AN INVESTIGATION OF A CASE OF TURKISH AND SYRIAN SEVENTH GRADE STUDENTS' MATHEMATICAL MODELING PROCESSES

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

AN INVESTIGATION OF A CASE OF TURKISH AND SYRIAN SEVENTH GRADE STUDENTS' MATHEMATICAL MODELING PROCESSES

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The aim of this study was to investigate a case of Turkish and Syrian seventh grade students' mathematical modeling cycle in their collaborative work on Model-Eliciting Activities (MEA). The study was conducted with a group of Turkish and Syrian students in a public middle school close to Syrian border in Gaziantep, Turkey. Two different Model Eliciting Activities (MEAs) were implemented in two weeks in spring semester of 2019-2020 school year.

Video and audio data, written works, and fields notes were used as main data sources to determine the steps that the students took in modeling cycle during "Let's Build Environmentally Friendly Structures with Plastic Bottles" and "Summer Job" MEAs. Findings were coded into categories. Moreover, during the modeling cycle, a new code list was prepared by arranging the codes seen in the students' modeling cycle.

Overall, this study showed that students understood real-life situations but were unable to make the necessary mathematical inferences to build models. In addition, Turkish students chose mathematical operations from the mathematical topics they just learned in the curriculum, while Syrian students tried to contribute to the modeling activity by using mathematical operations such as selecting, and sorting data.

This study demonstrated that cultural differences between the students did not adversely affect the model-eliciting activities, as Turkish and Syrian students carried out the modeling cycle in collaboration. It showed that students' academic, social, and cultural differences were not important in mathematical modeling activities, and even showed further that these differences were an asset as well as they supported the universality of mathematics. Hence, it can be concluded that multiple and sustained experience of MEAs is important for students and teachers who want to integrate MEAs into their instruction.

Keywords: Mathematical Modeling, Model Eliciting Activities, Middle School Students, Turkish and Syrian Students

ÖZ

TÜRKİYE VE SURİYE UYRUKLU YEDİNCİ SINIF ÖĞRENCİLERİNİN MATEMATİKSEL MODELLEME SÜREÇLERİNİN İNCELENMESİ

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Bu çalışmanın amacı, Türkiye ve Suriye uyruklu yedinci sınıf öğrencilerinin Model Oluşturma Etkinliklerine (MOE) yönelik işbirlikli çalışmalarında matematiksel modelleme sürecini incelemektir. Araştırma, Türkiye'nin Gaziantep ilinde Suriye sınırına yakın bir devlet ortaokulunda öğrenim gören bir grup Türk ve Suriye uyruklu öğrenci ile gerçekleştirilmiştir. 2019-2020 Eğitim-Öğretim yılı bahar döneminde iki Türk ve iki Suriyeli öğrenciden oluşan bir ogrenci grubuna iki hafta boyunca iki farklı Model Oluşturma Etkinliği uygulanmıştır.

"Pet şişelerle Çevre Dostu Yapılar İnşa Edelim" ve "Yaz İşi" adlı etkinlikler sırasında öğrencilerin modelleme basamaklarını belirlemek için video ve ses verileri, yazılı cevapları ve alan notları ana veri kaynakları olarak kullanılmıştır. Bulgular kategoriler halinde kodlanmıştır. Ayrıca modelleme sürecinde öğrencilerin modelleme sürecinde görülen kodlar düzenlenerek yeni bir kod listesi hazırlanmıştır.

Genel olarak, bu çalışma öğrencilerin gerçek yaşam durumlarını anladığını ancak model oluşturmak için gerekli matematiksel çıkarımları yapamadıklarını göstermiştir. Ayrıca Türkiye uyruklu öğrenciler müfredatta öğrendikleri konulardaki

matematiksel işlemleri seçerken, Suriyeli öğrenciler verileri seçme ve sıralama gibi matematiksel işlemler kullanarak modelleme etkinliğine katkı sağlamaya çalışmışlardır.

Bu çalışma, Türk ve Suriyeli öğrenciler modelleme döngüsünü işbirliği içinde yürüttükleri için, öğrenciler arasındaki kültürel farklılıkların model oluşturma etkinliklerini olumsuz etkilemediğini göstermiştir. Matematiksel modelleme etkinliklerinde öğrencilerin akademik, sosyal ve kültürel farklılıklarının önemli olmadığını, hatta bu farklılıkların matematiğin evrenselliğini destekleyen bir zenginlik olduğunu da göstermiştir. Bu nedenle, model oluşturma etkinlikleri öğretimlerine entegre etmek isteyen öğretmenler ve onların öğrencileri için çoklu ve sürekli model oluşturma etkinlikleri deneyiminin önemli olduğu sonucuna varılabilir.

Anahtar Kelimeler: Matematiksel Modelleme, Model Oluşturma Etkinlikleri, Ortaokul Öğrencileri, Türkiye ve Suriye Uyruklu Öğrenciler

To my family

ESRA & ALYA

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ABBREVIATIONS

ICMI	International Commission on Mathematical Instruction
ICTMA	The International Community of Teachers of Mathematical Modeling and Applications
MEA	Model Eliciting Activity
MMP	Modeling and Modeling Perspective
MOE	Model Oluşturma Etkinliği
MoNE	Ministry of National Education
RME	Realistic Mathematics Education

CHAPTER 1

INTRODUCTION

Over the years, not only has mathematics changed, but mathematics education has also changed as other areas has (Kilpatrick, 1992). These changes have formed new expectations from students such as "mathematical competence and basic competences in science and technology" which refers to solving daily life problems, devoloping mathematical thinking style and desire to use mathematical modes to different degrees. Besides, "learning to learn" means the competence of pursuing and insisting on learning so that an individual can organize his or her learning action individually or in groups, including effective time, knowledge management, and the awareness of learning needs and cope with difficulties for a successful learning (MoNE, 2018). Indeed, content knowledge is not thought to be sufficient considering the needs this age brings about because 21st century expects student to solve non-routine real life problems, make inferences and be creative (Hilton, 2008; Jerald, 2009). Solving routine problems, remembering rules and theorems or finding result of basic mathematical computations are not enough to meet the expectations, so mathematics curriculum needs to be informed by the requirements 21st century necessitates. In addition, new methods might be employed to educate creative scientists, high-tech engineers and mathematicians who will develop a brighter future (Leikin, 2009). To accomplish these goals, school curriculum might be appropriately designed to aid students to have such skills and abilities as solving non-routine problem, creativity and analytical thinking (Gilat & Amit, 2013).

Today, one of the most important aims of education is to raise individuals who have a sense of responsibility, are comptetent enough to have easy access to the information needed, have analytical thinking skills, can produce effective solutions to problems, have advanced decision-making skills, have skills of emphaty, can communicate in a healthy way, and can think critically and innovatively (OECD, 2018). Within this respect, it might be stated that gaining problem solving skills in real life might be the main target of education, and the use of mathematical modeling in mathematics teaching may also be a way to achieve this goal (Gravemeijer & Stephan, 2002; Lesh & Doerr, 2003).

It is possible to encounter mathematical modeling in different disciplines, such as physics, chemistry, engineering, medicine and many other areas. Such assumptions as mathematics includes real-life applications, mathematical knowledge can be applied to the daily life problems, and it provides the opportunity to produce more analytical and practical solutions to daily problems indicate that mathematics is more than just problem solving. Indeed, in recent years, many researchers in the field of mathematics education have been examining mathematical modeling in education.

Traditional methods and problem solving activities do not meet the demands for students, so these concerns have lately directed mathematics educators to work on mathematical modeling (Mousoulides et al., 2006). The significance of mathematical modeling in mathematics education has been emphasized by NCTM (2000) and many researchers (e.g., Gravemeijer & Doorman, 1999; Lesh & Doerr, 2003; Lesh & Lehrer, 2003). Since mathematical modeling allows student to think analytically and give chance to solve non-routine daily life problems (Lesh & Doerr, 2003), it appears to be one of the most favored application in the field of mathematics education (MoNE, 2013; NCTM, 2000) Moreover, advocates of mathematical modeling have contended that mathematical modeling plays an important role as a bridge between real-world and school-based mathematics (Blum, 2002; Kaiser & Maaß, 2007; Lesh & Doerr, 2003; Stillman et al., 2008). Mathematical modeling activities include rich opportunities for students, such as mathematical reasoning, learning in a more meaningful way, and sense making (English, 2009). Furthermore, it assists mathematics educators in helping their students gain 21st century skills (Sevinc, 2021).

It is possible to argue that mathematical modeling not only provides opportunities for students and establishes a direct relationship between real life and mathematics, but it also provides equality among students. Students' cultural backgrounds, family backgrounds, and socio-economic conditions create inequality of opportunity among students (Ursprung et al., 2008). However, it can be said that mathematical modeling eliminates differences such as socioeconomic, cultural and family backgrounds among students because modeling activities are a process in which students share their ideas and demonstrate their performance by working together in cooperation. Lesh (2005) stated that mathematical modeling caused more sophisticated conceptual developments than the knowledge that students could learn at school, and that students with average academic success could develop strong mathematical models. In addition to that, mathematical modeling promotes group work where students learn to communicate and work collaboratively to solve real life problems (English & Mousoulides, 2009). Mathematical modeling does not limit students to learn mathematics in the classroom, rather it extends it to their family and social lives (Velez et al., 2015).

Due to the war in Syria, students had to migrate to other countries, and Turkey is one of the leading countries hosting the asylum seekers. Syrian students are trained together with Turkish students in the same schools located in regions that receive immigration. Kirişçi (2014) stated that there were significant differences in the curricula and education systems of Turkey and Syria due to their culture, history, and social structure. Along with such differences, there were differences in both cultural and family backgrounds of Turkish and Syrian students. These differences have negatively affected the school adaptation process of Syrian students (Tut, 2018). Therefore, it gains importance to organize and adjust the instruction and carry out the studies considering the inequalities on the part of Syrian students. As a mathematics teacher having experience with teaching to both Turkish and Syrian students, I conjectured that using mathematical modeling in math class could possibly eliminate these differences and help students learn mathematical topics together. Mathematical modeling entails a process that requires collaborative work in the group and includes real-life situations, and students could participate in this process with motivation. Therefore, in this study, Turkish and Syrian students were brought together, and representation of the classroom environment was made, and mathematical modeling processes were examined.

1.1 Purpose of the Study and Research Questions

The aim of this study was to investigate a case of Turkish and Syrian seventh grade students' mathematical modeling process in their collaborative work on model-eliciting activities. This study addressed the following research questions:

1. How does a group of 7th-grade students involving two Syrian refugee children and two Turkish children experience a modeling cycle in solving mathematical modeling problems?
2. Do Syrian refugee and Turkish children's perspectives contribute differently to the modeling cycle? If yes, how?

1.2 Significance of the Study

In mathematics education, students need to be encouraged to learn with different practices and contexts so that the knowledge transferred to students might become more meaningful (Bransford et al. 1999). Previous research on mathematical modeling demonstrates that most of the students' academic success was above the average in the cases where mathematical modeling was utilized. These studies were mostly carried out in schools with good physical conditions and facilities in the city centers. Due to the limited number of studies conducted on mathematical modeling investigating its effects on middle school students in Turkey (Güder & Gürbüz, 2017; Kant, 2011), it would be quite significant to conduct and examine modeling processes in different regions of Turkey. Although the literature involved various studies investigating the modeling process of students from different perspectives, what students would bring into the modeling perspective regarding their cultural background has not been studied much.

In addition, some researchers (Diezmann et al., 2001; English & Fox, 2005; English & Watters, 2004, 2005a, 2005b) explicitly stated that not enough attention was paid to the modeling processes of primary and middle school students. Researchers argue that mathematical modeling might be made at lower grade levels (Diezmann et al., 2001; English & Fox, 2005; English & Watters, 2004, 2005a, 2005b). These researchers also emphasized that primary and middle school students can also work successfully with modeling problems. On the other hand, modeling problems provide an opportunity for students to experience how to cope with complex data presented in challenging but meaningful contexts (English & Watters, 2004, 2005a, 2005b). Therefore, in the literature, there is a need for studies dealing with the mathematical modeling process focusing on the middle education level. Hence, this study is important in that it aims to reveal the mathematical modeling processes of middle school students.

This study was carried out with a group of participants whose socio-economic level was low and whose academic success was below the average. In addition, some of the participants were students who had to migrate due to the war in Syria. The school where the study was conducted was located very close to the Syrian border. Therefore, all students were claimed to be affected adversely by the war. The coexistence of different cultures and ethnic students brought out many problems. The first of these was cultural difference. Most of the Turkish public schools provided many Syrian children with access to education and a warm and safe learning environment. However, poor school conditions associated with insufficient resources and inappropriate curriculum planning hindered the delivery of high-quality education (Aydın & Kaya, 2017). Many countries such as Turkey have lived with immigrants for many years and seem to live even more. In this respect, the fact that some of the participants in the study were Syrian immigrant students makes the study important.

In this study, mathematical modeling activities were applied in an environment where immigrant students were also present, and the results were evaluated. In this respect, the present study differs from other studies with its participants, hoping to inform future educational practices.

As a mathematics teacher employed in public school near to Syrian border, I was directly exposed to the devastating influence of the war in Syria at school. The Syrian students' difficulties experienced in mathematics lessons, their struggles to be integrated into classroom, and their low performances in mathematics triggered my interest and I decided to conduct such a study to provide a better learning environment to the students.

1.3 Definition of Terms

The following important terms are associated with the study.

Models: Models are "conceptual systems that are expressed using external notation systems, and that are used to construct, describe, or explain the behaviors of other system(s)-perhaps so that the other system can be manipulated or predicted intelligently" (Lesh and Doerr, 2003, p.10). In this study, students' solution paths including the final answer encompassed the model.

Modeling: Modeling is the process of creating a model that represents a situation (Sriraman, 2006). In this study, students experienced a modeling cycle, the path that led students to reach an answer to the problem situation.

Mathematical Model: Mathematical model is all of the conceptual structures such as equations, functions, graphics and mathematical thinking skills that exist or are created in the mind so that a problem or real life situation can be expressed and interpreted mathematically (Lesh & Doerr, 2003). In this study, the mathematical aspects of students' model were identified at the mathematical model.

Mathematical Modeling: Mathematical modeling is the process of mathematically describing a situation, phenomenon and relations between situations that are not based on mathematics and revealing the mathematical patterns within these situations and phenomena (Verschaffelet al., 2002). A model as the product of a mathematical modeling activity is described by Lesh and Doerr (2003, p.3) as conceptual tools which are “sharable, manipulatable, modifiable, and reusable for constructing, describing, explaining, manipulating, predicting, or controlling mathematically significant systems.”

Model-Eliciting Activities (MEAs): These activities are open ended and real word problems which are intented improve problem-solving skills and conceptual learning (Lesh et al., 2000). MEAs encourage students to create mathematical models to help students to solve complex problems about real world (Lesh & Doerr, 2003). In this study, two MEAs were used to understand the modeling process of Syrian and Turkish students.

CHAPTER 2

LITERATURE REVIEW

In this section, the related literature is examined in detail, and then the theoretical framework of the study is given in light of the related literature. Before elaborating on modeling studies and approaches in mathematics education, the problem-solving that forms the basis of the modeling approach is addressed, and then the definition of mathematical modeling and modeling approach in mathematics education is discussed in detail.

2.1 Problem Solving and Its Place in Mathematics Education

The significance of understanding, associating, and expressing verbal or different representations of information conveyed in mathematics lessons appears during problem-solving process. Therefore, problem-solving activities can be the most important tool of mathematics education and one of the most frequently studied topics in mathematics education research. Mathematical problem-solving can roughly be defined as "the search for a powerful procedure that links well-specified givens to well-specified goals" (Zawojewski & Lesh, 2003, p. 318). Greer (1997), Verschaffel et al. (1994) and many other mathematics education researchers stated that the current problem-solving activities were far from meeting the needs of the century.

Problem-solving has more than one meaning as an activity, as a process, and as a context. Schwieger (1999) defined it as "the process of using tools, knowledge, problem skills, and strategies to find or develop the solution to a problem" (p. 113). Mayer (1985), on the other hand, defined it as "the process of moving from the given state to goal state of a problem" (p. 124). Problem-solving is an activity where students see problems as an obstacle which causes a skirmish between student's previous knowledge and new knowledge (Grugnetti & Jaquet, 1996). Among many other fields of study, problem-solving in the area of mathematics is also an issue that has been widely studied by many influential researchers such as Polya (1957) and Schoenfeld (1992). There are even further classifications in the literature on mathematics such as verbal problems, algebraic problems, routine and non-routine problems (Selden et al., 2012), and real-life problems (Freudenthal, 1991; Gravemeijer, 1997).

The competency of problem-solving activity depends on the nature and purpose of the problem used. The purpose and appropriateness of the problems posed to students in mathematics education are discussed by researchers. Researchers like Schoenfeld (1992) and English (2003) stated that problem-solving activities need to be separated from traditional verbal problem-solving activities and math exercises. According to Schoenfeld (1992), problems and problem-solving activities need to involve students' high level cognitive and metacognitive processes.

As a result of the findings obtained from the studies on traditional verbal problems, mathematics education researchers has focused more on modeling problems as a problem-solving activity. Investigating problem-solving activities taught in the classroom in terms of social and cognitive consideration, Reusser and Stebler (1997) stated that when students solved problems for improving their mathematical modeling skills, they did it without taking real-life situations and its limitations into account. So, they argued that solving mathematical problems in mathematical classrooms limited itself into classroom culture and was isolated from real life conditions.

According to the study by Reusser and Stebler (1997), the following didactical contracts existed in students against mathematical modeling problems:

- “students frequently solve problems without understanding them (Raddatz, 1983; Reusser, 1984; Stern, 1992);
- students readily “solve” unsolvable, even absurd, problems if presented in ordinary classroom contexts (Baruk. 1989; Reusser, 1988; Schoenfeld, 1989);
- students almost never ask themselves if a problem given to them is solvable or not (Wertheimer, 1945);
- students frequently use superficial keyword methods (or direct translation strategies) rather than thinking deeply about the implied real-world situation when solving stereotyped word problems (Bobrow, 1964; Nesher, 1980; Nesher & Teubal, 1975; Paige & Simon, 1966; Schoenfeld, 1982; Wertheimer, 1945);
- students’ factual problem-solving behavior is heavily influenced by contextual information (Reusser, 1984, 1988);
- students who can easily deal with additive and subtractive problems within the classroom seldom use the formal arithmetic notations when asked to write down what happened in real-world situations dealing with candy, flowers. or dice (Schubauer-Leoni & Perret-Clermont, 1985).” (p.310).

Traditional verbal problems do not improve students’ problem-solving skills since students use some stereotypes in problem sentence, which is not meaningful for them while solving problems (Greer, 1997; Nunes et al., 1993). Greer, Verschaffel, and De Corte (1993) considered the applications of mathematics as mathematical modeling to solve real-life problem situations. Researchers such as Greer (1993), Verschaffel, De Corte, and Lasure (1994) stated in their studies that traditional mathematics teaching method led students to develop a tendency to reduce mathematical modeling to the level of choosing and solving only correct, formal arithmetic operations without really understanding the nature and context of the problem.

Many researchers (e.g., Blum & Niss, 1991; English & Doerr, 2004; Lesh & Doerr, 2003; Schoenfeld, 1992; Verschaffel et al., 1994) who focused on mathematical modeling problems claimed that study with non-routine problems helped students to grow up having real-life problem-solving skills both for school and outside of school in their future lives. The idea that mathematical modeling helps students learn mathematics more meaningfully by relating it to real life and that traditional problem types in achieving a more meaningful learning proves to be insufficient constitute the necessities of using modeling in mathematics education (Erbaş et al., 2014). In this case, mathematical modeling problems have the features of being non-routine and open-ended.

2.2 Modeling in Mathematics Education

It is important to realize that a more meaningful learning is achieved by establishing a relationship between the situations that people encounter in their daily lives and the mathematical content they learn in schools. For this reason, mathematics educators have turned to investigate the methods different from the traditional problem-solving activities that could enable students to use mathematics more efficiently in their lives. So, many studies were conducted on mathematical modeling method that contained tight bonds with the real life and offered students rich mathematical situations (Doruk, 2010).

Many researchers (e.g., Blum, 2002; Lesh & Doerr, 2003; Sevinc, 2021) have delved more into mathematical modeling in recent years. Research strongly suggests that learning, teaching and applying mathematical modeling include mathematical thinking and different aspects of learning mathematics (Mousoulides et al., 2006). Lesh and Doerr (2003a) defined the model as the whole of the conceptual structures and their external representations that existed in the mind to interpret and understand complex systems and structures. Besides, the ideas, notations, rules, some tools, and equipment that people discover, develop, and use in order to understand nature of mathematics are related to the concept of “model” (Lesh & Doerr, 2003).

The model as a term is also used in mathematics education research as hypothetical problem-solving model and mental “schemas” that describe processes such as abstraction and generalization that take place in the problem-solving process. Models emerge as a result of students’ formal or non-formal activities in the classroom (Gravemeijer et al., 2002).

Modeling is a process of organizing problem situations in mind; coordinating, systemizing, organizing and finding a pattern; using, creating different schemes and models in the process of interpreting (defining, explaining or creating) events and problems. Our real-life interpretations are the interaction of the model in our minds with the real-life system. Generally, the mathematical model is a concept that includes mental representations and schemas. Lesh and Lehrer (2003) also defined the mathematical models as “purposeful mathematical descriptions of situations, embedded within particular systems of practice that feature an epistemology of model fit and revision” and mathematical modeling as “a process of developing representational descriptions for specific purposes in specific situations” (p. 109). The mathematical model entails all structures such as equation, function, graphic, and mathematical thinking skills that exist or are created in the mind to express a problem situation or real-life situation mathematically. Mathematical models are conceptual tools required for individuals to interpret the problems and events they encounter mathematically.

The difference of between model and modeling is similar to the one between process and product (Sriraman, 2005). Modeling is a process of creating model for problematic situation. From this point of view, model can be seen as a product, whereas modeling is a process of creating a physical, symbolic or abstract model of situation. In mathematical modeling, there is no strict and single procedure to reach a solution using the givens. On the contrary, there are more than one way to solve real life problem and procedure between those givens and the target to reach (Blum & Niss, 1991; Haines, 2001; Lesh & Doerr, 2003).

In the literature, traditional perspective and Models-and-Modeling Perspective (MMP) are two different aspects of problem-solving and learning (Lesh & Doerr, 2003). According to the traditional problem-solving perspective, after students study the necessary premises and computational procedures in context, these procedures are applied to a set of problems that requires strategies for solving problems. Therefore, students can deal with complex and realistic applied problems only in the last part of the instruction. By contrast, in MMP, students use their conceptual systems while creating strategies or procedures. According to the model and modeling perspective, students revise, adapt, and create mathematical models informed by real life context. Under this point of view, students learn problem-solving and mathematization of the problem during the modeling process. Therefore, according to model and modeling perspective, problem-solving becomes a sub-category of applied problem-solving (Lesh & Zawojewski, 2007). The following figure portrays a comparison between traditional perspective and model and modeling perspective.

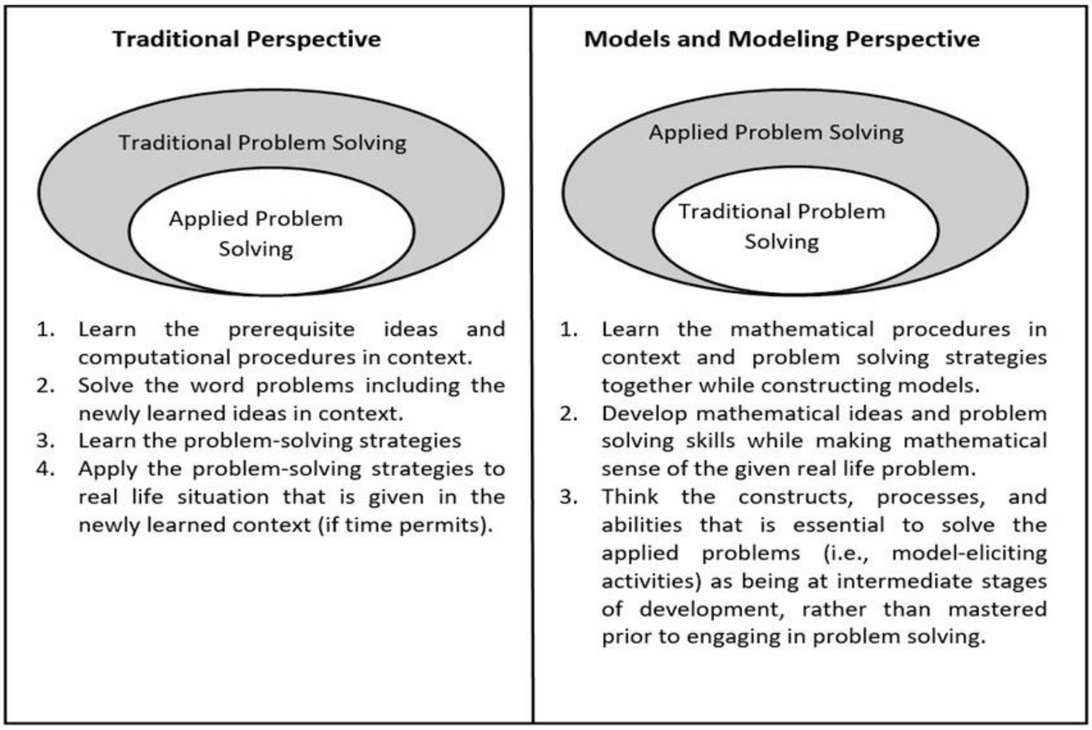

Figure 2.1 Traditional Perspective versus Models and Modeling Perspective (Lesh & Doerr, 2003, p. 4)

Mathematical modeling problems, when compared to traditional problems, are more open-ended, give students chance to work collaboratively, and enhance students' ways of thinking. As shown in Table 2.1, mathematical modeling has multiple cycles that require students interpret the real life situation, develop a solution, and then relate the solution with real lie context. Thorough solving mathematical modeling problems students work together, share their ideas and have a chance to change their strategies; therefore, the process of modeling is as important as the model developed at the end. Mathematical modeling process includes stage of developing, reviewing, and revising the mathematical ideas (Lesh & Doerr, 2003a, 2003b; Lesh & Yoon, 2007). On the other hand, in traditional problem-solving perspective, the aim is finding an answer from the givens using the mathematical ideas and procedures taught previously in the class and often occur as individual problem-solving experience (Erbaş et al., 2014).

Table 2.1 A Comparison between Problem-Solving and Mathematical Modeling (Erbaş et al., 2014, p. 1623)

Traditional Problem Solving	**Mathematical Modeling**
Process of reaching a conclusion using data	Multiple cycles, different interpretations
Context of the problem is an idealized real-life situation or a realistic life situation	Authentic real-life context
Students are expected to use taught structures such as formulas, algorithms, strategies, and mathematical ideas	Students experience the stages of developing, reviewing, and revising important mathematical ideas and structures during the modeling process
Individual work emphasized	Group work emphasized (social interaction, exchange of mathematical ideas, etc.)
Abstracted from real life	Interdisciplinary in nature
Students are expected to make sense of mathematical symbols and structures	In modeling processes, students try to make mathematical descriptions of meaningful real-life situations
Teaching of specific problem-solving strategies (e.g., developing a unique approach, transferring onto a figure) transferable to similar problems	Open-ended and numerous solution strategies, developed consciously by students according to the specifications of the problem
A single correct answer	More than one solution approach and solution (model) possible

The related literature on modeling reveals that there are different approaches to mathematical modeling. In the following section, different mathematical modeling approaches and some significant studies are addressed.

In the literature on mathematics education, a number of different theoretical approaches and perspectives are adopted that affect the main objectives of the research conducted on modeling teaching and learning **(**Blomhoej, 2008; Erbaş, et al., 2014; Hıdıroğlu & Bukova-Güzel, 2016; Kaiser et al., 2006; Kaiser & Sriraman, 2006). There are two main approaches emerged in the 1980s, namely the pragmatic and the scientific-humanistic perspective. It has been observed that these two main approaches actually foregrounded two main ways of modeling, namely theoretical modeling and real-life modeling (Kaiser & Sriraman, 2006). However, with the development of current discussions on modeling and the influence of the constructivist paradigm shift in education, these approaches have further been developed and differentiated in recent years, and there emerged various modeling perspectives (Blomhoej, 2008; Kaiser et al., 2011; Kaiser & Sriraman, 2006). Kaiser (2006) and Kaiser and Sriraman (2006) examined and classified the studies on modeling presented in the congresses organized by the International Commission on Mathematical Instruction (ICMI) and The International Community of Teachers of Mathematical Modeling and Applications (ICTMA). This classification distinguished the various perspectives in the discussion according to their main objectives in connection with modeling and describes the backgrounds on which these perspectives are based. In line with this, Kaiser (2006) classified the modeling approaches available in the literature as realistic (applied), contextual, educational, cognitive, socio-critical and epistemological approaches (see Table 2.2).

Table 2.2 Classification of current perspectives on modeling (Kaiser & Sriraman, 2005, p. 304)

Name of the perspective	Central aims	Relations to earlier perspectives	Background
Realistic or applied modelling	Pragmatic-utilitarian goals, i.e.: solving real world problems, understanding of the real world, promotion of modelling competencies	Pragmatic perspective of Pollak	Anglo-Saxon pragmatism and applied mathematics

Tablo 2.2 (continued)

Contextual modelling	Subject-related and psychological goals, i.e. solving word problems	Information processing approaches leading to systems approaches	American problem solving debate as well as everyday school practice and psychological lab experiments
Educational modelling; differentiated in a) **didactical** modelling and b) **conceptual** modelling	Pedagogical and subject-related goals: a) Structuring of learning processes and its promotion b) Concept introduction and development	Integrative perspectives (Blum, Niss) and further developments of the scientific-humanistic approach	Didactical theories and learning theories
Socio-critical modelling	Pedagogical goals such as critical understanding of the surrounding world	Emancipatory perspective	Socio-critical approaches in political sociology
Epistemological or theoretical modelling	Theory-oriented goals, i.e. promotion of theory development	Scientific-humanistic perspective of “early” Freudenthal	Roman epistemology
Cognitive modelling	Research aims: a) analysis of cognitive processes taking place during modelling processes and understanding of these cognitive processes Psychological goals: b) promotion of mathematical thinking processes by using models as mental images or even physical pictures or by emphasizing modelling as mental process such as abstraction or generalization		Cognitive psychology

Each approach highlights a different aspect of mathematical modeling in this classification. According to the realistic modeling, mathematical modeling refers to the practical applications of mathematics in real life. It aims to develop students’ problem-solving and modeling skills. In this approach, what is important is to give students problem situations from engineering and other disciplines and to apply the mathematical knowledge they have learned in different contexts. Crouch and Haines (2003) defined realistic mathematical modeling as the activity of students to make sense of different ideas, problems, mathematical, and non-mathematical concepts. In this perspective, mathematical models and their real-life applications are the focus of the definition of mathematical modeling. The contextual modeling is regarded as "realizing mathematics through realistic problems, solving of which required not only analysis of the problem context but also mathematical reasoning and computation" (Sevinc, 2021, p. 614). In this approach, students are given meaningful real-life situations. Thus, it is assumed that students can learn mathematical concepts in meaningful contexts.

In the educational modeling, modeling is seen as school practices which are related to curriculum goals. In this approach, the aim is to teach concepts to students by creating appropriate learning environments and processes with mathematical modeling. The socio-critical modeling emphasizes the role of mathematics in society and highlights that critical thinking might be promoted to foreground. This approach suggests that students' critical thinking skills that they could use specific to their own society and cultural structure should be improved. It is thought that mathematical modeling activities are important for realizing this aspect of mathematics. It is also assumed that students' discussions using mathematics from simple to complex will contribute to the development of their critical thinking skills in the modeling process. In the epistemological modeling, modeling could be used in both mathematical and non-mathematical studies. The last perspective, the cognitive modeling is perceived as meta-perspective and consists of complex modeling activities (Kaiser & Sriraman, 2006). This approach highlights that modeling activities need to provide a guiding environment for teachers in order to understand and support students' thinking processes.

The contextual perspective, called verbal problem-solving, together with the model eliciting perspective, created a theory-based perspective that goes beyond problem-solving at school (Kaiser & Sriraman, 2006). According to Lesh and Doerr (2003), models are conceptual systems in the mind that are transferred to the outside world with different notation systems, used in the process of creating, defining and explaining complex systems, and containing rules, operations, relationships and other structures. Mathematical modeling is a process during which existing models are used or new conceptual models are created. There is no strict and single procedure application in the process of reaching the goal by using the information given in the modeling process. Lesh and Doerr (2003) approached the modeling from the constructivist perspective after conducting many studies on mathematical modeling for many years. According to the constructivist understanding, every knowledge or structure in our mind goes through a structuring process. Therefore, it is very important to contribute to the processes of structuring students' own knowledge.

Models-and-modeling perspective is "categorized under the contextual modeling perspective" (Sevinc, 2021, p. 614) and described as a "problem-solving and learning perspective in mathematics education" (Sevinc, 2021, p. 611). In this modeling perspective, what is fundamental to all modeling perspectives is to relate real-life situations to mathematics (Borromeo Ferri, 2018). Simulations of real-life situations are called model-eliciting activities which are defined as "problem-solving activity constructed using specific principles of instructional design in which students make sense of meaningful situations, and invent, extend, and refine their own mathematical constructs" (Kaiser & Sriraman, 2006, p. 306), and as real-life situations where students' conceptual understanding is revealed and evaluated (Sevinc & Lesh, 2018). Therefore, it is possible to claim that MEAs have reflexive and collaborative process.

2.3 Modeling Process

In recent years, mathematical modeling appears as one of the topics that sparks growing interest among the mathematics education researchers (Mousoulides et al., 2005). As previously stressed, the definitions of mathematical modeling were established on different theoretical foundations (Kaiser et al., 2006). Since the approaches are different, mathematical modeling attains different purposes and offers different application types depending on the definitions. While some researchers see the modeling as a paradigm beyond structuralism for mathematics education (Lesh & Doerr, 2003b), in some other perceives, it as a reduction of daily situations into a mathematical language (Haines & Crouch, 2007; Verschaffel et al., 2002).

Although there appears no consensus on the use of mathematical modeling in education among researchers, it is still possible to make a simpler classification within the scope of the goal of using mathematical modeling in mathematics teaching (Erbaş et al., 2016; Galbraith, 2012). It would not be wrong to claim that there are two general approaches to modeling in education, namely “learning by mathematical modeling” and “learning mathematical modeling”. The learning with mathematical modeling is the modeling that is concerned about students developing their own mathematical models and focuses on learning outcomes (Erbaş et al., 2014; Erbaş et al., 2016). MMP is based on the perspective of using modeling as a teaching tool to achieve other curriculum needs or educational goals (Lesh & Doerr, 2003). In other words, mathematical modeling functions as a method and context in the acquisition of mathematical concepts and structures in these approaches. In the learning with mathematical modeling approach, there is a real-life mathematics orientation, and the process during which relevant mathematical structures are created, developed, and generalized is at the forefront.

On the other hand, the learning mathematical modeling approach focuses on helping students learn mathematical modeling and aims to develop students’ modeling skills. While real-life applications of mathematical structures, concepts, and models are included in the modeling, they are considered as objects that can be used in real-life situations (Erbaş et al., 2014). This modeling provides students with real-world problem-solving experience and also aims to help them develop a mental modeling infrastructure where they can be independent users of mathematical knowledge so that they can address problems in the world independently (Erbaş et al., 2014; Galbraith, 2012; Kertil et al., 2016).

Mathematical modeling consists of a cyclical structure that can be evaluated and renewed, which is inherent in mathematics and science, includes professional applications of mathematicians and scientists (Lesh & Zawojewski, 2007; Romberg et al., 2005). During the process of modeling, one switch between real world and mathematics, as the process of modeling begins with a complex real-life situation. The relevant literature clearly reveals that there are different perceptions and approaches towards modeling, and therefore the researchers presented modeling process differently (Blum & Ferri, 2009; Borromeo-Ferri, 2006; Erbaş et al., 2014; Galbraith & Stillman, 2006; Sevinc & Lesh, 2018). Contrary to the traditional problems found in the course books, the process stressing the interplay of real-life and mathematics is not linear in mathematical modeling (Lesh & Harel, 2003).

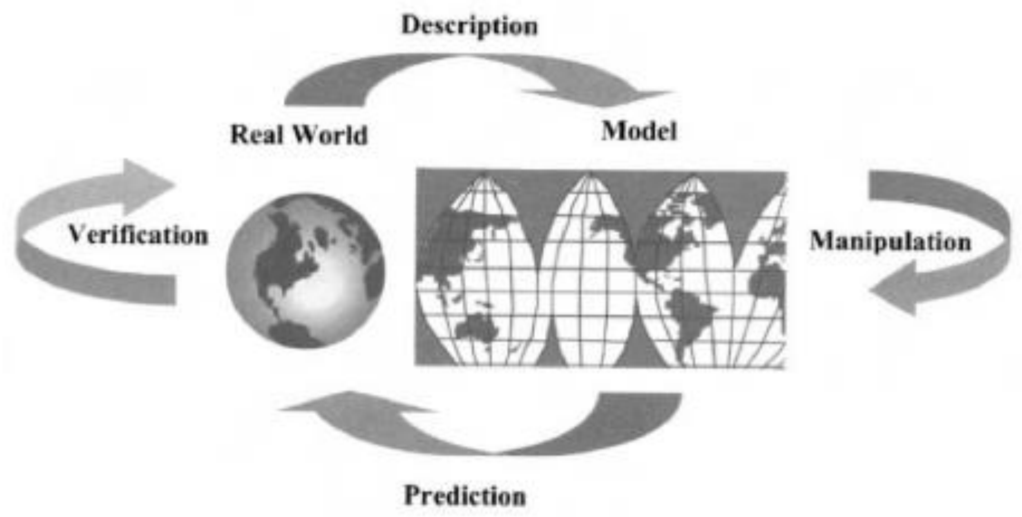

Figure 2.2 Four-step modeling cycle (Lesh & Doerr, 2003, p. 17)

Defining modeling cycles, Lesh and Doerr (2003) referred to four steps: description, manipulation, prediction and verification (see Figure 2.2). According to Lesh and Doerr (2003), these steps include:

(a) description that establishes a mapping to the model world from the real (or imagined) world, (b) manipulation of the model in order to generate predictions or actions related to the original problem-solving situation, (c) translation (or prediction) carrying relevant results back into the real (or imagined) world, and (d) verification concerning the usefulness of actions and predictions. (p. 17)

Apart from Lesh and Doerr's cycle, Ferri (2006) used a seven-step modeling cycle to explain modeling cycle adopting a cognitive perspective (see Figure 2.3). This modeling cycles includes the steps of constructing, simplifying, mathematising, working mathematically, interpreting, validating, and exposing.

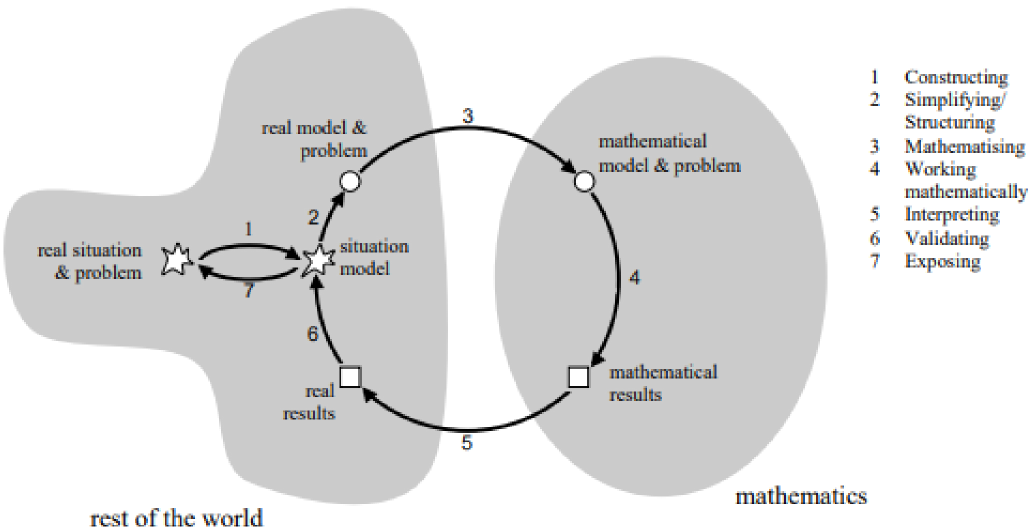

Figure 2.3 Modeling cycle proposed by Blum and Leiß (Blum & Borromeo Ferri, 2009, p. 46)

This modeling cycles include "(1) understanding the real-world problem situation, (2) structuring the situation model, (3) mathematizing to develop a mathematical model, and (4) working mathematically to develop mathematical results that will then be (5) interpreted and (6) validated within the real-world situation, and (7) presented as a solution of the real situation" (Sevinc, 2021, p. 614). It is important to note that this modeling cycle proposed by Blum and Leiß were utilized in the current study. The modeling cycle begins with a real-life problem situation. First, the problem situation must be understood by the problem solver, that is, a mental model of the situation must be constructed. The situation should then be simplified, structured, and refined to identify what needs to be done to solve the problem. At this stage, the variables should be identified and explained.

During the mathematization phase, the relationships between the variables should be determined and defined. As a result of the mathematization process, a mathematical model or models should be created. By working on these models mathematically (e.g., solving the problem using numerical operations, interpreting graphics, etc.), mathematical results are obtained. The mathematical results obtained are interpreted and their real-life counterparts are tried to be explained. Finally, the agreement between real results and mental representations is checked and verified using real-life experiences. Verification also includes checking the transactions made. Verification can also be performed by making comparisons with the data obtained as a result of problem-solving in similar situations or making additional research on the context. If the result obtained is not validated in the real-life problem situation, the cycle is started again.

Doerr (1997) emphasized that interrelations of cognitive operations during a modeling process did not necessarily have to occur in any order, but each of them was in close relationship with each other (see Figure 2.4). Although this statement appears to be a common point of view highlighted by many other studies, Doerr (1997) actually drew attention to the interrelation circularity in the process of modeling, which makes it different from the others (Ferri, 2006; NGACBP & CCSSO, 2010).

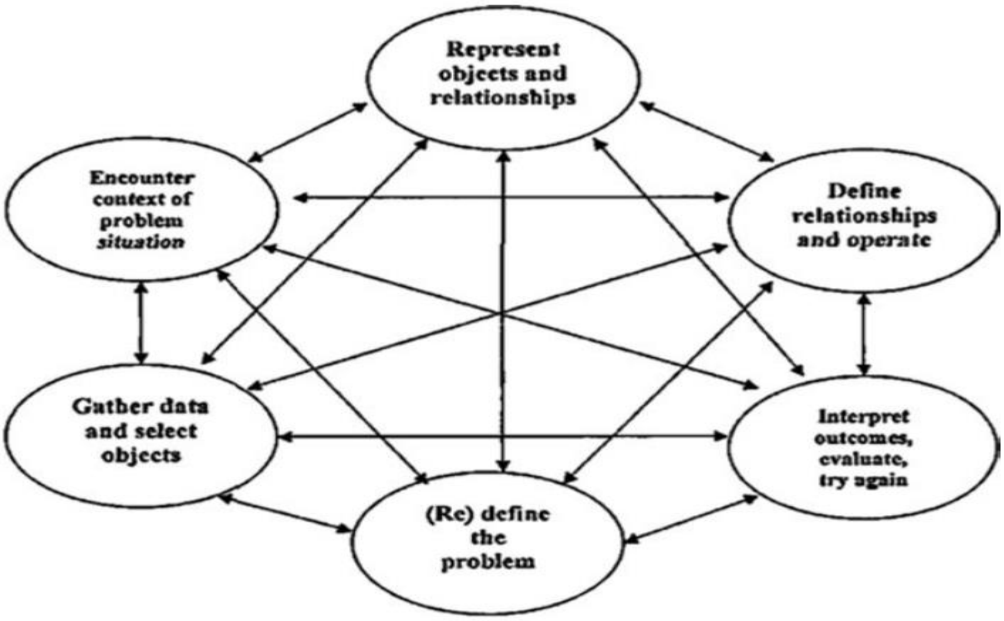

Figure 2.4 Modeling Process (Doerr, 1997, p. 268)

The Figure 2.4 shows that a certain sequence is not strictly followed; there will be transitions from each stage to the next in this model. In addition, Doerr (1997) stated that students matched their perceptions with cognitive models at every stage in the cycle, transformed their models and continued to argue by returning to the perceived problem situation in this model.

In the modeling process of Galbraith and Stillman (2006), there are explanations about seven different stages for individuals who perform mathematical modeling and the transitions between these stages (see Figure 2.5).

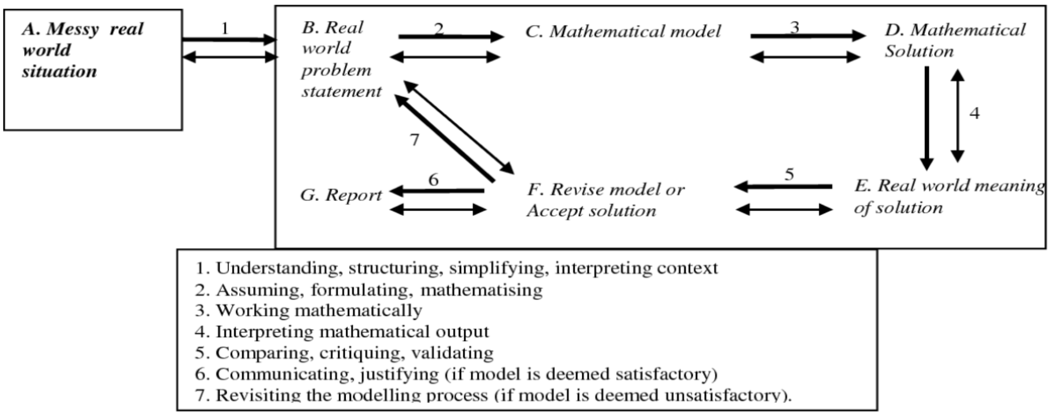

Figure 2.5 Modeling Process (Galbraith & Stillman 2006, p. 144)

As shown in Figure 2.5, the problem-solving process is explained by tracking the arrows around the diagram from the top left clockwise. As a result of successful modeling, if the report or solution is considered inadequate in any way, it results in another modeling cycle. This pattern consists of arrows that indicate the direction of the modeling cycle, as well as arrows pointing in the opposite direction to them. While the opposite arrows underline that thinking is far from linear or unidirectional in the modeling process, it also shows the presence of metacognitive activity that permeates every part of the process. Therefore, metacognitive activity could look both forward and backward due to the stages in the modeling process (Borromeo-Ferri, 2006; Galbraith & Stillman, 2006).

While real situation, situation model, real model, and real result are defined as the “rest of the world” in the modeling process in Figure 2.3, these steps are defined outside the “messy real world situation” in the modeling process in Figure 2.5. There are ordering differences between the modeling steps in both modeling cycles (Figure 2.3 vs. Figure 2.5). In the modeling in Figure 2.5, the constructing and simplifying steps are given before the real world problem situation statement. Furthermore, while the working step comes after the mathematization step in Figure 2.3, the modeling in Figure 2.5 is considered together with these two steps. Apart from these, although there is a validating step in the modeling cycle in Figure 2.3, there is a justifying step in the modeling cycle in Figure 2.5. This shows that the operations performed in the mathematization step in the modeling are verified and checked in the cycle in Figure 2.3, while the operations in the cycle in Figure 2.5 are checked in order to justify. Although both modeling cycles are similar to each other, it is realized that the steps change according to the purpose of the modeling.

2.4 Review of the Related Literature

This part zooms into the studies investigating mathematical modeling processes carried out with primary and middle school students. When the studies in the literature are examined, it has been observed that various studies were conducted on the applications of modeling problems. It is because students can define the simple relationships in nature, apply the models, and realize the potential and limitations of the models. Moreover, students can comment on existing models and switch between the theoretical and practical aspects of mathematics related to modeling and problem-solving while discussing (Blomhøj & Kjeldsen, 2006).

Kant (2011) examined the modeling processes of 8th grade students and aimed to reveal the difficulties encountered in these processes. The mathematical ideas developed by the students to create a model, and the written documents obtained were analyzed using the theoretical framework offered by Stillman et al. (2007). The findings of the study revealed that the students encountered difficulties in the transition between the steps according to the mathematical modeling process.

Şahin and Erarslan (2016), on the other hand, aimed to reveal the difficulties that students faced in these processes by examining the thinking processes of 4th grade students on model building activities. The focus group worked on a mathematical modeling problem called “the Crime Problem.”

The findings of the study showed that on the one hand, students experienced some important difficulties in this process such as understanding the problem and interpreting the data, but on the other hand they made assumptions about daily life and produced ideas.

Besides, English (2004) reported a mathematical modeling application conducted in the second year of a three-year long-term study in which a class of students and teachers participated in mathematical modeling activities from grades 5 to 7. The activity focused on mathematical considerations, such as sorting, weighting orders, selecting, and adding ordered quantities students had applied these ideas in different ways to produce models independent of the instructions. In another study, English (2006) analyzed the conceptual development and mathematization processes of 6th grade students while working with a set of model building activities. The findings of the study revealed that students independently constructed structures through meaningful problem-solving and successfully completed the process. Students' processes of constructing structures operationally included creating systems for describing structures; selecting, classifying, and ordering factors, quantification of quantitative and qualitative data, and involving conversion of quantities.

Mousoulides and English (2008) investigated the mathematical development of students living in Cyprus and Australia while working on a modeling problem. The findings showed that students in these two countries with different cultural and educational backgrounds went through a series of modeling cycles such as applying mathematical operations to deal with the data set and identifying relationships with their tendencies. This study also showed that students in these two countries showed similar approaches in the model-building process. The findings showed that students in both countries simply summed up the amounts presented in each table given in the activity and then ranked the workers. On the other hand, some groups in Australia made the average calculation. Most of the groups focused on relationships within a single table and were often unsuccessful in identifying relationships between different tables.

English and Watters (2004) considered the first year of three-years study that introduced mathematical modeling to young children and provided professional development for their teachers. The analysis of the data revealed that the students showed different levels of development in their mathematization processes. It also revealed that modeling activities were powerful tools that developed important mathematical ideas and problem-solving processes at an early age. In a similar study, English and Watters (2005a) investigated the development of mathematical knowledge and reasoning processes. The findings of the study showed that the modeling problems used to encourage young children to develop important mathematical ideas and processes that they would not encounter in school curriculum. Although some groups had difficulties, students' ability to interpret and use of data tables improved. In addition, in both modeling problems, it was demonstrated that the students used their personal information to explain and interpret the data. Furthermore, it was found necessary for young children to be confronted with mathematical knowledge presented in a variety of formats, including data tables. The study also demonstrated that these modeling activities contributed significantly to the development of young children in mathematical description, explanation, reasoning, and discussion.

Zawojewski, Lesh and English (2003) scrutinized the role of small group work with model eliciting activities to understand the significance of model eliciting activities' and provided initial guidance for implementing these types of activities. In this study, model eliciting activities provided students with opportunities to communicate each other and share their thoughts. Researchers found out that model eliciting activities with small groups led to conservation where productive ways of thinking were preserved over time. Using model eliciting activities in school mathematics classrooms helped students to share their ideas and communicate with each other. Besides, model eliciting activities gave students the opportunities of discussing with each other, so modeling process improved mathematical power in collaboration. All of these findings showed that model eliciting activities with small groups provided alternative ways to think about the real-life situation and communication between students.

In another study focusing on model eliciting activities, Lesh and English (2005) showed that model eliciting activities eliminated the differences between students. In fact, average ability students were capable of developing more powerful models (Lesh & English, 2005). Apart from these studies, there are many other studies carried out at primary and middle school levels, examining the difficulties faced by students (Kant, 2011; Şahin & Erarslan, 2016), students' mathematical and social processes (English, 2004), students' mathematization processes, and students' reasoning processes (English & Watters, 2004). Under the light of all these, it has been thought that the current study will contribute to the relevant literature by examining the mathematical modeling processes of students with different cultural and educational background.

CHAPTER 3

METHODOLOGY

The aim of this study was to investigate a case of Turkish and Syrian seventh grade students' performances in a modeling cycle in their collaborative work on model-eliciting activities. In this section, I mentioned the study's methodology in detail. First of all, I described the design of the study, context, participants, and data collection tools. Following this, I introduced the quality and limitations of the study.

3.1 Design of the Study

Case study is one of the qualitative research methods which gives a researcher the opportunity to analyze and interpret a group, events or relationships in a context. (Cohen et al., 2000). In a case study, researchers choose a limited context, including a person, an organization, a class, a policy, or any unit of study. A limited context also helps a researcher define what is not to include in research. If a researcher cannot specify a limit on the number of participants or the time required for his research, it cannot be considered a case study (Merriam, 1998).

Since each context has a unique and dynamic structure, a case study aims to "reveal the dynamic, complex and unclear relationships of events, human relationships or other factors within a context" (Cohen et al., 2000, p.182). In other words, it examines the events, facts, and relationships between them as a whole. According to Yin (2009), a case study is "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 18).

In this study, the researcher employed a qualitative case study as the research design. In the present study, the case constituted an integrated group of 7^{th} grade students. Since the number of Syrian students in the classrooms was generally less than the number of Turkish students, a small demonstration of the class was made with two Turkish and two Syrian students, and they were asked to work collaboratively.

As mentioned above, the context is important in a case study; therefore I explained the context of the case study in detail below.

3.2 Context

After the civil war in Syria, millions of people left their homes and took refuge in other countries as immigrants. Turkey, one of these countries, is hosting millions of immigrants. Gaziantep is one of the places where these immigrants mostly live. With the integration of the Syrian students into the Turkish education system, it is now quite possible to find immigrant students in many schools. These students are now becoming part of education systems rather than being guest students. Many immigrant students lost their relatives and even their parents or siblings in the war and fled to Turkey. Therefore, the adaptation of students into new school environment in Turkey were not easy due to both psychological and physical conditions. the Syrian students came to Turkey but they did not receive any psychological support. There was no guidance or psychological counselor due to the insufficiency of the current conditions in the school. This aggravates the conditions of immigrant students and even complicates the adaptation process further. Therefore, it is very important to include immigrant students in educational research and projects.

The context of the study was a public middle school in Gaziantep. The school opened in 2011. It was close to the Syrian border, thereby consisting of Turkish and Syrian students. As there was no other school nearby, the building encompassed the elementary and middle school together.

There were approximately 70 students from 1st grade to 4th grade and 130 students from 5th grade to 8th grade. Most of the students, who came to school from different villages with school buses, were from low socioeconomic backgrounds; their parents were mainly farmers and truck drivers. After the spring season, some of the students were not able to attend the school, as they helped their families. Unfortunately, there were so many families that do not want their daughters to be schooled, as well.

The school was located far from the city center. Teachers provided transportation with their own cars. School conditions such as transportation and accommodation were not sufficient. That is why, the school was not much preferred by the teachers to be employed due to its location. There were some students who constantly changed teachers and sometimes attended school without teachers since middle school ages. In terms of mathematics lessons, students were mostly taught by teachers whose expertise were not on mathematics for a long time. Therefore, almost all the 7th grade students were below an average mathematical achievement. Some of the students were not even familiar with basic calculations. Even worse, some of them do not know how to write and read. Especially immigrant students had difficulties in reading and writing.

A math teacher had been employed at the school in 2016. There was only one mathematics teacher out of the total nine. A mathematics curriculum suggested by MoNE was utilized. It was often not possible to teach a course in accordance with the prepared curriculum. The reason for this was that the required background information of the students was not sufficient. On the one hand, the teacher tried to teach lessons in accordance with the curriculum, on the other hand, he tried to make up for the shortcomings of the students in previously-covered subjects.

Within the scope of Fatih Project initiated throughout Turkey, there were smart boards in the school, but the Internet and electricity were too problematic to use them. The researcher had also been a mathematics teacher in the school since 2018.

There were not enough manipulatives and materials to use for teaching mathematics.

3.3 Participants

Convenient sampling and purposive sampling were used in selecting the participants for the study. According to Patton (1987), the purposeful sampling allows a researcher to examine the situations that are thought to provide rich knowledge. Participants of this study consisted of a group of seventh grade students involving two Syrian and two Turkish students selected from two integrated seventh grade classrooms (from 37 students in total). In the classrooms from which the case participants were selected, there were eight immigrant students and six of them had been in Turkey for more than 4 years and they could speak Turkish; however, seven students had difficulty in understanding and interpreting what they read. All students who had difficulties in reading and understanding took a reading course.

The model-eliciting activities were implemented in two 7th grade classrooms, but the data was collected only from the focus group participants involving two Syrian and two Turkish students. While applying activities, the participants were divided into groups of four. There was one group which was determined by the researcher as a focus group. Due to the insufficient number of Syrian students, the number of Turkish and Syrian students in the groups was not equal. Therefore, the researcher formed the focus group from two Syrian and two Turkish students. While selecting the students in the group, attention was paid to include students who could work in harmony with each other and contribute to group work. To make it easier to follow the result of the study, Turkish students were named Burcu and Merve , while the Syrian participants were named Abdullah and Salih. The names attributed to them were pseudonyms. A more detailed information about the case participants was presented in the following.

Table 3.1 Characteristics of the Case Participants and Students’ Pseudonyms

Participants (PTs)	**Class**	**Gender**	**Nationality**
Burcu	7	Female	Turkish
Abdullah	7	Male	Syrian
Merve	7	Female	Turkish
Salih	7	Male	Syrian

The researcher also had detailed information about the participants as he was the teacher of the participants. He collected this information by paying family visits during his teaching period. In the following, a detailed description of the participants in the focus group was demonstrated one by one.

Burcu: She was a Turkish citizen living with her family in a village close to the border. Burcu was very ambitious and a determined student, and she was the youngest of 6 siblings. Because her family did not have a regular income, her parents worked as seasonal workers. Burcu was a student who loved reading books and she could also write beautiful essays.

Abdullah: He fled to Turkey due to the war in Syria, and he had been living in Turkey for about 4 years. Abdullah lost his brother in the war, and some of his relatives remained in Syria. The student was older than his classmates because Abdullah had not been able to go to school for a long time. In general, Abdullah did not talk a lot with his friends, but lived his feelings intensely. Regarding this participant, the teacher said, “On the teachers’ day, the students gave small and big gifts to their teachers. However, Abdullah was quieter than the others in that day. I could not ask about this situation among his friends and I could not see Abdullah again that day. The following day Abdullah came to me with a paper in his hand and gave the paper to me and ran away. On the paper, Abdullah wrote that his writing was bad, so he had asked his brother to help him write about teachers’ day. Although Abdullah’s academic success was very low, he tried to attend the classes regularly. He helped his father after school and his family at the farm where they worked.

Merve: The participant was a Turkish citizen living in a family of 10 siblings, and she attended the school regularly. Since there was not enough room in the house, Merve was staying in the same room with his siblings and parents. Although her academic success was low, she was a very good athlete. She was ranked in the competitions, and she received medals. Although she had a good social relationship with her friends outside classroom, she did not participate in the classroom very much.

Salih: The participant was a Syrian student who attended the school later. Due to the displacement of his family, he came to the school at the beginning of the semester when the study was conducted. Salih lived with his relatives because he lost his mother in the war. Although he could speak Turkish, he had troubles in understanding what he read. For this reason, his academic success was low. The focus group's data was used for the findings in this research. Almost all the students had an average mathematical achievement.

3.4 Data Collection Tools

In this study, video recordings, audio recordings, written works of the participants, and field notes were employed. During the implementation process, two activities were recorded on video, and audio of the focus group was recorded. Every group's written works and field notes were also used as a main data source.

3.4.1 Video and Audio Recordings

Two cameras were used during the implementation process. One recorded the research focus group, whereas the other recorded the whole class. Data was also collected by using the audio recording method for the focus group. The researcher could understand participants' gestures, intonations, conversations or movements better with video and audio recording. In addition to this, video and audio recording enabled the researcher to listen and watch data multiple times. In this way, the researcher had an opportunity to examine the data in detail.

3.4.2 Written Works and Field Notes

The researcher supported the findings with written works of the participants and field notes. The participants' notes and their papers were used for the findings. Moreover, the researcher took notes during the implementation process. The written works and field notes made significant contributions to the findings of the research. They helped the researcher to see the big picture. The diversity of data helped the researcher to obtain the findings in more detail and meticulously.

3.5 Modeling Activities (MEAs)

In this study, MEAs were used as data collection tool. Two different MEAs were adapted to observe the participants. MEAs' contents were presented in the Appendix A. Having different solutions of modeling activities created the opportunity to examine students' problem-solving skills and ways of thinking. The researcher chose activities according to the participants' grade level. The content validity of the 7th grade subjects was taken into consideration when choosing the activities. While choosing the activities, attention was paid to two different topics so that the researcher could have the opportunity to observe the different mathematical thoughts and behaviors of the participants. The "Let's Build Environmentally Friendly Structures with Plastic Bottles" activity was chosen because it was appropriate for the students' real-life situations. The "Summer Job" activity, on the other hand, was chosen because it was used by many researchers in the middle schools (e.g., Larson, 2013; Lesh & Lehrer, 2000; Lesh & Doerr, 2003).

The first activity called “Let’s Build Environmentally Friendly Structures with Plastic Bottles” was taken from Gürbüz and Doğan’s study (2018) (see Figure 3.1).

PET ŞİŞELERLE ÇEVRE DOSTU YAPILAR İNŞA EDELİM

Her yıl bir milyondan fazla hayvan plastik tüketimi yüzünden hayatlarını kaybediyor. Dış etmenlerin etkisiyle parçalanan pet şişeler, mikro plastik olarak doğaya ve doğal yaşama zarar veriyor. Önüne geçilmezse bilinçsiz pet şişe kullanımı doğayı ve yaşamı tehdit etmeye devam edecektir. Oysa kullanılan pet şişelerin hayata kazandırılması için farklı alternatifler bulunmaktadır. Örneğin, pet şişeler özellikle gelir seviyesi düşük ülkelerde ev yapımında kullanılarak dayanıklı ve maliyeti düşük evler yapılıyor. Böylelikle hem ekonomik kazanç sağlanıyor hem de doğa korunmuş oluyor.

Ülkemizde yaşam koşulları dikkate alındığında pet şişeler kullanılarak inşa edilen yapıların inşaat sektöründe kullanımı pek yaygın değildir. Ancak ülkemizde çevre kirliliğine vurgu yapılmasını ve yeniden kullanım konusunda farkındalık oluşturulmasını sağlamak için park ve okul bahçeleri gibi çeşitli sosyal alanlara pet şişeleri kullanılarak yapılar yapmak mümkündür.

Çevre dostu yaşam alanlarının oluşturulmasını sağlamak ve çevre kirliliğinin önlemenin en etkili yolları maddeleri geri dönüşümleri, geri kazanımı ve yeniden kullanımıdır. Bu yüzden “Çevreci Yapılar” adlı bir proje kapsamında okul bahçelerine birer oyun evi yapılacaktır.

Sizden bu proje kapsamında okulunuzun bahçesine bir oyun evi yapmanız istenmektedir. Yapılacak bu oyun evi için kaç adet pet şişeye ihtiyacınız olduğunuzu gerekçeleriyle açıkladığınız bir rapor istenmektedir. (Not: Oyun evinin boyutlarını kendiniz belirleyeceksiniz.)

Not: Pet şişelerin esnemesinden kaynaklanan kayıplar göz ardı edilecektir.

Figure 3.1 Let’s Build Environmentally Friendly Structures with Plastic Bottles

In this activity, the students were asked to build houses using plastic bottles they collected from hotels, restaurants and the surrounding area. In this activity, the students would fill the plastic bottles they collected with soil or rubble and use filled plastic bottles instead of bricks.

The second activity, “Summer Job” (see Figure 3.2), was taken from the case studies prepared by Purdue University College of Engineering website (Purdue University, 2016). In this activity, the students were presented with data tables including the details about the wages of the employees’ working hours and the amount of money they earned (see Appendix A2 for the given data table).

Ahmet geçen yaz bir lunaparkta çalışan öğrencilerin müdürü olarak işe başladı. Öğrenciler parkta müşterilere patlamış mısır ve içecek satarak para kazanıyorlardı. Ahmet gelecek yaz hangi öğrencilerin çalışmasına devam edeceğine karar vermek için sizden yardım istemektedir.

Geçen yaz Ahmet 9 öğrenci çalıştırmıştı. Bu yaz ise 3 tanesi tam zamanlı 3 tanesi yarı zamanlı olmak üzere 6 kişi çalıştıracaktır. Ahmet en fazla para kazanan 6 kişi ile çalışmak istemektedir. Öğrencilerin çalıştıkları saatler farklı oldukları için Ahmet çalışan öğrencileri nasıl karşılaştıracağını bilmemektedir. Çalışma saatleri bu iş için oldukça önemlidir. Örneğin; kalabalık bir Cuma gecesindeki satışlar yağmurlu bir cumartesi gününden daha fazla para getirmektedir.

Ahmet geçen sene çalışma saatleri ve kazanılan paraların kayıtlarını tutmuştur. Ahmet tabloları hazırlarken çalışma saatlerini ve çalışılan saatlerdeki yoğunlukları dikkate almıştır. (Tabloları kontrol ediniz.) Geçen yılın verileri kullanılarak oluşturulmuştur tablolara bakarak Ahmet’in seçeceği kişilere yardımcı olmanız istenmektedir. Seçilecek kişilerden 3 tanesi tam zamanlı ve 3 tanesi yarı zamanlı olarak çalışacağını unutmamalısınız.

Bulduğun sonuçları Ahmet’e mektup yazmalısınız. Mektubunda değerlendirmeni nasıl yaptığını açıkça belirtmeni ve her şeyi detaylıca yazman istenmektedir. Şimdi hangi yolu kullanarak değerlendirme yapacağını bulma zamanı.

Figure 3.2 Summer Job

The students were asked to dismiss some of these employees and to clearly write their reasons for dismissal. Following this, the participants were asked to indicate the method they used to fire the employees. It was stated that the methods of the participants would be used by the employer in the future.

Prior to the implementation, the problems were translated into Turkish and adjusted to suit the Turkish culture and the region of the participants. At the same time, expert opinions were obtained from two different mathematics teachers in order to check the suitability for the student level, language-expression, intelligibility, and cultural harmony.

Validity issues had to be revised as MEAs were translated by the researcher. To review these issues, an English translator, a faculty member interested in mathematical modeling, a doctorate student in mathematics education, and a mathematics teacher were recruited as experts. These experts first checked the relevance and format of the events for validity. In line with the information obtained from the experts, MEAs were reviewed and adjusted for the study and the participants.

3.6 Data Collection Procedure

The researcher took the necessary permissions from the university and school where the study would be implemented. Before the study was carried out, necessary permissions were obtained from Middle East Technical University's Human Subjects Ethics Committee (see Appendix B for ethics committee permission). A pilot study and actual study were implemented after the permissions. Before the actual study, the pilot study was carried out at the beginning of the spring semester of 2019-2020 school year. The changes and procedures were determined by considering the results of the pilot study. According to the findings obtained from the pilot study, the study was rearranged and reviewed for the actual phase. Later, in the 2019-2020 school term, the actual study was carried out with focus group for 2 weeks.

The activities consisted of two parts: warm-up and modeling process for each MEA. In the warm-up part, the participants were given an assignment to read problems outside the school. This assignment included text and corresponding reading questions. The aim of the warm-up part was to enable the participants to make meaningful connections between their real life situations and MEAs. In the classroom, the researcher asked the participants what they thought of the reading text and elicit responses from some students. After that, the researcher distributed the activities containing the problem situation and asked the participants to read it quietly. Once the case participants read the problem statement, one of them often read the statement aloud. The researcher initiated a discussion about what the activity required. Thanks to the discussion, it was ensured that the subject and problem situation were understood by the participants before initiating the study.

The duration of the activity was determined as two class hours without a break. To determine the length of this period, the students' ideas were also taken into consideration. At the end of the event period, the case participants were expected to write a letter about their models, as stated in the directions of the activity. The researcher's role was to become a facilitator throughout the event so that the creativity and productivity of the participants were not intervened by the researcher.

3.7 Data Analysis Process

Data analysis is one of the most difficult stages for qualitative researchers. It is the process of gaining the meaning of data (Merriam, 2009). It is not an simple process even for experienced researchers to present the findings obtained as a written report by analyzing the collected data (Yıldırım & Şimşek, 2005). There are different concepts and approaches in the literature on the analysis of qualitative data. However, what is common to all these approaches is the significance attached to the description of the data and the determination of categories. It is also important that the researcher's comments and the associated categories are meaningfully associated. The main purpose here is to reach the concepts and relationships that can explain the data obtained. For this reason, the data is conceptualized first, then it is arranged in a logical manner according to the concepts emerged, and the categories that describe the data are determined accordingly (Yıldırım & Şimşek, 2005). The basic process in content analysis is to gather similar data within the framework of certain concepts and categories and to organize and interpret them in a way that the reader can understand.

Bearing these in mind, the researcher examined all the video and audio recordings obtained during the study without forgetting the purpose of the research. The researcher decided on critical behaviors, students' blockages, and how they changed from MEA-1 to MEA-2. The findings were supported by the notes collected during the event and the notes of the participants.

Before analyzing the data, audio record of focus group work was transcribed. Written transcripts, solution papers of the students gathered during the modeling process of each group, and observation notes were examined. Highlights were recorded. Audio and video time intervals were examined repeatedly to find critical behaviors and patterns. The patterns derived from these difficulties and critical behaviors were divided into codes. For the analysis of the data, firstly, the relevant studies in the literature (e.g., Blum & Borromeo Ferri, 2009; Doerr & English, 2003; English, 2004, 2006; Lesh & Doerr 2003) were examined. Second, the codes were determined, and lastly a pre-code list shown in Table 3.2 was created.

Table 3.2 Preliminary Code List

Preliminary Code List
• Understanding situation of problem • Configuring the problem's situation • Making problem's situation simple • Explication of the content • Understanding the tables, graphics and verbal information, and making inferences from them • Presenting an opinion for model • Deciding on model

Table 3.2 (continued)

- Hypothesizing
- Practicing model
- Mathematical processes used for problems
- Transition period (between qualities and quantities indication figures which are used
- Explication of table data
- Mathematical ideas which are used
- Explication of mathematical outputs according to real-life situation
- Criticizing
- Evaluation
- Revising model/repeating modeling process
- Accepting model
- Reporting
- Getting understand situation of problem
- Making configuration problem's situation
- Making simple problem's situation
- Explication of content
- Getting understand tables, graphics and verbal informations and making inference from them
- Presenting an opinion for model
- Deciding on model
- Practicing model
- Hypothesizing
- Mathematical processes used for problems
- Transition period (between qualities and quantities indication figures which are used
- Explication of table data
- Mathematical ideas which are used
- Explication mathematical outputs according to real life situation
- Criticizing
- Evaluation
- Revising model/repeating modeling process
- Accepting model
- Reporting

Some of the data were interpreted and coded by two researchers with the help of the codes in the table. After the remaining data were coded by the researcher according to the codes in the table, the codes not used in the table were removed from the code list. The remaining codes were organized, and the category list given in Table 3.3 was prepared.

Table 3.3 Categories, Codes and Descriptions

Categories	Codes	Description of Categories
Understanding the Problem Situation	• understanding the situation of problem • configuring the problem's situation • making the problem's situation simple • explication of the content • understanding the tables, graphics and verbal information and making inferences from them	Reading the given problem's situation by students; debating process about what is given and requested in problem's situation; simplifying the givens, explication the content, and inference about givens
Presenting Idea(s) for the Model	• presenting an opinion for the model	Before making mathematical calculations, initial opinions presented by students
Mathematization	• hypothesizing • mathematical processes used for problems • transition period (between qualities and quantities) • indication figures which are used • Explication of the table data Mathematical ideas which are used	Students' stating real life problems as mathematical, and working on it as mathematical
Evaluation, Interpretation and Retry	• Explication of mathematical outputs according to real-life situation • Criticizing • Evaluation • Revising the model/repeating modeling process	Students' explication of mathematical opinions, evaluating them; trying again by changing the false ones
Evaluation and Interpretation	• Explication of mathematical outputs according to real-life situation • Criticizing • Evaluation	Students' explication of mathematical opinions and evaluating them
Creating and Exposing the Model	• Deciding on the model • Practicing the model • Accepting the model reporting	Students' creating the decided the models and reporting modeling processes

It is important to note that this revision process of pre-code list to final code list was guided by Blum and Leiß's modeling process (Blum & Borromeo Ferri, 2009) modeling process explained in the previous section in detail (see Figure 2.3).

3.8 Quality of the Study

In this study, triangulation method was used to ensure the credibility of the data analysis. The triangulation is a method where more than one data source, method and theory might be used (Creswell, 2007). In the current study, video and audio recordings, field notes, and the participants' writings about the event were used as multiple data sources. Findings from different data sources were compared to each other to make sure that they were consistent with each other. Other factors that demonstrate the validity of the study are long-term observation and adequate participation (Creswell, 2007; Merriam, 2009). Therefore, the study was carried out for four weeks. This working time was sufficient to learn the participants and learning culture formed in the process. In addition, this period allowed the researcher to collect more accurate and detailed data about the desired phenomenon.

The position of the researcher is important in qualitative methodologies for the interpretation of the target phenomenon without bias (Creswell, 2007). For this reason, the researcher might state assumptions, biases, and dispositions in research to ensure the credibility of the study and to enable readers to better understand how interpretation of the findings is achieved (Merriam, 2009). In this study, the researcher was the actual teacher of the participants. Therefore, the course and nature of the course were not affected during the research. The participants expressed their ideas easily, because they knew the researcher and carried out their work in a free environment. The researcher's recognition of the participants allowed him to make more accurate and reliable observations. The fact that the researcher was also the actual teacher of the participants made the participants very comfortable. Therefore, some undesired chatting took place between some participants. To prevent such distractions, the researcher warned the participants who chatted or disrupted the flow of the study.

CHAPTER 4

FINDINGS

In this section, the findings of the focus group's mathematical modeling processes are presented in the order of application of the mathematical modeling problems named “Let's Build Environmentally Friendly Structures with Plastic Bottles” and "Summer Job”.

4.1 Let’s Build Environmentally Friendly Structures with Plastic Bottles MEA

In this activity, the students were asked to build a playhouse in the school garden using plastic bottles, one type of the recycling products. The students were expected to find the number of plastic bottles required for the playhouse they designed. The students in the group produced solutions according to the situation given in the activity.

4.1.1 Initiating the Modeling Cycle: Making Sense of the Situation

Modeling cycle includes the processes in which students begin to put forward their initial ideas in order to understand and mathematize the real-life problem situation when faced with a problem situation.

> Burcu: I realized that a playground should have been built in our school.
> Abdullah: We will build a playhouse, not a playground.
> Burcu: Where is it written?
> Merve: Look, it says here that you are asked to build a playhouse in the garden of your school within the scope of this project.
> Burcu: Yes, I haven’t seen it.

Merve: We are asked to build the playhouse using bottles. I think we will collect the bottles to keep the environment clean.
Burcu: Yes yes, we need to use bottles. What do you think guys?
Merve: I think you should give your opinion, too.
Abdullah: I think we also need to build using bottles.
Burcu: Then, if we are going to use the bottles, we have to decide on the size of the bottles?
Merve: I think so, too.

Merve also read the question aloud and listened to other friends in the group during the process of understanding the problem. Modeling cycle starts with understanding the problem situation. Turkish students reading comprehension level was higher than Syrian students, so they could make sense of the problem better and helped the Syrian students in the step of cycle. The participants started to discuss what they understood from the problem situation in the group after a period of silence. They tried to decide on the size of the bottle to be used. As it can be understood from the dialogue above, the students started talking about the size of the bottle without making a plan for the solution. As the students were aimed to do matematization, they mathematically set the quantities involved in the problem and needed for the solution. Hence, although the students did not have a solution plan yet, they tried to determine the data they would use.

Burcu: But first we have to decide on the building size. I don’t think we should make the building big.

Merve: Why?

Burcu: Because, in a big construction, while we build one, the other side can be destroyed. So, it can be long in length and small in width.

Merve: I think we should decide on which bottle to use first.

Burcu: How many liter-bottle size do you think we should use?

Abdullah: 1.5.

Merve: 2.5.

Burcu: I think we should use half-liter bottle size.

Merve: Then lots of bottles would be required, but instead we could use large bottles to finish the construction quickly.

Burcu: Yet, I think the most used bottles are half-liter bottles. It can be found more easily. In daily life, even at school, half-liter bottles are more, but other bottles are not easily found. The number of bottles we need is quite high, so I think we should prefer half-liter bottles. Otherwise, the construction may have to stop after a while. Besides, we will keep the environment cleaner as we collect more bottles. And look, there's even a half-liter water bottle on our table.

As it is apparent in the conversation above, Merve and Burcu had different ideas about the size of the bottles. When choosing the size of the bottle, the students evaluated it in terms of size and availability. Merve stated that small bottles were not useful, so large bottles would be more efficient. It can be seen that Merve held the idea of using larger sized bottles to increase the speed of building and reduce the construction time of the building. Burcu, on the other hand, explained why half-liter bottles were useful, based on mathematical data analysis. The students exploited both mathematical data and daily life situations while making their decisions.

Students tended to take the decision that was appropriate depending on their perspectives. It has been observed that Syrian students often did not participate in group conversations, while Turkish students were trying to get Syrian students to participate in the conversation. The process of deciding the bottle size was based on associating the problem situation with the daily life situation of the students. Turkish students in the group were initially checked several times whether there was information about the size of the bottle in the problem text. In the Turkish education system, problems that require establishing a relationship between what is given for students and what is wanted from them are frequently asked. This might be the reason why the students searched for the information they needed to use in case of a problem in the question. Syrian students, on the other hand, did not participate much in this process.

Abdullah: I also agree.

Burcu: Salih, why don’t you express your thoughts?

Salih: I think everyone should come up with an idea for himself, then let’s choose the good idea.

Merve: Then there is no point in being a group. We are asked to do it as a group. You can also speak your mind.

Burcu: Besides, I think small bottles will be more advantageous than other bottles in terms of durability since they will be closer to each other.

Merve: Now that we have determined the bottle, let’s decide what kind of structure we will make.

Merve: Let’s go back to a question first and look at the question again.

Burcu: It would be nice if we could use the small bottles. Because in case of an earthquake, the caps of small bottles are opened less than others.

Abdullah: Do we need to consider the earthquake situation?

Burcu: Of course we have to consider all situations.

As the conversation above clearly shows the students established a general relationship, considering the questions asked in the problem situation. They decided the type of the bottle by discussing the dimensions of the building. In the decision-making process, the students made questioning according to the situations they might encounter in daily life. One of the Syrian student also thought about earthquakes because of the earthquake they experienced. Burcu said that close bottles with small volumes would increase durability although there was no topic related to resilience in the school curriculum.

In addition, students tried to encourage each other to increase the participation in the group. Students who made individual efforts in exams and similar applications were asked to find a result as a group in this process. This actually increased the dialogue among the students and allowed them to see each other as teammates rather than rivals. After that, the students moved on to the process of developing the structure they were going to build.

4.1.2 Pursuing the Modeling Cycle: Mathematizing the Situation

This stage of the modeling cycle includes the processes of evaluating the ideas presented by the students in order to mathematicalize the given problem situation, interpreting, retrying, and trying to understand the problem situation by returning to the problem when necessary; therefore, it was presented in parenthesis in the flow of the modeling cycle, and creating the models.

At this stage, the students struggled to decide on the dimensions of the building they would build by using the dimensions of the bottle they decided on.

> Burcu: First, let’s look at the size of the bottle and decide on the building accordingly.
>
> Salih: We should measure its base.
>
> Merve: You measure the size of the bottle first. What is the height of the bottle?
>
> Burcu: Shall we round 19.38?
>
> Merve: I think it will be easy when calculating, let’’s round it up.

Here, the students tried to provide ease of operation by using rounding in numbers. Meanwhile, Merve stated that the height of the students at the school need to be measured. As can be seen from the dialogue above, although Saliht thought that it was necessary to measure the bottom of the bottle, Merve asked about the height of the bottle. Here, it was seen that the students planned to construct the structures differently. Later in the study, the students focused on the bottom of the bottle. However, at this stage, Salih’s opinion was not taken into account. The reason for this could be that Syrian students could not explain themselves very well.

Merve: Convert that measure to meters.

Burcu: Okay, I'll translate. 5x20=100. Was it a hundred centimeters or a meter? Ask the teacher.

Merve: Sir, isn't a meter a hundred centimeters?

Teacher: One meter is equal to 100 cm.

Burcu: If 100 cm is equal to one meter…

Merve: We need billions of bottles.

Abdullah: No, you don't need that much.

Burcu: I think we should determine the size according to the number of students.

Here, the students asked the teacher about the number of students in the school. It was seen that they took the average of the student's heights to determine the necessary dimensions for the building. However, although the averages they accepted were not the true averages of the students at the school, they reached this conclusion by estimating. The students continued their studies with the values they had predicted.

Turkish students tended to ask the teacher questions when using mathematical knowledge or when they could not remember the necessary mathematical operations of the subject they wanted to use. Syrian students, on the other hand, tried to find a solution to the problem situation without asking questions to the teacher by using their existing knowledge. The students confirmed the process required to make the average by checking their books. Afterwards, they asked the teacher about this information and make calculations. Turkish students asked the teacher questions to use the information they had learned to solve the problem and to check the accuracy of this information.

Merve: The dimensions we have determined should be proportional to each other.

Burcu: Yes, I think it can be more robust if we make it proportional.

Merve: For example, if we make it 5 meters tall, its width should be 3 meters.

It is seen that the values determined by the students were more often based on assumptions rather than mathematical calculations. The students agreed that they needed to pay attention to the average height of their height during the decision stages. In the meantime, they realized that the averages they took in the above quotations were estimates and decided to calculate the averages within the group.

While calculating the mean, the students used mathematical features such as rounding and approximation for the convenience of the operations. While estimating and rounding, the students discussed in the group with justification. Before the study, the students learned the mode, median, and mean subjects in the data analysis in the classroom. It was thought that the students tried to associate the problem situation with the subject they had learned. However, mistakes made in calculations and operations caused different results. The students especially had difficulty in the division process and found the value by rounding the result they reached. In addition, another observed situation during the process was that when students had operational difficulties, they started to think that the path they had taken was wrong, and they tended to look for different ways for a solution. In general, the students tried to find solutions to the problem situation by using their current mathematical knowledge.

Burcu: We need to calculate the average.

Merve: To do this, we need to know everyone’s height

Abdullah: Let’s take the average of our heights instead.

Salih: However, we are in middle school. How do we find the average of students in elementary school?

Burcu: We approximate their average. After all, their average cannot exceed us.

Abdullah: Yet, there are students in elementary school who are taller than middle school students.

Merve: However, they are either written late or they are up to grade repetition. I think everyone should tell me their height.

Burcu: The sum of our heights is 175+158+163+139= 635. If we divide this by 4, it becomes approximately 158. Actually, there are some decimal numbers, but I cannot calculate it now.

The students found the mean of the group, because they thought it was difficult to find the mean of all the students in the school. According to the group average, they aimed to obtain information about the school. It can be suggested that the students made a general approach from a particular to a general approach. This idea was put forward by Abdullah. To calculate the average, Turkish students thought about determining the height of all students in the school and calculating. Here, Turkish students thought that all participants, whose average wanted to be calculated, need to be included in the calculation. On the other hand, Abdullah aimed to obtain information about the average in the group and the school in general. Turkish students had frequently been given exams and quizzes on the subjects they learned. In these exams, information about data was given clearly and students were expected to make calculations using this data. In this study, the students aimed to determine their data group and obtain information about the determined group, which was reasonable from the researcher's perspective. Calculation of the average height of all students in the school would take a lot of time to find and calculate the height values of the students in the school. It did not seem possible to make this calculation during the duration of the study.

The students tried to determine the dimensions of the playhouse they had planned to build with the group average. However, it took a long time for the students to decide on the dimensions of the building using the average.

> Abdullah: You stop calculating the average. Let's do it for the longest.
>
> Burcu: Let's write it anyway. "Write everything clearly," said the teacher.
>
> Salih: OK.
>
> Burcu: Let's use proportion, but I don't know how to do it.
>
> Merve: Let's define the width
>
> Abdullah: 2.5m
>
> Salih: 3m
>
> Merve: 2m.
>
> Burcu: Let it be 3 m
>
> Merve: All right.
>
> Salih: Write 3 m.
>
> Burcu: I now take it as 3 meters.
>
> Abdullah: Length 2 m.
>
> Merve: 2 m.
>
> Burcu: Now I'm going to make a ratio, but if we were getting 100, I don't remember exactly what we were doing.
>
> Merve: We were multiplying.
>
> Burcu: 2 times of 3 is 6, 2 times of 2 is 4, 2 times of 6 is 12, 2 times of 4 is 8. It will go on like this, it's best to ignore the ratio.

As can be seen in the quote above, the students tried to decide by making mathematical calculations, but they continued by guessing, thinking that the operations they had been done did not give them a correct result. Turkish students generally tried to relate them to the subjects they had learned in the decision-making process. It was observed that they tried to present a justification for the actions taken based on the information they had learned. However, they constantly changed their minds because they were hesitant about how to use the data and the actions to be taken. As the conversation above demonstrates, the decisions made by students were not deliberative in final step as the time of the project decreased. Salih thought that the average would not be appropriate because he thought the outliers were different from the mean and thought that it would be a suitable value for everyone if they took the tallest student as a reference. Since the mean value gives information about the overall group, it becomes difficult to evaluate extreme values. Salih might have thought that building dimensions were calculated according to extreme values and thought that it was unnecessary to make an average. Turkish students, on the other hand, tried to decide on the building dimensions by considering the ratio-proportion issue. However, the determined values were decided without any mathematical justification. The students could not remember exactly what the operations on the ratio-proportion were, and they checked this in their books. Turkish students tended to get help from their books and teachers in the procedures to be done. On the other hand, Syrian students made an effort to find solutions by using their existing knowledge. Turkish students especially tried to associate them with the subjects they had just learned.

Furthermore, some expressions used by the students showed deficiencies in mathematical knowledge. The students could not decide where to use the results of the mathematical operations they had done.

> Merve: Can you fit in a place less than 10 meters tall?
>
> Burcu: I can’t fit.
>
> Merve: Then it should be greater than 1.60.
>
> Abdullah: So, let’s take it as 1.70
>
> Burcu: One minute. Let’s call the length 3, let’s call it 2, too. Let’s say 60 a x. 3x +60 times 2 though. It becomes 40, but what did I find?
>
> Merve: I think let’s say 1.80 in height, and it’s over.

Salih: Let's increase the width and decrease the length.

Abdullah: Let's find out how many bottles we need for a wall using the dimensions of the bottle.

Merve: We need thousands.

Because the duration of the activity decreased, the students rushed in their decisions. As can be seen from the example above, students did not know why and for what reason they did those calculations. Besides, the students presented ideas about different subjects at the same time in the group. However, the ideas were presented without relying on mathematical justification. Since mathematical problems are generally solved by using operations, it is thought that students try to justify themselves by doing operations. The students showed similarity in the exams held at schools. The students tried to justify their results by writing operations in case of problems that they could not perform.

Burcu: Ok, let's draw a shape and do calculations on it.

Merve: Okay, I am drawing.

Abdullah: I will help you.

Burcu: I also find the base circumference of a bottle, we learned this in our previous lessons.

The students discussed the dimensions of the building for a while in the group. Afterwards, they measured the dimensions of the classroom with the help of meters, getting permission from the teacher. There was a large ruler in the classroom but Another group was using the only ruler. When Salih stated that he could measure the classroom by footsteps, Turkish students asked him to measure with a ruler. However, it was not obligatory to use only a ruler as a measuring tool. Salih tried to do what was faster and easier. In addition, the information given to the students in the length questions was usually numerical data. The students were asked to perform mathematical operations using this data.

The students worked on the drawing for a while and tried to calculate the number of plastic bottles needed to construct the building, whose image was presented in Figure 4.1.

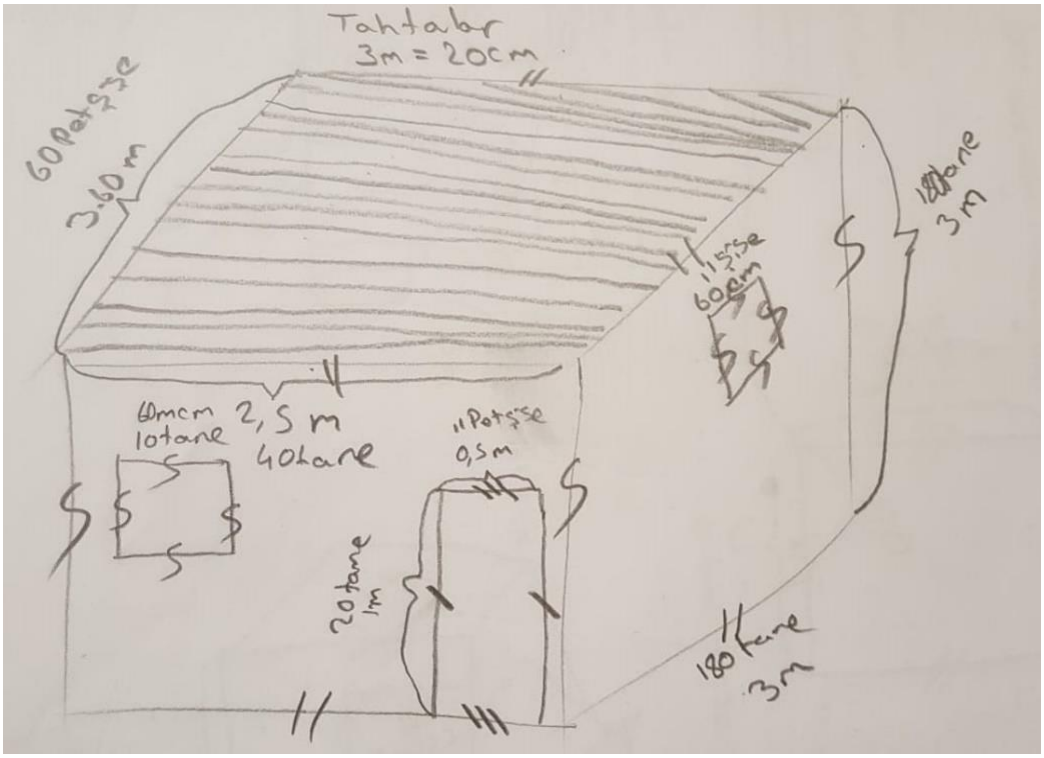

Figure 4.1 The visual that the students drew for the dimensions of the building.

The students used their knowledge of a building from daily life in developing a model. The stages of determining the building dimensions were not clear. There were differences between the dimensions of the plastic bottle they used and the dimensions specified in the drawing. The students did not use the mathematical data they obtained by discussing it in the group. They took real-life situations into account, such as the volume of the bottle to be selected, the material to be used to fill it, the size of the building suitable for school students. It was observed that the students more often noted down the calculations they had made but they could not establish a relationship between them.

Salih: How wide is a bottle?

Burcu: 5 cm.

Merve: Then let's find out how many bottles are needed for one meter?

Burcu: Since 100 cm is a meter, wouldn't the number of bottles required for one meter be 20?

Abdullah: Isn't it 7 meters that we set as the maximum?

Burcu: Yes.

Salih: Then let's calculate based on this value.

Burcu: Now, see if 15 bottles are required for 1.5 meters, let's find the number of bottles required for 7 meters by proportion.

Although the students used the correct mathematical method, they did the calculation incorrectly (see Figure 4.2). The students tried to make the necessary calculation for the width.

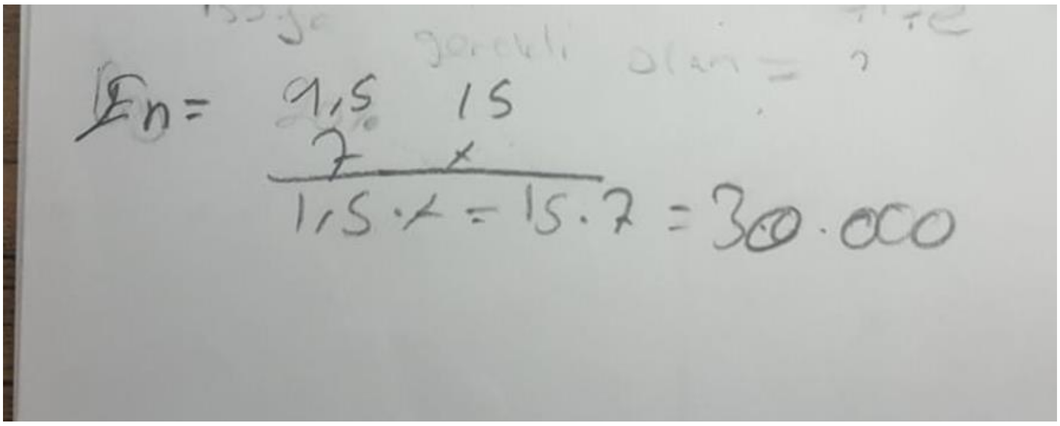

Figure 4.2 The image of the calculation made by the group using ratio and proportion

However, they did not check the accuracy of their results. The students found only one edge length of the wall, but they thought that the result they found represented the area of the wall. The students could not see the relationship between edge and area. The mathematical calculations they had made did not seem to be related to the model they had drawn above.

This showed that the students only did mathematical calculations to find a result. It was thought that with the decrease in the time, the students were in a hurry and they wanted to reach a result before the time run out, as the following dialogue demonstrated.

Burcu: How do I divide 105 by 1.5?

Merve: We can’t bother division it for two hours now.

Abdullah: Ask the teacher.

Salih: Stop asking the teacher.

Burcu: What if you could count on the figure you drew.

Merve: How will I count?

Abdullah: Let’s write a number in our head.

Contrary to the previous conversations, Abdullah might have thought that it was necessary to ask questions to the teacher in the conversation above. Salih, on the other hand, said that asking questions must be passed, and a conclusion must be reached. It can be seen that students tried to reach a numerical result by performing mathematical operations. In the meantime, it was realized that they struggled to get away from the problem situation and to achieve more results. It was determined that they continued by taking the approximate values of the mathematical operations, not the results of the operations they had done. It was also determined that the students moved away from the building dimensions they had decided by drawing and continued with the dimensions in their speech.

Burcu: Not just by looking at the width and height.

Merve: Why?

Burcu: We will create a wall with these bottles.

Merve: So?

Abdullah: Will the middle of the wall be empty?

Burcu: No, the middle of the wall cannot be empty.

Merve: What do you mean?

Burcu: We need to calculate the area of the wall.

Merve: Calculate then.

Burcu: We multiplied what and reached 30 000.

Merve: We made a ratio and we found 30 000 there.

Salih: I found 25 000.

Merve: Just wait. We need to write a number which is not important now.

Burcu: We need to write more reports.

Merve: Come on, let's write a number out of your head.

Burcu: But it's not like that.

Abdullah: Just look at it, the time is running out.

Merve: I'm starting to write the report.

Here, the students tried to reach a conclusion by performing a few mathematical operations. The students saw the relationship between the edge and the area and realized the mistake they had made. At the point of calculation, the students found a number without basing the result on mathematical calculations. Afterwards, the students tried to report the numbers they had obtained in the group. The students concentrated on reporting their work. In the meantime, the decisions were taken and the applied process was made without evaluating it within the group. The researcher thought that the studnets' concerns for the time stemmed from the exams and applications performed during the education and training process. There was only a process of finding a result, leaving the effort to find a result and the processes and products of the studies for this.

It was observed that the students did not discuss and interpret the data they gathered from the model they created. It was also observed that the students could not use the values they collected from a particular model that they constantly changed.

However, the students generally tried to relate the values they were trying to achieve to daily life. The work done by the students during this activity was summarized in Table 4.1 in terms of mathematical modeling.

Table 4.1 Summary of the Group's Modeling Cycle for the Let's Build Environmentally Friendly Structures with Plastic Bottles Problem

Stages of the Modeling Cycle	**Categories**	**Modeling Process**
Initiating the Modeling Cycle	Encountering and understanding a real-life problem situation	-Reading and trying to understand the problem situation
	Presenting the idea(s) for the model	-Prediction of the size of bottle -Using real data (size of bottle, and classroom)
Pursuing the Modeling Cycle	Mathematization	-Data collecting (groups height) -Measurement (classroom size) -Arithmetic mean (average of the groups height) -Approximation (size of bottle and game house)
	Evaluation, interpretation, and retry	Evaluation, interpretation, and retrying by experimenting with ideas introduced in the mathematization (e.g. arithmetic mean of of height of group, aprroximation of size of bottle, number of bottles-size of game house ratio)

Table 4.1 was a summary of the work done by the students in the modeling activity. In this table, it is understood that the students understood the real-life problem in initiating stage of the modeling cycle and used the estimation and real data for the model. The presentation of ideas for understanding and solving the problem in the initiating stage was mostly done by Turkish students. Syrian students did not contribute much at the beginning of the study. Turkish students considered their daily life situations to find the size of the bottle they could use to solve the problem.

In pursuing modeling cycle stage, the mathematical operations that the students made for the model were measurement, data collection, arithmetic mean, and approximation. However, the students could not make sense of the mathematical operations they used for the model. The mathematical operations performed by the students could not go beyond the process. The relationships between the obtained results could not be established. It was observed that the students moved away from the problem situation after creating a model and tended to find results. With the decrease in the activity period, it was understood that the students evaluated the results they found only numeric, and they did not establish a relationship between the results and the problem situation. In pursuing modeling cycle stage, Turkish students tried to associate the operations they did with the subjects they learned. Turkish students tended to ask the teacher questions where they had difficulty at this stage. They tried to decide on the dimensions of the building to be built by establishing a relationship between their daily life situations and the mathematical data they obtained. However, Syrian students participated more in this stage. They joined more in the conversations taking place in the group. For the solution of the problem, they tried to make a general interpretation by using the mean value within the group. In addition, Syrian students worked in cooperation with Turkish students in the processes necessary for problem-solving.

4.2 Summer Job MEA

In this activity, the students were asked to dismiss a few of the workers working at the amusement park. Working hours and earned wages were written on the two different tables given to the students. In addition to that, the students were expected to report the method they used to dismiss.

4.2.1 Initiating the Modeling Cycle: Making Sense of the Situation

The students first read the problem situation individually and started to examine the table as a group without discussing what they understood from the problem situation. Before the group work started, Merve asked the teacher about the table and assumed the summer working hours as the number of people. The students first tried to make comments by looking at the values given without paying attention to the table's name. The students, who were examining the tables together with the teachers, started to argue about the tables after a while. In order to understand the problem situation, the students read the study aloud in the group and tried to understand it together. At this stage, the group worked as a whole, and all the students in the group contributed to the understanding of the problem.

Abdullah: What should we write here?

Merve: First, we should try to understand the tables.

Burcu: I agree with you.

Merve: They gave two tables.

Burcu: The table above is about working hours and the following is about the money they earn.

Salih: How so?

Burcu: For example, Alim (an employee given in the data table) worked 12.5 hours and earned 690 liras in return.

Salih: Can I have a look at it, too?

Merve: Sure.

The students tried to understand the given tables as seen in the dialogue. They tried to establish a relationship between the information given and the table. Once the students grasped the problem situation, they commented on the data given for the month of June.

Merve: Who worked the most in June?

Salih: Working times are changing.

Burcu: I think we should add up and divide the working times. So, let's find their average.

Abdullah: I think everyone should look at one person.

Merve: I will find Sumeyye's (an employee given in the data table) average.

Burcu: I will find Zehra's (an employee given in the data table).

Abdullah: Alim (an employee given in the data table)

Burcu: Everyone hurries up.

Merve: Average 28.

Burcu: Write in the corner.

Abdullah: I found 29.5.

Merve: How?

Burcu: You need to find the mean.

Abdullah: You told me to collect it. You didn't say I had to do the division.

Merve: But you have to find an average. You need to divide the numbers you have collected by how many numbers you have in total.

Burcu: Whose values did you collect?

Abdullah: Alim.

Merve: You miscalculated the sum of Alim's values.

Burcu: When adding decimal notations, commas should be one after the other. Total …

Merve: 36.5.

Burcu: I think we will find decimal numbers.

Abdullah: Are you serious?

Burcu: Should we try another way?

The students tried to calculate the average of the working hours of the employees by using the data in the table. They were expected to establish a relationship between the average and the wage. Abdullah stated that he did not know how to calculate the mean, so Merve helped him. While comparing the averages they obtained, they encountered recurring decimal notation. Since they did not know how to calculate recurring decimal notation, they tried to find another solution to the problem. The students could not continue the strategy of finding average of working hours they were trying to implement due to their lack of mathematical knowledge. As in building game house activity, the students could find the average of their working hours using approximate values. Thus, by finding the wages earned per hour, the students could comment. The students thought of other solutions because they had difficulty in finding the average of working hours because of decimal numbers.

> Salih: I think we should sort and decide.
>
> Merve: How?
>
> Salih: Let's look at the sum of their income and sort. Then we decide according to the data we get from there.
>
> Abdullah: I think it makes sense.
>
> Burcu: Yet, income alone is not important. There are also crowded, normal, and quiet times of the amusement park. It's not as easy as you think.
>
> Merve: Let's try, but it's pointless.

The idea of collecting and sorting the money earned by the employees was presented by Syrian students. On the other hand, Turkish students thought that the amusement park had different situations depending on whether it was crowded and quiet, so the data obtained would be meaningless. The students considered looking at the relationship between the working hours and the earned money. However, it was not clear whether they would calculate the money earned per unit hour or the total money in the study to be conducted. In this process, the working hours of the employees in the amusement park and the crowdedness of the amusement park were neglected. The students thought that the work done after a while was a waste of time. The reason for this might be that there was more than one variable in the data table, and the students ignored these variables and thought on the total.

> Burcu: There are working hours and many variables depending on whether the amusement park is crowded or not. We can't just collect coins and decide.
>
> Merve: I also agree with you Burcu, because it would be unfair to look at it only with money.
>
> Burcu: Do you care about it? The Alim worked for 12.5 hours when it was crowded.

Merve: He earned 690 liras. Let's divide 690 by 12.5.

Abdullah: Why are we dividing?

Burcu: I think everyone should have their own opinion.

Salih: I think we should add up money and divide it into hours.

Burcu: Information about crowded and normal quiet times is given in the table. Let's see Alim worked 12.5 hours in the crowd in June and earned 690 liras. Fatma (an employee given in the data table), on the other hand, earned 474 liras in 5.5 hours. There is a huge difference in working hours of Fatma and Alim, but the difference in the money they earned is not that much. That's why Fatma worked better here.

Merve: Let's find the hourly wages.

As can be seen in the dialogue above, the students decided that sorting was not the right decision, so they worked to find the wages earned by the employees in an hour. The students aimed to find the money earned in an hour by dividing the total amount of Salih money by the working hours. Salih was making comparisons here by dividing two quantities; in other words, he was using the ratio issue. Salih aimed to find the money earned by employees per hour and compared them accordingly.

At the beginning of the study, the students tried to find the working hours of the people and the average of the money they earned. In response to the opinion of Salih, Burcu made a comparison according to the crowdedness of the amusement park. Burcu said that Fatma worked better than Alim, and while making this comparison, Burcu only compared the data.

The path followed by Burcu was mathematically correct. Merve, on the other hand, thought of finding the money earned per hour. The students presented three different ideas for the solution of the problem situation. The students worked on these ideas for a while. However, the fact that the mathematical operations to be performed were decimal numbers, and the data given in the tables were extensive, which caused the students to find a different way of solution. The students thought that they would waste a lot of time due to the high number of mathematical operations that had to be done. Therefore, they were more cautious in this activity because they had problems with the time in the first MEA.

Abdullah: These operations are very difficult.

Merve: We cannot finish these processes within the given time

Burcu: I think I agree with you. We have to find something else.

Merve: How?

Burcu: I think let's just look at the values in the crowd. Let's just evaluate them without thinking deeply. Alim did very well in the crowd in June.

Merve: Although working hours in August are equal to those in June, he earned more in August. Let's write it as he had made more profit in August.

The students had difficulties in interpreting the data in the table. They did not want to have too many mathematical operations due to the decrease in time. The main reason was that there was too much data, and some of the numbers were given in decimal form. In addition, since the data for each month was given in three groups, it was thought that the students had difficulties in interpreting. In addition to all these, having more than one table was considered as another difficulty faced by students. Although Merve mentioned that Alim made a profit in August, there was no objection from the students in the group. In order to calculate the profit, the inputs and outputs must have been known. After discussing it in the group for a while, the students decided to look at the time period when the number of customers in the park was the highest.

Abdullah: Yet, how are we going to decide by looking only at what happens at the crowded time?

Burcu: The most important thing is the crowded times.

Merve: Let's evaluate the employees at the same hour.

Burcu: Azra worked less and earned more money in June, but that's what she earned in the crowd. We'll check the others as well.

Merve: Let's see if it's organized.

Burcu: Let's also eliminate those who experienced a decline in the process.

Merve: Then let's eliminate Tuğçe.

Burcu: She did not work in June. It would be meaningless to look at Tuğçe for the month of June.

Merve: Let's eliminate. So what?

While the students were considering the comparison according to the earned money in crowded times, different ideas emerged between Turkish students. They thought of dismissing the employee who showed a decrease in the earned money. This idea was mathematically different from other ideas. This difference was the decision to be made according to the change in the money earned over time. This mathematical approach could be easily solved with the help of graphics. The students came up with this idea disregarding the issue of equation graphs. However, since there was more than one idea for the problem situation in the group, it was thought that this idea was not emphasized much. While thinking of eliminating one person, Tuğçe (one of the employees in the given table of the MEA), the students in the group objected to this. The group opposed this decision, which had no mathematical validity.

Burcu: No way.

Abdullah: I don't think so either. Then it would be the same as random sifting.

Salih: Tuğçe earned 125 TL in 3 hours.

Burcu: I don't know what to do.

After discussing for a while in the group, the students decided that Tuğçe's dismissal was a random decision. In this process, the students evaluated the decisions they had taken and tried to put forward mathematical reasons for the determination of the people to be fired. As it could be understood from the quotations above, the students changed their solution strategies to solve the problem. They would try to decide on the person to be fired by calculating the average.

4.2.2 Pursuing the Modeling Cycle: Mathematizing the Situation

The modeling cycle continued with the processes of evaluating the ideas presented by the students in order to mathematize the given problem situation, interpreting, retrying, and trying to understand the problem situation by returning to the problem when necessary and creating models.

During this time, the students thought about adding the total amount of money they earned.

> Salih: So, let's decide based on the total money they earned.
>
> Merve: I think it makes sense. Then let's decide.
>
> Burcu: I don't know if it will. Let's take a look at their total working hours as well as the amount of money they earn.

The students returned to the idea of determining the people to be dismissed based on the relationship between the total working hours and the total earned money at the beginning of the study. During this time, the students thought about adding the total amount of money earned by employees and giving a decision. After collecting the working hours of the employees and the money they earned, the students wrote down the data they obtained as in Figure 4.3.

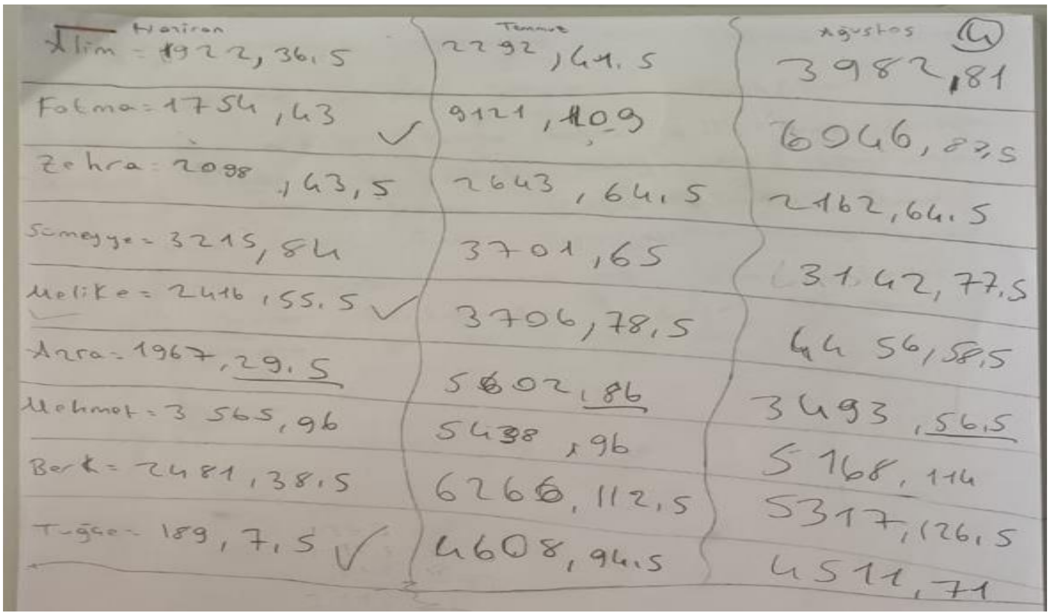

Figure 4.3 Students' calculations of the total amount of money

The students prepared this table, because the data given in the study were seen as complicated and difficult to perform mathematical operations. The students combined two different tables given in the activity and gave a single value for time and money depending on the months. Using this table, the students aimed to see the relationships between the total time and total money of the employees in the table they prepared. However, the students created the table without deciding on the mathematical justification they would use for dismissal.

Burcu: Okay, how are we going to decide now?

Salih: Here we can lay off the lowest paid employees.

Merve: Do you think it makes sense?

Abdullah: I think it makes sense.

Burcu: He maybe earned less because he worked less, how can we decide?

Merve: You are right. I think we should give up this idea.

The students could not obtain any results from this strategy they tried. The students tried to compare the hourly wages earned by the employees by calculating. It was seen here that the students determined their decisions by trial and error and did not base them on mathematical foundations. The students were able to establish the relationship between working hours and the wages earned, but they could not develop an appropriate comparison method. Although the ideas put forward by the Syrian students for the solution of the problem were mathematically correct, they did not contain any mathematical justification. The ideas put forward involved sorting and decision-making processes. On the other hand, Turkish students sought to establish a relationship between the data given in the case of a problem and sought a solution by using this relationship.

> Burcu: We should divide the money earned by the students by the working hours.
>
> Merve: What will we achieve as a result of this?
>
> Burcu: The results we found will allow us to interpret according to the customer situation in the park. For example, we will be able to compare the money students earn when there are lots of customers in the park with the money they earn when they are quiet.
>
> Merve: How so?
>
> Burcu: According to the results we found, the students who earn a lot of money when the number of customers is high work well and we can choose these students to work next year.
>
> Merve: Got it. We will calculate the average wages earned by the students per hour.

Burcu suggested the idea of comparing averages. She would compare the general average of the employee with the average of the number of customers in the park when it was crowded. She was able to explain this idea she put forward to her groupmates and justified it mathematically. The students made a study plan in the group for this idea and started to implement their plans.

Abdullah: Then let's share the students among ourselves, calculate how many TL they earn per hour and interpret them according to the customer status in the park.

Burcu: I will find Melike's (an employee given in the data table) and Alim's.

Abdullah: I will calculate Sümeyye's.

Salih: Zehra's.

Burcu: I found the salary of a student named Melike when the park was crowded in June: around 60 TL.

Abdullah: How did you find 60?

Burcu: In June, when the park was crowded, Melike earned 1264 TL in 9.5 hours. In order to be able to make transactions easily, I thought 20 hours and 1200 TL for the money earned.

Syrian students helped the model to be created by calculating the average. The students wanted to speed up the time by making use of the rounding numbers while calculating averages. Here, it was understood that the students were trying to implement the model they tried to develop despite the decreasing time.

Merve: I think we will find approximately the wages they earn per hour.

Abdullah: Let's evaluate the same ones hourly then?

Burcu: There is no one that is the same. How will we evaluate? Let me explain my strategy.

Abdullah: Tell us.

Burcu: Alim earned 690 TL in 12.5 hours when the park was crowded. When the park was normal, he earned 780 TL in 15 hours. What is the difference between the earned money?

Abdullah: 90 TL.

Burcu: What is the difference between working hours?

Abdullah: 2.5 hours.

Burcu: This means that he earns 90 TL in 2.5 hours. Now, let's see if there are any higher earners than this?

Abdullah: Let's also take a look at the money Alim earned while the park was quiet.

Burcu: When the park was quiet, he worked 6 hours less than normal, and his income is very less. He earned less money.

Salih: Then the manager will fire Alim.

As the dialogue shows, the students thought about two different solutions: sorting and individual evaluation of employees. The students could not progress on a single solution path. Abdullah, a Syrian student, thought of comparing the people who worked the same hour without finding the average values. After Abdullah's suggestion, Burcu, a Turkish student, changed its strategy. According to this change, she decided to make an individual assessment to compare people. She aimed to see the relationship between the money earned by the employees and their working hours according to the number of customers in the amusement park. Instead of working on the strategy they developed and decided with the decrease In time, the students were constantly trying to decide by trying different ways.

Turkish students wanted to create models using different solutions. The opinion of Syrian students was not taken into consideration by Turkish students. After the idea of the Syrian student, the Turkish student revised his idea. Thanks to the collaborative work of Turkish and Syrian students in the group, students' ideas had changed.

Burcu: Alim earned 90 TL less. While he should have earned more in the crowd, he earned less.

Merve: Now, let's check Fatma.

Burcu: They made less money when it was always crowded.

Merve: Yet, we do not pay attention to this point. They may have earned little in the crowd, but their working hours are also short.

Burcu: Right.

Merve: While Fatma's earnings when park is crowded and less populated are almost the same, her working hours are very different.

Burcu: Right. She has to earn a lot when the park is already crowded. This doesn't work with this logic.

Abdullah: We have to develop other mathematical logic.

Merve: What if we add up and divide the hours Tuğçe worked for the money she earned that month?

Burcu: No, I don't think that would happen either.

Abdullah: If there is the same hour or the same wage for each student in the months they work, I think we should interpret them by looking at them.

Abdullah, one of the Syrian students, did not find it appropriate to evaluate the employees only on the basis of the money earned. Abdullah thought that working hours were also important. For this reason, he thought that the comparison of employees working the same hour was correct. Although Abdullah expressed this idea twice in the group, Turkish students did not consider this idea. The reason for this attitude could be the fact that in-group conversations were mostly among Turkish students.

Salih: Let's move forward by putting plus and minus next to the students according to the increase and decrease.

Burcu: So let's put a plus on Alim. Compared to June, there is an increase in August. This is a good thing.

Abdullah: Let's finish Alim and move on to the others.

Merve: Should we look at part-time workers?

Burcu: Let's go in order, it's best.

Abdullah: We cannot comment like that either.

Salih: Should we just find the average of the crowds?

Salih, one of the Syrian students, expressed the idea of determining the increase or decrease in the money earned by the employees by putting plus and minus signs. This idea was expressed for the first time in the group. Although other students agreed, they soon thought that this idea was not appropriate because it was difficult to interpret. The students then thought to find the average of the money earned by the employees during the time period when the amusement park was crowded.

Burcu: Let’s add up all the crowded hours for June, July, August and divide it by the total number of hours.

Abdullah: Can you look at Tuğçe?

Burcu: She never worked when the market was crowded.

Abdullah: Then let’s remove Tuğçe. It was supposed to work when it was actually crowded.

Merve: This can never be compensated.

Burcu: Friends, then we did Tuğçe an injustice.

Merve: Why?

Burcu: It is not her fault that Tuğçe does not work when crowded.

The students realized that Tuğçe did not have any data when they made the evaluation by taking the crowded time into account. They thought that the decision to be taken in this case would not be objective, so they decided that they could not make decisions by looking at the crowded time. The students realized that they needed to have data in order to make an assessment. Deciding that they could not make an evaluation by looking at the crowded time data of the amusement park, they tried to make an evaluation of their previous ideas.

Abdullah: So let’s try again to find the money they earn per hour.

Merve: But we did that, it didn’t work.

Burcu: Alim earns 690 TL by working 12.5 hours in June when the park is crowded, and 788 TL by earning 12.5 hours in August when the park is crowded.

Merve: Pretty much the same.

Burcu: That’s why we shouldn’t lay off. He realized his mistake and worked harder.

Salih: You think wrong.

Abdullah: Why?

Salih: This is not an error. Maybe, there were more customers in the park then.

Abdullah: I don’t think we should remove anyone. Everyone earned money.

Burcu: I think so, too.

In summary, it was observed that the students understood the problem situation in general, but they applied the idea that no one needed to be fired without discussing what they understood, interpreting and making inferences. After the written reports, it was realized that they did not go to check the result in any way or to discuss and interpret the solution they used. On the other hand, the fact that the students evaluated all the tables by averaging them in the same way showed that they understood and applied the term “a general method” correctly. In addition to these, it was thought that the scoring developed by the students, adding the scores, and ranking the total scores could be a valid method. The students created a new table by collecting the data in the tables containing the information about the money earned and the hours worked. The students made an evaluation on the table they obtained by neglecting the crowded, normal, and less populated situations of the amusement park.

It was figured out that the students constantly changed their decisions as they made many decisions throughout the study and could not find the mathematical foundations that supported these decisions.

It suggested that insufficient mathematics knowledge had an important role in the decisions made by the students. Instead of four people they could randomly choose, Abdullah, one of the Syrian student, thought that no one need to be fired. Other students also agreed with this idea.

The modeling processes of the students in the group for the “Summer Job” Problem were summarized in the table 4.2 below.

Table 4.2 Summary of the Group’s Modeling Cycle for the “Summer Job” Problem

Stages of the Modeling Cycle	**Categories**	**Modeling Process**
Initiating the Modeling Cycle	Encountering and understanding a real-life problem situation	-Trying to understand the problem situation
	Presenting the idea(s) for the model	-Arithmetic mean of working hours and earning money -Prediction of total working time and earning money -Arrangement of working hours -Scoring the employees
Pursuing the Modeling Cycle	Mathematization	-Data collecting of working hour and earning money -Calculation the hourly wages earned by employees -Arithmetic mean of earning money and working hours -Approximation of earning money
	Evaluation, interpretation and retry	-Evaluation by discussing the mathematical results obtained within the group
	Understanding the problem situation*	-Trying to understand the relationship between tables -Trying to understand the data given in the table

* *This part of the modeling cycle was experienced many times as needed.*

This table was a summary of the work done by the students in the “Summer Job” modeling activity. In the initiating stage of the modeling cycle, the students examined two different data tables given after they grasped the problem situation. The students trying to establish a relationship between the data in the tables made mathematical inferences such as money earned per unit hour, average money earned by months, comparison and organization. While the students were trying to find the mean calculation, they had difficulty in doing the operations with decimal numbers and started to look for other solutions. The students generally had difficulties in performing mathematical operations during the activity and started to look for different solutions.

In this initiating stage, Syrian students contributed more than the first activity. Syrian students worked in cooperation with Turkish students and tried to contribute to the solution of the problem. Like Turkish students, Syrian students presented their ideas for the model. The ideas of Syrian students were weaker in terms of context, involving less mathematical operations. On the other hand, the ideas put forward by Turkish students involved more complex mathematical processes.

In the pursuing modeling cycle stage, on the other hand, the students created the data table in Figure 4.3 by combining two different data groups. It was thought that the reason for the students to create this table was difficult for students to interpret two different tables at the same time and make inferences about them. After the students worked on the table they had created for a while, they thought to find the amount of money earned by the employees per unit hour for the solution.

In this pursuing stage, Turkish students tried to use the information in the given tables. They thought of making an evaluation according to the difference in the number of customers in the park. Syrian students, on the other hand, defended the idea of making evaluations depending on the money earned by the employees. Turkish students offered the idea of evaluating employees according to the money they earned in the process. Salih, one of the Syrian students, tried to find a solution to the problem by placing plus and minus signs according to the increase and decrease of the money earned by the employees during the process. At the end of the activity, the students decided other the solutions they initially put forward. According to this decision, they thought that no one needed to be fired. The students took this decision without mathematically justifying it.

4.3 Summary of Turkish and Syrian Students' Modeling Process

The work produced by the students in the two modeling activities was summarized considering Blum and Leiß's modeling cycle (Blum & Borromeo Ferri, 2009). Modeling processes of Turkish and Syrian students were examined separately in both activities. The performances of Turkish and Syrian students in the modeling process of Let's Build Environmentally Friendly Structures with Plastic Bottles are shown in Figure 4.4.

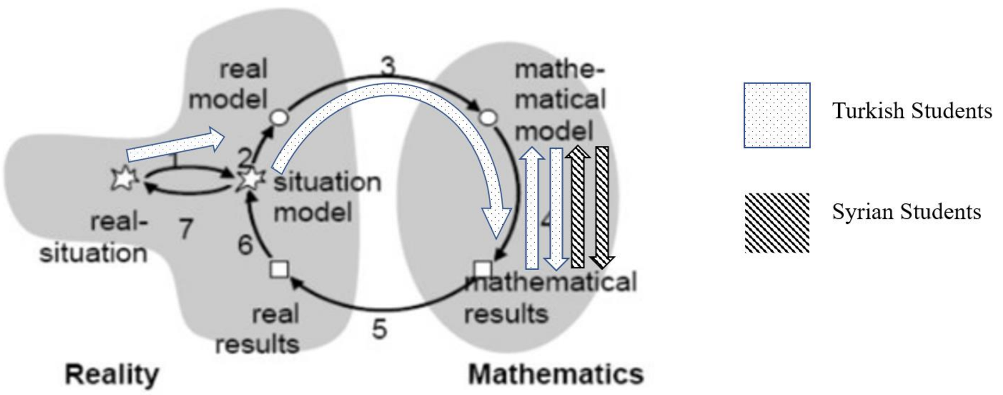

Figure 4.4 Modeling Cycle of Turkish and Syrian Students in Let's Build Environmentally Friendly Structures with Plastic Bottles MEA

In the "Let's Build Environmentally Friendly Structures with Plastic Bottles" activity, the students made sense with the real-life situation and developed a model in accordance with it. They changed the model when they encountered with a difficulty in mathematical operations, and this situation was repeated several times as seen in Figure 4.4. Although the real model developed by the students included real life situations, these situations were neglected in the mathematical model and the students made an effort to find mathematical results. After finding the mathematical results, students could not transfer it to real-life situation and therefore the modeling cycle ended with the mathematical result at step 4. As can be seen in

Figure 4.4, while Turkish students participated more in step 1, 2, and 3, Syrian students contributed to the development mathematical results in step 4.

In addition, modeling cycles of Turkish and Syrian students in the Summer Job activity are shown in Figure 4.5.

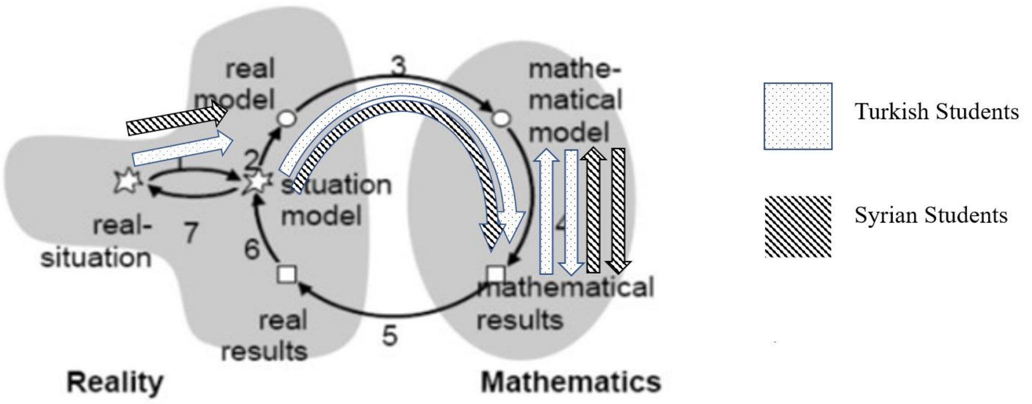

Figure 4.5 Modeling Cycles of Turkish and Syrian Students in the Summer Job MEA

As seen, Syrian students contributed more to the model development process in the second MEA when compared to the first MEA. Students comprehended the data tables given in the "Summer Job" activity, but they had difficulty in establishing the relationship between these tables. In this activity, the students often changed their mathematical models because mathematical operations were difficult and long (see the arrows in the step 4). Since the relationships between the obtained data were not established, the students underwent a difficult time in working mathematically. In this problem situation, Turkish and Syrian students worked together more in the modeling process than in the first problem situation. However, similar to the first MEA, the modeling cycle stopped at the step 4 where students reached a mathematical result. This indicated that students did not interpret their mathematical result in terms of the real situation and finalized the modeling process by a mathematical answer.

CHAPTER 5

DISCUSSION AND CONCLUSION

In this chapter, major findings were discussed according to the research questions of the study. The discussion was followed by limitations of the study, recommendation for future studies and educational implication.

5.1 Discussion

This study aimed to investigate a case of Turkish and Syrian seventh grade students' modeling cycle in their collaborative work on model-eliciting activities. In this section, firstly, the participants' modeling process was discussed, comparing them with the current body of literature. Then, the contributions of Turkish and Syrian students to the mathematical modeling process were elaborated on.

5.1.1 Students' Encountering and Understanding a Real-Life Problem Situation

Although the "Let's Build Environmentally Friendly Structures with Plastic Bottles" MEA seems like an environmental awareness activity, it consists of various mathematical features. These features can be grouped under the main headings such as circle, measuring-area, geometry in mathematics teaching.

As a result of the data analysis, it has been determined that the students experienced some difficulties inherent in mathematical modeling during the model development process. Syrian students had difficulties in understanding the questions. As Aydın and Kaya (2017) stated, Syrian students faced difficulty in understanding of what they read. It has been observed that Turkish students tried to help Syrian students by reading the question aloud in understanding the problem situation. Once Syrian and Turkish students understood the problem situation, Turkish and Syrian students made similar contributions to the study in assessing real-life situations. The students thought about the situations such as durability, earthquake, and usefulness that they encountered in their daily lives, and expressed the issues that needed to be considered in the model they would use. It has been understood that the students were trying to establish interdisciplinary relationships.

In the second activity, "Summer Job", Turkish students helped Syrian students, and the students quickly understood the verbal part of the problem situation. Both Turkish and Syrian students had difficulty in understanding the data tables given in the activity. Although the students captured the data in the tables in their daily life situations, they had difficulty in establishing a relationship between the tables containing the data of two different variables (e.g., working hours and earning money) and making sense of these tables. It has been detected that the students had difficulties in determining the variables and establishing a relationship between these variables. As Kant (2011) described in his study, although the students took real-life situations into account in problem situations, they could not use these situations in the mathematical model. The students' evaluation of the variables in the tables without establishing a relationship between them is in line with the findings of the study conducted by English and Watson (2018).

5.1.2 Students' Presenting Ideas for the Model

In the "Let's Build Environmentally Friendly Structures with Plastic Bottles" modeling activity, Turkish students were able to justify and explain their choices while deciding on the material to be used in the model in group. It has been observed that the students improved their argumentation skills during the mathematical modeling activity, communication skills, reflected on themselves and the model they developed as a team. The same results have been obtained by several studies (e.g. English, 2004; English & Watters, 2005; Zawojewski et al., 2003). Syrian students approved the decisions taken by the Turkish students and did not participate much in this part of the study. Turkish students made evaluations in terms of durability and availability of materials to be used while determining the dimensions of the playhouse they planned. The students in the current study tried to associate the data about bottle's size with the real-life context. In the study by Galbraith and Clatworthy (1990), mathematical models were considered solutions to real-life problems. In that sense, their study supports this finding of the current study in that the problem situation in model-eliciting activities required a solution with real-life into consideration.

Syrian students did not express an opinion, but they contributed to the development of the model presented by Turkish students. Turkish students constructed a mathematical model using arithmetic mean, estimation, and using real data. Turkish students first tried to decide on the values to be used in the mathematical model with the idea of arithmetic mean. Because of the decimal numbers they encountered while calculating the average, they gave up the average calculation. They did not want to use the arithmetic mean calculation due to their low level of mathematical operation skills. It has been observed that Turkish students tended to create a model using the prior knowledge they learned in the mathematics classroom. The reason behind this might be the Turkish examination system. The questions in the exams given to Turkish students cover the subjects learned. The students may have tended to consider the mathematical modeling activity as an exam and use the mathematical content they learned in the modeling process, which was similar to Uğurlu and Kıral's (2011) conclusion. The research findings offered by Uğurlu and Kıral (2011) have revealed that since the exams administered to students in Turkey were mostly subject-based and rote-based, students tended to apply the new content knowledge they had just learned in every exam.

Syrian students performed mathematical operations in a more effective way than Turkish students. Turkish students could not revise the calculations they wanted to make to the real-life situation. For example, when finding the arithmetic mean value, the students wanted to find the mean by taking all students in the school into account and stated that a ruler need to be used to measure the classroom. Syrian students, on the other hand, thought of obtaining information about the school by using the average of the group and measuring the size of the classroom by stepping instead of a ruler. This difference may be caused by the education system. In the Turkish education system, the exams and studies in schools are mostly subject-based. Moreover, it might be that the relationships between the subjects are not focused on much, and the subjects are taught independently from each other. Therefore, it would not be wrong to suggest that Turkish students thought that the activity was related to the subjects they had learned recently so they were trying to establish a relationship with the subjects they had just learned. This difference between Turkish and Syrian students may stem from the life experiences of Syrian students. Syrian students usually helped their families after school. They may have used different measurement tools while helping their families. For example, they can measure the weight of a sack and estimate the total amount of peanuts during peanut collection or measure the garden or farmland by stepping. Another reason behind this difference may be that Turkish students saw the study as an evaluation tool and therefore they wanted to obtain the results of mathematical operations with precision. Although there are differences between students' approaches, these differences form a model by coming together. This, in return, clearly demonstrates the influence of collaborative work on mathematical modeling.

Students often deal with the problems related to the topics that have already been conveyed by their teachers. They do not frequently encounter real-life situation problems, and the data necessary for the solution of the problem are mostly given to students. Therefore, the students had difficulties in transferring skills to make successful connections between the real world and the mathematics. Similar results have been observed in the studies conducted by Nunes and Bryant (1996) and Christiansen (2001).

In the “Summer Job” MEA, the students tried to create models suitable for the problem situation by benefiting from the topics such as arithmetic mean, estimation, scoring and arrangement. Turkish students wanted to create a model by finding the mean values. While performing addition to find the mean value, it was noticed that the Syrian student added the decimal numbers incorrectly. The Turkish student helped the Syrian student to add the decimal numbers. Another difficulty that students faced while finding the mean values was interpreting the result that was a decimal number. Similar to the Summer Job MEA in the current study, English and Watters (2005) presented students with two modeling problems involving data tables in a style they did not encounter in the school curriculum. They observed that some groups of students had difficulties in working with data tables and in interpreting these tables. Supporting the findings presented by English and Watters (2005), the students in the current study had difficulty in understanding and relating data tables.

Furthermore, Syrian students suggested that they should have sorted the earned money and then they should have made decision. This suggestion was quite easy as a mathematical operation. Turkish students, on the other hand, claimed that it would not be appropriate to decide by comparing only the money earned. Turkish students tried to justify their actions. The students revisited the model once they had trouble in mathematical operations they encountered. Although Turkish and Syrian students were at different levels in their mathematical achievements, the final model was built up with the participation of all students, and they collaborated with each other during the modeling cycle.

Syrian students participated more in the second activity compared to the first activity. The reason for the increase in group work could be explained by the increase in communication within the group. More specifically, it has been observed that the

Syrian students participated more towards the end of the first activity and in the last activity. This might be because students perceived the problems as similar to the problems found in the classical coursebook. Most questions in coursebooks have only one correct answer. In order to reach this correct answer, students need to apply certain mathematical operations. These operations are mostly related to the mathematical topics that have just been covered. Particularly Syrian students might have thought the MEAs as traditional textbook problems that had only one correct answer which might be reached through a single solution process, and they might have hesitated to engage in the problems at the beginning. After the activity started, the students might have realized that the questions in the activity were open to everyone’s ideas and opinions and that they could participate in the discussion without using certain mathematical formulas.

Apart from this reason, the students usually solved questions based on mathematical operations in the classroom environment. These questions were quite far from everyday life situations. The fact that the questions in the study included daily life situations might have increased the interest of the students. The reason for the gradual increase in students’ participation, particularly Syrian students’ participation, into the group work may have stemmed from the increase in communication within the group. Verifying the findings of the current study, Doerr and Tripp (1999) concluded that group work helped students to interact between themselves in depth, and these interactions continued throughout the study.

Students had the opportunity to freely express their ideas in the group and to hear and evaluate the opinions of other students. This environment may have contributed to the students’ establishing relationships between mathematics and other courses. Researches had revealed that students were more productive (more creative, generalizing, communicating, etc.) in a democratic and collaborative environment (Deniz & Akgün, 2014; English, 2003; Kelly & Lesh, 2012; Korkmaz, 2010; Lesh, et al., 2000).

5.1.3 Mathematization

It has been observed that the students had difficulties in mathematizing and establishing the relationship of the model with real-life. On choosing the dimensions and materials of the house they planned to build, the students considered durability, earthquake, and availability of bottles to be used during construction. Although the students understood the problem situation, they had difficulties in mathematizing the information they obtained. The students' difficulties in mathematizing are consistent with previous modeling studies (Özaltun et al., 2013). Differences were seen between Turkish and Syrian students whenever students tried to present their ideas for the model. Turkish students reminded Syrian students how to calculate the average. Turkish students thought of obtaining the data of the whole school while calculating the average. Syrian students, on the other hand, thought to obtain information about the school by finding the average of the study group. In calculating the mean value, Turkish students had difficulty in adapting the mathematical knowledge they learned in the school to real-life situations.

In the mathematization part, Turkish students tried to create a model using topics such as arithmetic mean and estimation. Turkish students tried to justify their actions by using the subjects they learned. In addition, Turkish students rounded up when they had to perform operations using decimal numbers and tried to find another solution. However, Syrian students found easier ways to do mathematical operations than Turkish students. Turkish students thought of using the ruler in the classroom to determine the dimensions of the classroom in which the study was conducted. Realizing that the ruler was being used by another group, Turkish students decided to wait to use the ruler. On the other hand, Syrian students thought of measuring the size of the classroom by taking steps. The reason why Turkish students thought about using a ruler but not step measurement might be that the students made measurements with the help of rulers in the topic of "Measuring Length and Area". Syrian students helped the Turkish students with the mathematical operations. At this stage of the study, Syrian students could not contribute much on the model to solve the problem.

While drawing, the ideas articulated in the group were not taken into account, and the students did not use the drawing they made during the activity. During the drawing process, Turkish and Syrian students worked together. Model drawing is a very important process as drawings contribute greatly to the mathematization process. Lowrie (2001) stated in his comprehensive study of the effects of visualization on students' problem-solving skills that students performed better when they used visual methods. Although the students in the present study produced visuals, they did not benefit much from these visuals, or at least I could not observe the benefits of the visuals.

The students frequently talked about the problem verbally, but the students had difficulty in transferring the ideas they talked about to the model. In addition, the students spent more time speaking verbally. Although the students presented many ideas for the model, they could not work on these ideas sufficiently and often tried to change the model. The mathematical information used by the students for the model was determined as arithmetic mean, estimation, measurement, approximate value, and using real-life data. The students had difficulties in mathematizing the ideas they talked about in the group. The insufficient level of mathematical literacy of the students may have caused the students not to be able to implement the ideas they thought for the model.

5.1.4 Evaluation, Interpretation, and Retry

The students did not evaluate the mathematical operations they performed (see Figure 11 and 12). Modeling cycle was terminated when they found the answer to the problems. A relationship could not be established between the results found and the context. The students performed many mathematical operations during the activity process, but they could not use these operations either. Hence, the students could not establish a relationship between the mathematical results they obtained during the modeling and the the real-life situation that required the modeling process. This might be because students were familiar to mathematics problems in the textbooks that often involve one mathematical (numerical) answer.

Although there were studies conducted in integrated classrooms in the literature (Xin, 1999; Affleck et al., 1988), these studies were not particularly mathematical modeling studies. However, Mousoulides and English (2008) examined the mathematical development of two ten-year-old students living in Cyprus and Australia with a mathematical modeling activity involving interpretation and association with multiple datasets. As a result of the research, it was shown that the students in the two countries showed similar approaches in the model building process. In addition, Doerr and English (2003) conducted a mathematical modeling study with students living in the USA (12-13 years old) and Australia (10-11 years old). The findings of the study showed that students could create generalizable and reusable systems or models for selecting, sorting and weighing data. In the current study, it has been observed that Syrian and Turkish students selected and sorted the data, and although they obtained mathematical results using the data, they could not use the results in the model.

Furthermore, the results of the studies (Doerr & English, 2003; Mousoulides & English, 2008) show that there are no cultural differences in mathematical modeling activities. These studies have supported that the cultural differences of Syrian students were not an obstacle to their participation in the mathematical modeling activity. As seen in Doerr and English (2003) study, cultural differences caused different ideas in the mathematical modeling process. The fact that Turkish and Syrian students worked together in groups and offered models collaboratively shows that cultural differences were not an obstacle to modeling activity. In addition, the positive contribution of cultural differences to the modeling process showed the importance of mathematical modeling activities. The fact that mathematical modeling activities eliminated cultural differences and everyone contributed positively to this process highlights that mathematics is a universal language. It was observed that Syrian students contributed positively to the modeling cycle with their increased participation and practical ideas throughout the activities. These results show the significance of the mathematical modeling activities in mathematics education, which may help the integration of students who have to migrate to other countries due to a war or different reasons.

It was inevitable that mathematical modeling activities would eliminate cultural differences as well as socio-economic level differences. Thus, it was seen that mathematical modeling activities would provide equal opportunities for every student, as well as equal opportunities in education.

5.2 Limitations and Recommendations

First, the data collection methods and techniques used in this present study are limited. Students' mathematical modeling cycles are limited to two mathematical modeling problems (activities) selected from the literature. Since examining modeling process requires long term observations, I suggest teachers and other researchers use more than two MEAs in a longer period of time.

Second, the participants of the study are limited to a focus group of two Turkish and two Syrian 7th grade students. This study could be conducted with larger groups of Turkish and Syrian students. Besides, by increasing the number of activities, the processes of the students could be observed better. In future studies, an interview can be utilized as a data collection tool and data analysis can be made using more extensive data. In an integrated classroom environment, a study can be carried out by observing and recording all of the students. Furthermore, the performances of Syrian students can be compared by reducing the text part of mathematical modeling activities.

Third, in this study, although it was not purposeful, the participating Turkish students were female and Syrian students were male. This might have created a gender issue. Therefore, mathematical modeling studies focusing on gender difference can also be carried out on a larger scale.

5.3 Educational Implications

In this age where technology is developing rapidly, it has become very easy to access information. Therefore, it is no longer important for a person to know the information. Instead of knowing the information, it is important to establish relationships between different pieces of knowledge and make the knowledge applicable in daily life situations. For this reason, it is very important for individuals to have interdisciplinary knowledge and to be able to solve problems using this knowledge. Mathematical modeling is an effective tool that serves for these purposes. The importance of mathematical modeling in mathematics teaching is increasing, and mathematical modeling can be seen in the curriculum of different countries (MoNE, 2013; National curriculum framework, India, 2005; NCTM, 1989).

Instead of mathematical modeling activities, there are problems with applications in the textbooks. These problems are not sufficient to show the relationship between real-life situation and mathematics. The importance of modeling activities needs to be explained in textbooks and curricula, and it is very important to carry out the necessary studies for teachers on how to implement these activities in their classrooms. This study has revealed that modeling activities might be an important part of the education system. The students in the current study tried to create models suitable for real-life situations and performed mathematical operations on the models they created. The mistakes that students made during the mathematization process and the difficulties they encountered were similar to the difficulties in other mathematics activities. If students have the opportunity to encounter more modeling questions, it will be easier for them to associate the mathematical knowledge learned at school with the real-life, through which their mathematical thinking will be improved.

Along with it, modeling activities are important in order to break the teachers' prejudices about the mathematics performance of Syrian students. This study has showed that students' cultural differences did not appear as an obstacle on the modeling cycle. Modeling problems can help mathematics teachers during instruction as they bear a huge potential of increasing students' integration into classroom activities and collaboration with their peers. What is more, teachers who perceive cultural differences as an obstacle for teaching can effectively teach mathematics by eliminating the differences of students with the help of mathematical model-eliciting activities.

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APPENDICES

A. Mathematical Modeling Activities

A.1 PET ŞİŞELERLE ÇEVRE DOSTU YAPILAR İNŞA EDELİM

TUĞLA YERİNE PET ŞİŞE

Kullandığımız plastik şişelerin yaklaşık yüzde 80'i denizlere atılıyor, yüzyıllarca yok olmuyor. Peki plastik şişelerden yapılmış bir ev hayal edebilir misiniz? Andreas Froese bu çılgın fikrini Afrika'da hayata geçirdi.

Boş plastik şişeler kum ve moloz ile dolduruluyor. Üst üste dizilen şişelerin üzeri balçık v harç ile sıvanıyor. Ortaya çıkan yapı da plastik kordonlarla sabitleştiriliyor. İşte Alman Andreas Froese bu şekilde inşa ettiği plastik ev projesiyle hem doğayı korumayı amaçlıyor hem de fakir insanlara yaşam perspektifi sunuyor:

"Başlangıçta insanlar daha çok kuşkuyla yaklaşıyor. Hayal etmesi güç olduğu için merak edip inşaata geliyorlar. O zaman onlara inşaat malzememizin, yani normal plastik şişenin tuğladan daha dayanıklı olduğunu gösterebiliyoruz. Basınca ve darbeye karşı da daha dayanıklı."

Bu iş için özel eğitilen işçiler, ev için gerekli şişeleri otel, restoran ve çevreden alıyorlar. Elektrik ise güneş panellerinden sağlanıyor ve ileride her evin kendi atık su ve içme suyu sistemi olması planlanıyor.

Plastik şişelerden ev inşa etmek çok daha ucuza mal oluyor. Nijerya'da bir tuğla yaklaşık olarak bir işçinin günde aldığı ücretin üçte biri fiyatında.

Ancak asıl sorun bu tür projelerin finansmanının sağlanması. Çevreci projelerin başarısına rağmen sponsor bulmak oldukça güç.

Pet şişe binalar kerpiç evlere benziyor; dışarısı soğukken içerisi sıcak oluyor, yaz sıcağında ise serin bir ortam sunuyor. Plastik şişelerden yapılan evlerin avantajları bunlarla sınırlı değil. Plastik şişelerin bu sektörde kullanılması petrol kaynaklarını korumaya katkı sağlıyor. İlginç tasarımları sayesinde turizmi canlandırıyor. Ayrıca inşaat sırasında görev alan okul çağındaki çocuklar çevre sorunlarına çözüm getirmeyi amaçlayan bir projenin parçası oluyorlar.

Okuma-Anlama Soruları

1. Andreas Froese plastik şişelerden ev yapma fikrini hangi ülkede gerçekleştirdi?

2. Boş plastik şişelerin içleri hangi malzemeler ile dolduruluyor?

3. Andreas Froese bu proje ile neyi amaçlıyor?

4. Evlerin elektrik ihtiyacı nasıl karşılanıyor?

5. Gerekli olan plastik şişeler nerelerden temin ediliyor?

6. Plastik şişelerden yapılan evlerin avantajları nelerdir?

PET ŞİŞELERLE ÇEVRE DOSTU YAPILAR İNŞA EDELİM

Her yıl bir milyondan fazla hayvan plastik tüketimi yüzünden hayatlarını kaybediyor. Dış etmenlerin etkisiyle parçalanan pet şişeler, mikro plastik olarak doğaya ve doğal yaşama zarar veriyor. Önüne geçilmezse bilinçsiz pet şişe kullanımı doğayı ve yaşamı tehdit etmeye devam edecektir. Oysa kullanılan pet şişelerin hayata kazandırılması için farklı alternatifler bulunmaktadır. Örneğin, pet şişeler özellikle gelir seviyesi düşük ülkelerde ev yapımında kullanılarak dayanıklı ve maliyeti düşük evler yapılıyor. Böylelikle hem ekonomik kazanç sağlanıyor hem de doğa korunmuş oluyor.

Ülkemizde yaşam koşulları dikkate alındığında pet şişeler kullanılarak inşa edilen yapıların inşaat sektöründe kullanımı pek yaygın değildir. Ancak ülkemizde çevre kirliliğine vurgu yapılmasını ve yeniden kullanım konusunda farkındalık oluşturulmasını sağlamak için park ve okul bahçeleri gibi çeşitli sosyal alanlara pet şişeleri kullanılarak yapılar yapmak mümkündür.

Çevre dostu yaşam alanlarının oluşturulmasını sağlamak ve çevre kirliliğinin önlemenin en etkili yolları maddeleri geri dönüşümleri, geri kazanımı ve yeniden kullanımıdır. Bu yüzden "Çevreci Yapılar" adlı bir proje kapsamında okul bahçelerine birer oyun evi yapılacaktır.

Sizden bu proje kapsamında okulunuzun bahçesine bir oyun evi yapmanız istenmektedir. Yapılacak bu oyun evi için kaç adet pet şişeye ihtiyacınız olduğunuzu gerekçeleriyle açıkladığınız bir rapor istenmektedir. (Not: Oyun evinin boyutlarını kendiniz belirleyeceksiniz.)

Not: Pet şişelerin esnemesinden kaynaklanan kayıplar göz ardı edilecektir.

A.2 Summer Job

Gazete Haberi

Yaz Tatili İçin çalışmak İsteyenlere İş

Yaz Tatili İçin çalışmak İsteyenlere İş

Cumartesi günü Yaz Tatilinde Çalışan Öğrenciler Kulübü yazın çalışmak isteyen öğrencileri bilgilendirmek üzere bir toplantı düzenledi. Toplantıda yaz aylarında öğrencilerin nasıl para kazanabileceklerinden bahsedildi ve bu yaz için planlamalar yapılmaya başlandı.

Toplantıda öğrencilerin yaz aylarında çalışarak para kazanmalarının hem kendilerine olan güvenlerini hem de sorumluluk almalarına katkıda bulunulduğu dile getirildi. Ayrıca kulüp geçtiğimiz yaz evcil hayvanlara bakarak ve bahçe işlerini yaparak para kazanan Samet adlı öğrenciyi ödüllendirdi.

Kulüp başkanı Berna "Yazın öğrencilerin yapabileceği çok farklı işler vardır. Toplantımız öğrencilerin yapabileceği ve para kazanabileceği işler hakkında da bilgi veriyor." diye ekleme yapıyor. Farklı işler ve kazanılabilecek farklı paralar hakkında toplantıda konuşulmuş ve bilgi verilmiştir.

Aşağıda öğrencilerin çalışabileceği işle ve kazanabilecekleri paralar hakkında tablolar verilmiştir.

ARABA YIKAMA	
Küçük araba	**4 TL**
Büyük Araba	**7 TL**

ÇİM BİÇME	
Küçük Bahçe (5 m^2-25 m^2)	**10 TL**
Büyük Bahçe (25m^2 ve daha fazlası)	**15 TL**

GAZETE DAĞITIMI	
Günlük 15 ile 25 arası gazete dağıtım	**10 TL**
Günlük 25 gazeteden fazla dağıtım	**20 TL**

Okuma-Anlama Soruları

1. **Toplantıda bahsedilen konu nedir?**

2. **Öğrencilerin yaz aylarında çalışmaları onlara ne gibi katkı sağlamaktadır?**

3. **Kulüp başkanı Berna toplantıda hangi konular hakkında konuştu?**

4. **Bir öğrenci haftada 5 küçük araba yıkayarak bir ayda kaç lira kazanabilir? Yaptığınız işlemleri aşağıdaki boşluğa açıklayarak yazınız.**

5. **Ahmet haftada 3 kere büyük bahçe, Mehmet ise haftada 5 kere küçük biçerek bir ay çalışmışlardır. Bu durumda Ahmet ve Mehmet'in bir ayda kazandıkları para miktarları arasındaki fark kaç liradır?**

6. **Bir kişinin gazete dağıtarak bir hafta boyunca en fazla kaç lira kazanabilir?**

Ahmet geçen yaz bir lunaparkta çalışan öğrencilerin müdürü olarak işe başladı. Öğrenciler parkta müşterilere patlamış mısır ve içecek satarak para kazanıyorlardı. Ahmet gelecek yaz hangi öğrencilerin çalışmasına devam edeceğine karar vermek için sizden yardım istemektedir.

Geçen yaz Ahmet 9 öğrenci çalıştırmıştı. Bu yaz ise 3 tanesi tam zamanlı 3 tanesi yarı zamanlı olmak üzere 6 kişi çalıştıracaktır. Ahmet en fazla para kazanan 6 kişi ile çalışmak istemektedir. Öğrencilerin çalıştıkları saatler farklı oldukları için Ahmet çalışan öğrencileri nasıl karşılaştıracağını bilmemektedir. Çalışma saatleri bu iş için oldukça önemlidir. Örneğin; kalabalık bir Cuma gecesindeki satışlar yağmurlu bir cumartesi gününden daha fazla para getirmektedir.

Ahmet geçen sene çalışma saatleri ve kazanılan paraların kayıtlarını tutmuştur. Ahmet tabloları hazırlarken çalışma saatlerini ve çalışılan saatlerdeki yoğunlukları dikkate almıştır. (Tabloları kontrol ediniz.) Geçen yılın verileri kullanılarak oluşturulmuştur tablolara bakarak Ahmet'in seçeceği kişilere yardımcı olmanız istenmektedir. Seçilecek kişilerden 3 tanesi tam zamanlı ve 3 tanesi yarı zamanlı olarak çalışacağını unutmamalısınız.

Bulduğun sonuçları Ahmet'e mektup yazmalısınız. Mektubunda değerlendirmeni nasıl yaptığını açıkça belirtmeni ve her şeyi detaylıca yazman istenmektedir. Şimdi hangi yolu kullanarak değerlendirme yapacağını bulma zamanı.

	Geçen Yaz Çalışma Saatleri								
	Haziran			Temmuz			Ağustos		
	Kalabalık	*Normal*	*Sakin*	*Kalabalık*	*Normal*	*Sakin*	*Kalabalık*	*Normal*	*Sakin*
Alim	12.5	15	9	10	14	17.5	12.5	33.5	35
Fatma	5.5	22	15.5	53.5	40	15.5	50	14	23.5
Zehra	12	17	14.5	20	25	21.5	19.5	20.5	24.5
Sümeyye	19.5	30.5	34	20	31	14	22	19.5	36
Melike	19.5	26	0	36	15.5	27	30	24	4.5
Azra	13	4.5	12	33.5	37.5	6.5	16	24	16.5
Mehmet	26.5	43.5	27	67	26	3	41.5	58	5.5
Berk	7.5	16	25	16	45.5	51	7.5	42	84
Tuğçe	0	3	4.5	38	17.5	39	37	22	12

	Geçen Yaz Kazandıkları Para								
	Haziran			Temmuz			Ağustos		
	Kalabalık	*Normal*	*Sakin*	*Kalabalık*	*Normal*	*Sakin*	*Kalabalık*	*Normal*	*Sakin*
Alim	690	780	452	699	758	835	788	1732	1462
Fatma	474	874	406	4612	2032	477	4500	834	712
Zehra	1047	667	284	1389	804	450	1062	806	491
Sümeyye	1263	1188	765	1584	1668	449	1822	1276	1358
Melike	1264	1172	0	2477	681	548	1923	1130	89
Azra	1115	278	574	2972	2399	231	1322	1594	577
Mehmet	2253	1702	610	4470	993	75	2754	2327	87
Berk	550	903	928	1296	2360	2610	615	2184	2518
Tuğçe	0	125	64	3073	767	768	3005	1253	253

Not: Kalabalık, normal ve sakin olarak belirtilen parktaki müşterin durumunu ifade etmektedir.

B. Ethics Committee Permission

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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28 Haziran 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Dr. Öğretim Üyesi Şerife SEVİNÇ

Danışmanlığını yaptığınız **Sinan MAVİ'nin "Matematiksel Modelleme ile Verilen Soruların Öğrencilerin Matematiğe Bakış Açıları Üzerindeki Etkisinin İncelenmesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **275-ODTÜ-2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Tülin GENÇÖZ

Başkan