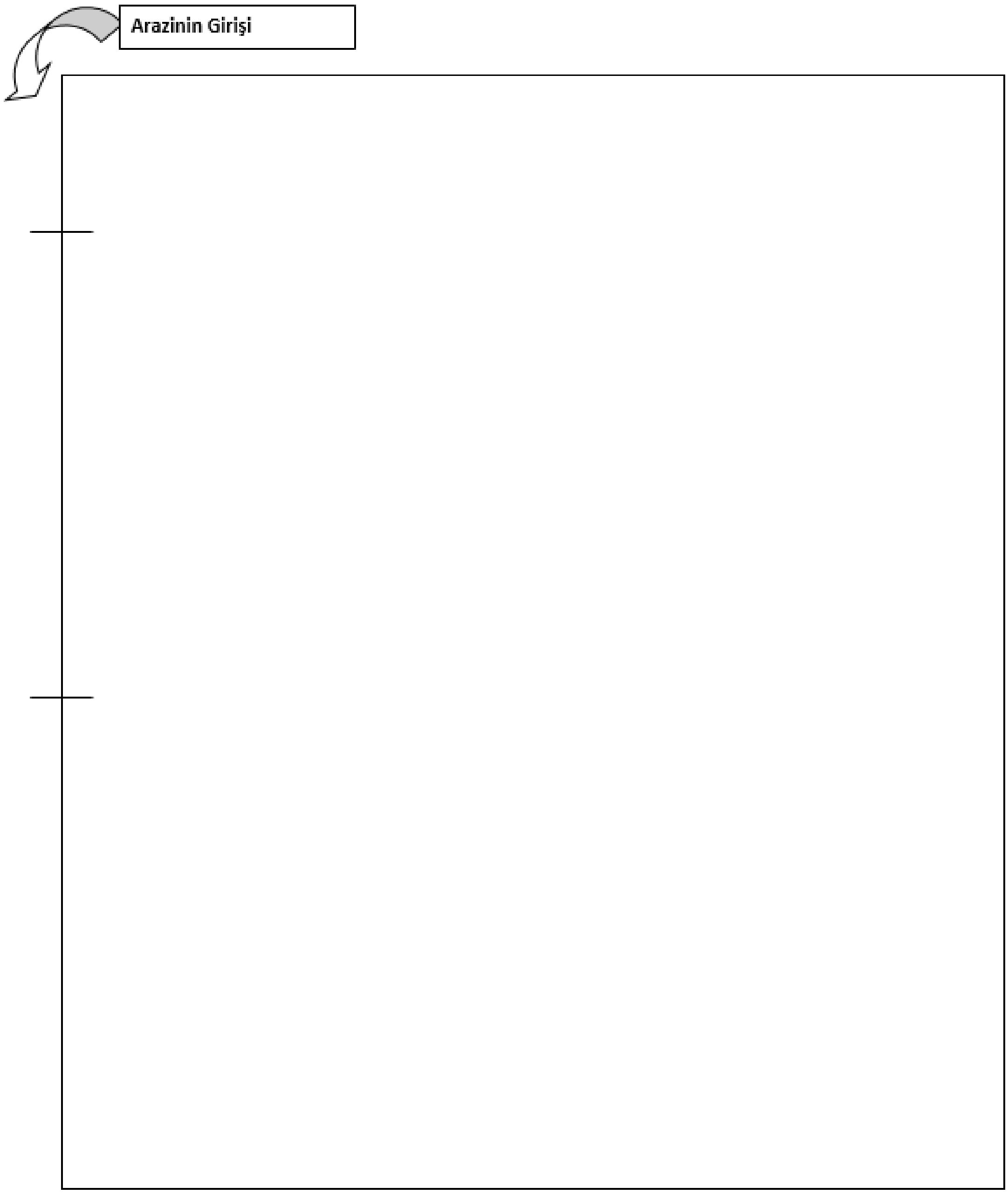
Kerem arazisini park yeri olarak tasarlarken sizden yardım istiyor. Kerem'in isteklerini göz önünde bulundurarak onun için bir park yeri tasarlayabilir misiniz?

Tasarımınızı bitirdiğinizde, Kerem'e araziye kaç arabayı nasıl sığdırdığınızı bir mektup yazarak ayrıntılı olarak anlatmalısınız. Kerem'in arkadaşlarından bazıları da arazilerini park yerine dönüştürmeyi düşünüyor. Bu yüzden hazırladığınız park yeri tasarımınızı bütün ayrıntılarıyla anlatmalısınız. Böylece Kerem'in arkadaşları da kullanabilsin.

4 TİP ARAÇ TASLAĞI



Kerem'in Arazisi



HAYDİ, KAR YAĞSIN!

Ankara'da bir ortaokulun öğrencileri karın yağmasını dört gözle bekliyorlardı. Okullar tatil olsun diye değil, kar tanelerini ilk fotoğraflayan ünlü Amerikalı fotoğrafçı Wilson A. Bentley gibi kar tanelerini fotoğraflamak için.

Öğrenciler kar tanelerini, kar tanelerinin nasıl oluştuğunu, aynı zamanda iki kar tanesinin nasıl olup da hiçbir zaman birbirine benzemediğini araştırıyordu. Bir kar tanesinin hiçbir zaman diğerinin aynısı olmadığı gerçeği öğrencilere imkânsız bir olay gibi gözüküyordu. Ünlü Amerikalı fotoğrafçı Bentley bu gerçeği bulan ilk kişidir.

Bentley, 5000'den fazla kar tanesi fotoğrafı üzerinde çalışıp hiçbir zaman bir kar tanesinin diğerinin aynısı olmadığını kanıtlamıştır. 14 yaşında okula başlayan ve Vermontlu bir çiftçi olan Bentley, ilk kar tanesinin fotoğrafını 15 Ocak 1885'de çekmiştir. 1931 yılına kadar kar tanelerini fotoğraflamaya devam etmiştir.

Bentley'nin annesi Fen Bilgisi öğretmenidir. Öğretmenlik yaptığı yıllarda okulunda kullanmış olduğu küçük bir mikroskobu oğluna hediye etmiştir. 1880'den 1882'ye kadar Bentley kış günlerinin çoğunu çiftlik evlerinin arkasında bulunan, soğuk bir odada, bahçeden topladığı buz kristallerini annesinin hediye ettiği mikroskobuyla inceleyerek geçirmiştir.

Kar kristallerinin karmaşık yapısını ve güzelliğini elinde tutabilmek amacıyla resimlerini çizmiştir. Daha sonra babası Bentley'e fotoğraf çekebilen bir mikroskop almıştır. Resimlerini elle çizmek yerine fotoğraflarını çekmeye başlamıştır.

Bir yıl süren deneme sürecinin ardından 15 Ocak 1885 yılında o zamana kadar mikroskop vasıtasıyla çekilen ilk buz kristali fotoğrafını elde etmiştir. Bu olayı hayatının en güzel anlarından birisi olarak hatırlamaktadır.

Bentley, detaylı meteorolojik kayıtları tutmuştur. Kristallerin şekillerinin ve büyüklüklerinin fırtınadan fırtınaya niçin değiştiği üzerinde yoğun bir şekilde çalışmıştır. Buz kristallerinin farklı şekilleri olabileceğini gözlemlemiştir. Bu kristallerinden oluşan kar tanelerinin ise şekillerinin daima simetrik olduğunu ve hiçbir zaman birbirine tıpatıp benzeyen iki kar tanesi olmadığını keşfetmiştir.

Bu haftaki derste fen bilgisi öğretmeni 5-E sınıfına karın oluşumunu anlatmıştır. Bulutun sıcaklığı 0 veya daha altında olduğunda bulutlar nemi toplar ve buz kristalleri oluşur. Su buharı yoğunlaştıkça toz parçacıklarının üzerinde buz kristalleri oluşur ve kısmen eriyen kristaller kar tanelerini oluşturmak için birbirine yapışır.

Ortaokul 7. Sınıf öğrencisi Ali Yılmaz Bentley'in çalışmalarından oldukça etkilenir ve kendi çalışmasını ortaya koymaya çalışır. Hava Bentley'in çalışmasını sürdürdüğü kadar soğuk değildir. Eriyebileceği için kar taneleriyle çalışmak zor olacaktır. Bu yüzden Ali çalışması için kâğıttan yapılan kar tanelerini kullanır.

EN SOĞUK KAR TANESİ!

Temel olarak kar kristallerinin 6 farklı şekli vardır: iğne, sütun, tabaka, alt ve üst kısmı tabaka ile örtülü sütun, yıldız ve çapa şeklinde olanlar. Kar kristallerinin şekli oluşumları esnasında havadaki nem ve sıcaklığa göre değişir. Bu yüzden hava çok soğuk (sıcaklık sıfırın altında) ve kar yağıyorken kar taneleri küçüktür. Hava sıcaklığı 0 derece ve üzerinde ise kar taneleri büyüktür. Sıcaklık düştükçe kar kristallerinin uç kısımları sivrileşir. Daha yüksek sıcaklıklarda buz kristalleri yavaş ve daha düz bir şekilde oluşur. Böylece daha az karmaşık şekiller alırlar.

- Kar taneleri, bir kar kristalinin çoğalarak bir araya gelmesiyle oluşur.
- Kristallerin çeşitli yüzeylerindeki yansımalardan dolayı kar taneleri beyaz gözükür.
- Kar tanelerinin 6 kenarı ve 6 ucu vardır.
- Buz kristallerinin 6 kenarlı olması su moleküllerinin şekillerinden kaynaklanır.
- Çoğu yatay, dikey ya da hem yatay hem dikey olacak şekilde simetriktir.
- Bir kar tanesi hiçbir zaman diğerinin aynısı olmaz.
- Sadece çok farklı iklim koşullarından oluşan buz kristallerinde asimetrik şekiller gözlemlenebilir.

Ali'nin Yöntemi

1. Kâğıdı dışındaki kare boyunca kes.
2. **FOLD 1** yazan doğru boyunca ikiye katla.
   Not: Grili ve beyazlı üçgen şeklinin (taralı üçgen) her katlayış sonrası görünen kısımda kalmasına dikkat et.
3. **FOLD 2** yazan doğru boyunca ikiye katla.
4. **FOLD 3** yazan doğru boyunca ikiye katla.
5. Gri kısımları keserek çıkart. Sadece iç kısımdaki beyaz bölge kalsın.
6. Dikkatlice kat yerlerinden kâğıdı aç.

OKUMA ANLAMA SORULARI

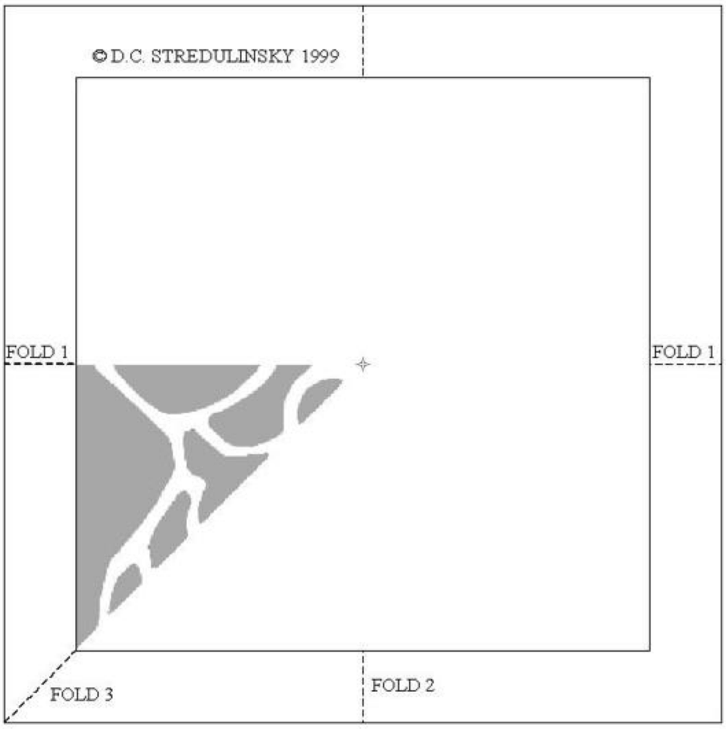
1. Wilson A. Bentley kimdir?

2. Kar taneleri nasıl oluşur?

3. Doğada kaç çeşit kar kristali bulunur?

4. Bütün kar taneleri simetrik midir?

5. Her bir kar tanesi kaç kenara sahiptir?



http://www3.ns.sympatico.ca/dstredulinsky/home.html

KENDİ KAR TANENİ NASIL YAPARSIN!

Ali'nin kar tanesi oluşturma yöntemini kullanarak Ali'nin kar tanesinden oluştur.

Ali'ye bir mektup yaz. Mektubunda Ali'nin kar tanesi neden doğada bulunmuyor açıkla. Kâğıdı katlayıp keserek doğada bulunan bir kar tanesini sen oluştur. Ali'ye kendi kar taneni nasıl oluşturduğunu detaylıca mektubunda anlat.

Ali'ye senin yöntemini kullanarak kar tanesi oluşturabilmesi için talimatları adım adım yaz yaz.

Yazdığın talimatların sonucunda oluşan kar tanesinin doğada bulunuyor olmasına dikkat et.

B: PERMISSION OBTAINED FROM METU APPLIED ETHICS RESEARCH CENTER

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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09 KASIM 2016

Konu: Değerlendirme Sonucu

Gönderilen: Prof.Dr. Erdinç ÇAKIROĞLU,

İlköğretim Anabilim Dalı

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın, Prof.Dr. Erdinç ÇAKIROĞLU;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Elif DEDEBAŞ'ın "Model Oluşturma Etkinliklerinin Matematik Öğretiminde Kullanılması ve Model Oluşturma Etkinliklerinin 5. Sınıf Öğrencilerinin Matematiksel Yaratıcılıklarının Geliştirilmesine Katkısı: Bir Öğretim Deneyi" başlıklı araştırması İnsan Araştırmaları Kurulu tarafından uygun görülerek gerekli onay **2016-EGT-149** protokol numarası ile **14.11.2016-28.02.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER

İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Mehmet UTKU
İAEK Üyesi

Prof. Dr. Ayhan SOL
İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR
İAEK Üyesi

Doç. Dr. Yaşar KONDAKÇI
İAEK Üyesi

Yrd. Doç. Dr. Pınar KAYGAN
İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK
İAEK Üyesi

C: TURKISH SUMMARY/TÜRKÇE ÖZET

5.SINIF ÖĞRENCİLERİNİN MODEL OLUŞTURMA ETKİNLİKLERİNİN ÇOKLU UYGULAMALARI ESNASINDA ORTAYA ÇIKAN DAVRANIŞLARININ VE GÜÇLÜKLERİNİN İNCELENMESİ

GİRİŞ

Son yıllarda matematik öğretiminde yeni metotlara ihtiyaç duyulmaktadır (Gilat & Amit, 2013). Bunun nedeni var olan uygulamaların öğrencileri STEM olarak da bilinen Bilim, Teknoloji, Mühendislik ve Matematik alanlarında yeterince iyi yetiştirememesidir (Bulgar, 2008). Bu noktada, ülkelerin öğrencilerin yeteneklerini STEM alanlarında geliştirecek yenilikçi STEM yaklaşımlarına ihtiyaçları vardır. STEM eğitimleri temel olarak 4 STEM alanının müfredata entegresine dayanmaktadır (Corlu, Capraro, & Capraro, 2014). OECD (2008) matematik müfredatının bilim ve teknoloji alanındaki yenilikçi ve yaratıcı uygulamalarını yansıtacak şekilde yeniden düzenlenmesi gerektiğini belirtmiştir. Bu amacı gerçekleştirmek için, matematik müfredatı yaratıcılık, problem çözme, analitik düşünme gibi temel becerileri geliştirecek etkili eğitim yaklaşımlarına göre şekillendirilmelidir (Gilat & Amit, 2013).

Model ve Modelleme yaklaşımı (MMY) temeli yapılandırmacı yaklaşıma dayanan etkili bir eğitim yaklaşımıdır. Bu yaklaşımda öğrenciler, kendi kavramsal sistemlerini kullanarak gerçek yaşam durumlarını anlamlandırmaktadır. Bu çerçevede, matematiksel modelleme, öğrencinin gerçek yaşam durumlarını değerlendirmek ve tanımlamak için genellenebilir ve paylaşılabilir bir model oluşturma süreci olarak tanımlanmaktadır (Kertil & Gürel, 2016; Lesh & Doerr, 2003). Matematiksel modelleme öğrencilerin analitik düşünme ve problem çözme becerilerini geliştirdiği için modelleme uygulamaları okul matematiği için en uygun yenilikçi öğretim yaklaşımlarından biridir (MoNE, 2013; NCTM, 2000).

Model Oluşturma etkinlikleri (MOE), MMY çerçevesinde okul müfredatı için özel olarak geliştirilmiş öğretimsel araçlardır (Moore, Doerr, Glancy, & Ntow, 2015). MOE'lerde öğrencilerden gerçek yaşam durumlarına entegre edilmiş matematiksel fikirleri keşfetmeleri ve gerçek yaşam durumunda verilen bir problem model geliştirerek çözmeleri istenmektedir (Erbaş, et al., 2014). Yapılan birçok araştırma MOE'lerin sınıf içi uygulamalarının öğrencilerin problem çözme, analitik düşünme, yaratıcılık becerilerini ve gerçek yaşam durumlarındaki temel matematik kavramlarını öğrenmesini geliştirdiğini göstermektedir (Chamberlin & Moon, 2005; Kertil & Gürel, 2016; Lesh & Zawojewski, 2007; Lesh, Cramer, Doerr, Post, & Zawojewski, 2003; Zawojewski, Lesh, & English, 2003). Bu yönüyle, MOEler STEM yaklaşımının sınıf içi uygulamaları için öğretimsel bir araç olarak önerilmektedir (English, 2017; Hamilton, Lesh, Lester, & Brilleslyper, 2008; Magiera, 2013). Bu yüzden, bu etkinlikleri kendi sınıflarında uygulamak isteyen öğretmenler gerekli yetkinliklere sahip olmalıdır. Literatürde bu yetkinliklerden bazıları (i) sınıfı MOE esnasında nasıl düzenleyeceğini bilmek, (ii) aktiviteler esnasında öğrenciye etkili ve yararlı cevaplar vermek, (iii) beklenmedik durumlara çözüm üretebilme olarak tanımlanmaktadır yeteneği (Doerr & English, 2006; Schorr & Richard, 2003). Bu yetkinlikleri geliştirebilmek için öğretmenlerin MOE'ler esnasında ortaya çıkan öğrenci davranışlarını ve güçlüklerini bilmesi gerekmektedir. Dahası, bu davranış ve güçlüklerin MOE'lerin çoklu uygulamalarında nasıl değiştiğini de bilmelidir. Fakat ilgili literatüre bakıldığında bu etkinlikler esnasında öğrenci davranışlarını ve güçlüklerini inceleyen yeterli sayıda araştırmaya rastlanmamıştır. Literatürde tanımlanan davranışlardan bazıları şöyledir: (i) öğretmenden geri bildirim isteme, (ii) çözüm yolu için onay alma (Moore, Doerr, Glancy, & Ntow, 2015), (iii) anlamaya çalışmadan çözüme hızlıca ulaşma isteği (Eraslan & Kant, 2015; Zawojewski, Lesh, & English, 2003), (iv) beraber çalışmak istememe (Eraslan, 2012; Eraslan & Kant, 2015), (v) cevabı için değerlendirme isteme, (vi) öğretmenden yardım isteme ve (vii) ne yapmaları gerektiğiyle ilgili açıklama isteme (Zawojewski, Lesh, & English, 2003). Benzer olarak literatürde tanımlanan güçlükler şöyledir; (i) problemi anlamama, ve (ii) uygun model oluşturamama (Eraslan & Kant, 2015; Şahin & Eraslan, 2016).

Bu çalışmada araştırmacı aynı zamanda öğretmendir. Ve kendi sınıfına MOE'leri en etkili bir biçimde uygulamak istemektedir. Bu bağlamda bu etkinlikler esnasında öğrencilerinin davranışlarını ve yaşadıkları güçlükleri bilmesi gerekir. Dahası bunların MOE'lerin çoklu uygulaması esnasında nasıl değiştiğini de bilmelidir. Bu nedenle bu çalışmayı yapmıştır. Bu çalışmanın amacı 5. Sınıf öğrencilerinin Model Oluşturma Etkinlikleri esnasında ortaya çıkan davranışlarını ve bu davranışların nasıl değiştiğini incelemektir. Bu çalışma ayrıca öğrencilerin bu etkinlikler sırasında yaşadıkları güçlükleri belirlemeyi de amaçlamaktadır. Çalışma aşağıda belirtilen üç tane araştırma sorusuna cevap aramaktadır.

a) 5. Sınıf öğrencilerinin MOE'lerin sınıf için uygulamaları esnasında ortaya çıkan davranışları nelerdir?
b) 5. Sınıf öğrencilerinin MOE'lerin sınıf için uygulamaları esnasında yaşadıkları güçlükler nelerdir?
c) 5. Sınıf öğrencilerinin davranışları MOE-1'den MOE-3'e hangi ölçüde değişmektedir?

YÖNTEM

Araştırma Deseni

Araştırma sorularına yanıt aramak için durum (örnek olay) çalışması yöntemi kullanılmıştır. Durum çalışması bir olay, aktivite veya süreç gibi belirli bir durum için derin bir anlayışa odaklanan nitel bir araştırma yöntemidir (Creswell, 2012).

Araştırmanın Bağlamı

Bu araştırma Ankara'nın Yenimahalle ilçesinde bulunan İmam Hatip ortaokulunda gerçekleştirilmiştir. Bu okul Milli Eğitim Bakanlığı tarafından 2016 yılında proje okulu olarak belirlenmiştir. Proje okulları yönetmelikte yenilikçi yaklaşımlar, ulusal ve uluslararası projeler uygulayan okullar olarak tanımlanmaktadır. Bu okullara öğrenciler özel giriş sınavıyla alınmaktadır. Okulda 5. Sınıftan 8. Sınıfa kadar yaklaşık 1000 öğrenci ve 72 öğretmen bulunmaktadır. 72 öğretmenin 12 tanesi matematik öğretmenidir. MEB'in belirlediği matematik müfredatına göre matematik dersleri işlenmektedir. Ve hiçbir matematik öğretmeni yenilikçi ve farklı bir eğitim yöntemi uygulamamaktadır. Uygulamanın yapıldığı 5. Sınıf öğrencileri okula özel giriş sınavıyla girdikleri için ortalama üstü bir akademik başarıya sahiptirler. Öğrencilerin hiç biri öğrenci merkezli öğretim metotlarına aşina değillerdir. Araştırmacı bu okulda 2016-2017 Eğitim Öğretim dönemi çalışmaya başlamıştır. Ve bu çalışmayı hem araştırmacı hem de öğretmen kimliğiyle beraber yürütmektedir.

Katılımcılar

31 tane 5. Sınıf öğrencisi bu çalışmanın katılımcısı olarak seçilmiştir. 31 öğrenci araştırmacı tarafından kişisel özellikleri dikkate alınarak gruplara bölünmüştür. Çalışmanın bulguları oluşturulan gruplar arasından seçilen 4 kişiden oluşan odak gruptan elde edilmiştir. Odak grup araştırmacı tarafından öğrencilerin kişisel özellikleri ve başarı düzeyleri göz önünde bulundurularak verimli verinin elde edileceği tahmin edilen grup olarak belirlenmiştir.

Seçkisiz ve seçkisiz olmayan olarak iki temel örnekleme yöntemi bulunmaktadır. Seçkisiz örnekleme yöntemi nitel araştırmalar için en uygun yöntemdir çünkü bu araştırmalar bulguları daha büyük örnekleme genelleme amacı taşımamaktadır (Merriam, 2009). Fraenkel, Wallen, and Hyun (2011)'a göre uygun örneklem, katılımcıların çalışma için ulaşılabilirliğine göre seçilmesidir. Bu araştırmada katılımcılar seçkisiz örneklemenin bir türü olan uygun örnekleme yöntemi kullanılarak seçilmiştir. Araştırmacı katılımcıların öğretmeni olduğu için veri toplamak kolay olacaktır. Bu durum zaman, para ve işgücü açısından araştırmacıya fayda sağlayacaktır. Ayrıca araştırmacı katılımcıları tanıdığı için verilerin analizini daha güvenilir bir şekilde yapabilecektir.

Veri Toplama Araçları

Öğrenci davranışlarını, öğrencilerin yaşadıkları güçlükleri ve bunların nasıl değiştiğini belirlemek için video ve ses kayıtları, öğrencilerin yazılı çalışmaları ve alan notları veri toplama aracı olarak kullanılmıştır.

Video ve Ses Kayıtları

İki kamera tarafından biri tüm sınıfı diğeri odak grubu olmak üzere 3 MOE etkinliği kayıt altına alındı. Dahası her etkinlikte odak grup için ses kaydı alındı. Video ve ses kayıtları sayesinde kritik davranışlar ve güçlükler araştırmacı tarafından çok kolay bir şekilde analiz edildi ve kodlandı. Kayıtlar ayrıca kodlama esnasında araştırmacının verileri tekrar tekrar inceleyip en doğru şekilde bulgulara ulaşmasını sağladı.

Yazılı Çalışmalar ve Alan Notları

Bulgular yazılı çalışmalar ve alan notları ile desteklendi. Araştırmacı her etkinlik sonunda öğrencilerin yazılı çalışmalarını topladı. Ayrıca etkinlik esnasında yaşanılan güçlükler ve davranışlar ile ilgili notlar aldı. Video ve ses kaydını eksik kaldığı noktalarda bu veriler araştırmanın bulgularını güçlendirdi.

Öğretim Materyali: MOE ve Pilot Çalışma

Bu çalışmada MOE'lar öğretim materyali olarak kullanıldı. Katılımcıların etkinlikler esnasındaki davranışlarını ve güçlükleri belirlemek için 3 farklı MEO seçildi ve katılımcıların sınıf seviyesine ve sosyo-kültürel özelliklerine göre uyarlandı (Ek A). Araştırmacı MOE'lerın içeriğini seçerken 5. Sınıf konularını göz önünde bulundurdu. Aktivitelerin uygulanacağı esnada öğrencilerin o güne kadar öğrendikleri matematik kazanımları arasından seçim yapıldı. Bütün MOE'ler İngilizce bir kaynaktan alındığı için Türkçeye çevrildi. Geçerlilik ve güvenilirliğinin sağlanması için 3 uzman MOE'leri hem içeriksel hem de biçimsel olarak değerlendirdi. Ardından yapılan pilot çalışma ile gerekli revizyonlar tekrar yapıldı.

Pilot çalışma 2016 yılı Mayıs ayının ilk haftası Mamak, Ankara'daki bir ortaokulda yapıldı. Bu çalışmanın amacı MOE'lerin sınıf içinde en etkili uygulama yolunu bulmak ve 5. Sınıf düzeyine uygunluğunu belirlemekti. Ayrıca, araştırmacı MOE'lerin ortalama uygulama süresini ve aktivitelerin anlaşılabilirliğini de test etmeyi amaçlamıştır. Pilot çalışma sonuçlarına göre etkinliklerin dili sadeleştirilmiş ve kısaltılmıştır. Ayrıca etkinliğin uygulama zamanı arasız iki ders saati (90 dk) olarak belirlenmiştir.

Veri Toplama Süreci

Gerekli etik izinler alındıktan sonra 2015-2016 öğretim yılının ikinci döneminde pilot çalışmalar tamamlanmıştır. Asıl araştırma 2016-2017 öğretim yılının ilk döneminde gerçekleştirilmiştir. Kasım ayında ilk MOE 31 5. Sınıf öğrencisine uygulanmış, diğer MOE'lerde birer hafta arayla aynı katılımcılara uygulanarak very toplama süreci bir ayda tamamlanmıştır.

Veri Analizi

Nitel araştırmalarda, elde edilen ham verilerden kategoriler belirlenip, bu kategorilerin isimlendirilip, verileri kategorilere yerleştirecek bir sistem bulunması tekniği kodlama olarak adlandırılmaktadır (Merriam, 2009). Bu araştırmanın bulguları kodlama tekniğiyle elde edilmiştir. Araştırmacı, araştırmanın amacını göz önünde bulundurarak ses ve video kayıtlarını dikkatlice ve tekrar tekrar izlemiştir. Daha sonra öğrencilerin aktiviteler esnasında gösterdiği davranışlardan ve yaşadıkları güçlüklerden kritik ve örüntü oluşturanları belirlemiş ve kendi belirlediği kodlar altında toplamıştır.

Bulgular, destekleyici davranışlar, engelleyici davranışlar ve güçlükler olmak üzere 3 ana tema şeklinde kodlanmıştır. Ayrıca bu ana temalar eldeki veriler yardımıyla alt temalara ayrılmıştır. Bu bağlamda, destekleyici davranışlar birlikte çözüm üretme ve iş yükünü bölüşme olarak; engelleyici davranışlar onay isteme ihtiyacı, açıklama isteme ihtiyacı ve yalnız başına çalışma isteği olarak alt temalara bölünmüştür. Güçlükler ise anlama güçlüğü ve zamanı yönetememe güçlüğü olarak bölünmüştür.

BULGULAR VE TARTIŞMA

Çalışmanın bulguları, Model Oluşturma Etkinliklerinin sürekli uygulanmasıyla öğrencilerin yaşadıkları güçlüklerin giderek azaldığını ortaya koymuştur. Ayrıca Model Oluşturma Etkinliklerinin sürekli tekrarıyla destekleyici öğrenci davranışlarının arttığı, engelleyici öğrenci davranışlarının azaldığı görülmüştür. Bu çalışma sayesinde, Model Oluşturma Etkinliklerini kendi sınıflarında kullanmak isteyen öğretmenler için bu etkinliklerin sürekli uygulanmasının son derece önemli olduğu sonucuna varılabilir.

Destekleyici davranışlar

Bu çalışmada, destekleyici davranışlar model oluşturma sürecini destekleyen ve öğrencilere güçlü modeller oluşturmaları için yardım eden davranışlar olarak tanımlanmıştır.

Birlikte Çözüm Üretme

Araştırmacı, öğrencilerin birbirini dinleyip, fikir alışverişinde bulunup, beraber karar vermesini "birlikte çözüm üretme" davranışı olarak kodladı. Bu davranış MOE-1'den MOE-3'e büyük ölçüde arttı. MOE-1'de öğrenciler başlangıçta bu davranışı göstermemelerine rağmen 15. dakikadan sonra fikirlerini paylaşmaya ve müzakere etmeye başladılar. MOE-1'den farklı olarak, öğrenciler MOE-2 ve MOE-3'te yalnız çalışma eğilimi göstermediler. Aksine, öğrenciler çözümün her ayrıntısını beraber yarattılar.

MOE-1'de öğrencilerin bu davranışı ilk 15 dakika göstermemelerinin nedeni bu tarz etkinliklere alışkın olmadıklarından kaynaklanmış olabilir. MOE-1 ve MOE-3'te bu davranışın ortaya çıkması öğrencilerin beraber çözüme ulaşmanın yalnız başına model geliştirmekten daha kolay ve etkili olduğunu fark etmiş olmaları olabilir.

İş Yükünü Bölüşme

Araştırmacı, çözüm yoluna karar verdikten sonra yapılması gereken iş yükünü bölüşmesini "iş yükünü bölüşme" olarak kodladı. Bu davranış MOE-3'te MOE-1 ve MOE-2'ye kıyasla daha fazla gözlemlendi. MOE-1'in ilk 15 dakikasını bir öğrenci domine etti. 15 dakikadan sonra diğer öğrenciler iş yükünü bölüşmesine ragmen karar verilen paylaşım etkili bir şekilde uygulanmadı. MOE-1'den farklı olarak, öğrenciler MOE-2 ve MOE-3'te iş yükünü etkili bir biçimde paylaştılar. Öğrenciler iş yükünü genellikle mektup yasmak ve çözüm üretmek olarak ikiye böldüler.

Bu davranış öğrencilerde giderek artmıştır. Bunun nedeni öğrencilerin model oluşturma etkinliklerinin daha önce karşılaştıkları matematik problemlerine kıyasla uzun, çaba gerektiren ve zaman alan bir çözüm sürecine sahip olduklarını anlamaları olabilir.

Engelleyici davranışlar

Bu çalışmada, engelleyici davranışlar, MOE etkinliklerini engelleyen ve öğrencilerin güçlü ve istenilen modeli oluşturmasına engel olan davranışlar olarak tanımlanmıştır.

Onay İsteme İhtiyacı

Araştırmacı, öğrencinin çözüm esnasında doğru yolda olup olmadığıyla ilgili öğretmenden onay beklemesini "onay isteme ihtiyacı" olarak kodlamıştır.
Bu davranış MOE-1'den MOE-3'e büyük ölçüde azalmıştır. Ancak tamamen yok olmadı. MOE-1'de öğrenciler bu davranışı bütün uygulama süreci boyunca gösterdiler. Benzer olarak, Bu davranış MOE-2'de azalmasına ragmen, öğrenciler başlangıçta, ortada ve sonra birer kez olmak üzere toplam üç kez onay alma ihtiyacı hissetmişlerdir. MOE-3'te öğrenciler sadece başlangıçta soruyu anlayıp anlamadıklarından emin olmak için öğretmenden onay beklemişlerdir. Daha sonra bu davranış MOE-3'te farklılaşmıştır. Onay beklemek yerine öğrenciler öğretmeni nasıl bir yol izledikleri ile ilgili bilgilendirmeyi tercih etmişlerdir.

MOE-1'de öğrenciler bütün uygulama boyunca öğretmenden onay beklemişlerdir. Bunun nedeni öğrencilerin önceki deneyimlerinden kaynaklanan her matematik sorusunun tek bir doğru cevabı olmalıdır düşüncesi olabilir. Ayrıca öğrenciler öğretmeni cevabı bilen tek kaynak olarak gördükleri için her adımlarını onaylatma ihtiyacı hissediyor olabilirler. MOE-2'de öğrenciler bu davranışı daha az göstermişlerdir. Bu durum öğrencilerin model oluşturma sürecinde çözümün tek olmadığını genellenebilir ve kişiye ait belirli modeller oluşturmaları gerektiğini anlamış olmalarından kaynaklanabilir. Belki de öğrenciler sordukları sorulara öğretmenden cevap alamadıkları için soru sormayı bırakmış olabilirler. MOE-3'te öğrenciler sadece uygulamanın başında onay istemişlerdir. Bu durum öğrencilerin her matematik probleminin tek bir doğru cevabı olmadığı kişiye göre çözümün değişkenlik göstereceğini fark etmiş olmalarından kaynaklanabilir. Dahası öğrenciler öğretmenin bu uygulamalarda gözlemci rolünü anlamış olabilirler.

Açıklama İsteme İhtiyacı

Araştırmacı, öğrencilerin ne yapacakları ve nasıl yapacaklarına dair öğretmenden açıklama beklemesini "açıklama isteme ihtiyacı" olarak kodlamıştır. MOE-1'de öğrenciler hem model oluşturma etkinliklerinde izlenmesi gereken yol ile ilgili hem de o etkinliğin kendisiyle ilgili uygulama boyunca öğretmenden açıklama beklediler. Farklı olarak MOE-2'de öğrenciler hiçbir şekilde öğretmenden açıklama beklemediler. MOE-3'te ise öğrenciler sadece etkinliğin kendisiyle ilgili öğretmenden açıklama beklediler.

MOE-1'de öğrenciler hem süreç ile hem aktivitenin kendisi ile ilgili öğretmenden onay beklemişlerdir. Bu durum öğrencilerin bu tarz aktivitelere alışkın olmamasından kaynaklanabilir. Öğrencilerin aktivitenin kendi ile ilgili açıklama beklemesinin nedeni onların düşük okuma yazma becerilerine sahip olmaları olabilir. Dahası öğrencilerin aktivitelerde ne istendiğini okuyup kendileri anlamaya çalışmak yerine öğretmenin anlatması ve özetlemesi onlara daha güvenilir ve kolay gelmiş olabilir. MOE-2'de öğrenciler bu davranışı göstermemişlerdir. Öğrenciler model oluşturma etkinliklerinin basamaklarına ve içeriğine aşinalık kazanmış olabilirler. MOE-3'te öğrenciler süreçle ilgili açıklama istememelerine rağmen aktivitenin kendisi ile ilgili açıklama beklemişlerdir. Süreçle ilgili açıklama beklememelerinden öğrencilerin bu tip aktivite süreçlerini benimsedikleri sonucu çıkarılabilir. Aktivitenin kendisi ile ilgili açıklama beklemeleri MOE-3'ün gerçek yaşam durumunun onlara yabancı gelmesi veya diğer iki etkinliğe kıyasla bu etkinliğin matematiksel olarak daha karmaşık olmasından kaynaklanmış olabilir.

Yalnız Başına Çalışma İsteği

Araştırmacı, öğrencilerin süreçte tek başlarına çözüme ulaşma isteğini "yalnız başına çalışma isteği" olarak kodlamıştır. Bu davranış sadece MOE-1'de gözlemlenmiştir. MOE-2 ve MOE-3'te öğrenciler çözüme beraber ulaşmıştır.

Bu durum öğrencilerin grup çalışmasına yatkın olmamalarından kaynaklanmış olabilir. Önceki deneyimlerinde grup çalışması gerektiren aktiviteler içinde bulunmamış olabilirler. Dahası öğrencilerin yalnız başına çalışma isteği Türk eğitim sisteminden kaynaklanmış olabilir. Çünkü var olan sistem öğrencinin bireysel başarısını ödüllendirmeye yöneliktir ve sıralama sınavlarıyla öğrenciler arasında rekabet duygusu yaratmaktadır. MOE-2 ve MOE-3'te öğrenciler grup çalışmasına yönelmişlerdir. Bu durumda öğrenciler öğretmenin yalnız çözüm üretmeyi değil beraber bir model geliştirmeyi ödüllendirdiğini fark etmelerinden kaynaklanmış olabilir.

Güçlükler

Bu çalışmada, güçlükler öğrencilerin aktiviteler esnasında üstesinden gelmeleri gereken güç durumlar olarak tanımlanmıştır.

Anlamama Güçlüğü

Araştırmacı, öğrencinin aktiviteyi anlamamasını veya yanlış anlamasını anlamama güçlüğü olarak kodlamıştır. MOE-1'de, öğrenciler başlangıçta aktivitede ne sorulduğunu anlamadılar. 15 dakikadan sonra yanlış anlayarak çözüme ulaşmaya çalıştılar. Daha sonra öğretmenin yönlendirmesiyle doğru bir şekilde onlardan istenileni anladılar. MOE-2 ve MOE-3'te öğrenciler bu güçlüğü yaşamadılar. Onlardan istenileni kolay bir şekilde anladılar.

MOE-1'i anlamada zorlanmalarının nedeni açık uçlu ve çözüm için bir model geliştirmeyi gerektiren problem durumlarına alışkın olmamalarından kaynaklanmış olabilir. Diğer iki etkinlikte bu tip problemlere aşinalık kazandıkları için anlamakta zorlanmamış olabilirler.

Zamanı Yönetememe

Araştırmacı, öğrencilerin zamanı akıllıca kullanamamasını ve çözüme zamanında ulaşamayacağı kaygısını duymasını "zamanı yönetememe" olarak kodlamıştır. MOE-1'de öğrencilerin zamanı yönetme konusunda çok başarısız oldukları gözlemlendi. Zamanı iyi planlayamadıkları için sürecin sonuna doğru yetiştirememe kaygısı yaşadılar. MOE-2'de ilk etkinliğe kıyasla daha başarılı bir zaman planlaması gözlemlendi ancak yine de zamanı yönetme konusunda sıkıntı yaşadılar. MOE-3'te öğrenciler zamanı yönetmeyle ilgili çok büyük problemler yaşamadılar.

Öğrencilerin süreçte zamanı yönetme ile ilgili yaşadıkları güçlüklerin azaldığı gözlemlendi. Bu azalış öğrencilerin bu tip aktivitelerin gerekliliklerini (mektup yazmak ve model oluşturmak) özümsemelerine ve her gereklilik için ne kadar zaman ayırmaları gerektiğini anlamış olmalarına bağlanabilir.

ÖNERİLER

Bu araştırmanın bulguları ışığında ileriki çalışmalar için öneriler verilebilir. Öncelikle bu çalışma sadece kızlardan oluşan bir beşinci sınıfta yapıldığı için ileriki çalışmalar karma sınıflarda yapılabilir. Elde edilen bulgular bu çalışmayla karşılaştırılabilir. Dahası, aynı çalışma farklı sınıf düzeylerinde yapılarak da ortaya çıkan güçlükler ve davranışlar belirlenebilir. Bu sayede MOE'lerin her sınıf düzeyinde etkili bir şekilde uygulanması için bir yol belirlenebilir.

İkinci olarak, literatürde MOE’leri sınıflarında uygulamak isteyen öğretmenler için yeterince kaynak olmadığından bahsedilmektedir (Erbaş, et al., 2014). Bu çalışma ortaokul öğrencileri için 3 tane uygulanabilir MOE sağlamıştır. Ancak farklı sınıf düzeyleri için ve farklı kazanımlara yönelik birçok MOE’ye de ihtiyaç vardır. Bu yüzden, öğretmenlerin sınıf için uygulamaları için kaynak olacak MOE’leri geliştiren çalışmalara ihtiyaç vardır. Bu çalışmada uygulanan MOE’lerin alınıp adapte edildiği proje olan Purdue Üniversite’sinin projesinde olduğu gibi Türkiye’de de MOE’lerin toplandığı bir web sitesi oluşturulabilir. Bu sayede öğretmenler MOE’lerin açık kaynak olarak sunulduğu bu siteden kendilerine uygun MOE’leri seçerek sınıf içinde uygulayıp test etme şansı bulabilirler.

Üçüncü olarak, literatürde MOE’lerin sınıf içi çoklu uygulamalarının farklı yönlenrden araştırılmasıyla ilgili sınırlı sayıda çalışma vardır. Bu nedenler ileriki çalışmalar MOE’lerin sınıf içi çoklu uygulamalarının öğrencilerin derse olan inanç ve tutumlarını nasıl değiştirdiğine odaklanabilir. Dahası, çoklu MOE uygulamalarının öğrencilerin sosyal becerilerini ve yeteneklerini ne ölçüde değiştirdiğinin araştırılması da ilgi çekici olabilir.

Son olarak, çoklu MOE uygulamasına katılan öğrencilerin katılmayan akranlarına kıyasla ileriki yaşamlarında eğitimsel ve kariyer seçimleri ne ölçüde farklılık gösteriyor sorusuna cevap aramak için boylamsal bir çalışma yapılabilir.

APPENDIX D: TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Dedebaş
Adı : Elif
Bölümü : İlköğretim Fen ve Matematik Alanları Eğitimi

TEZİN ADI (İngilizce) :An Investigation of Fifth Grade Students' Behaviors and Difficulties Through Multiple Implementation of Model Eliciting Activities

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: