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Primary School Pre-service Mathematics Teachers' Views on Mathematical Modeling

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The current study aimed to identify the views of pre-service teachers, who attended a primary school mathematics teaching department but did not take mathematical modeling courses. The mathematical modeling activity used by the pre-service teachers was developed with regards to the modeling activities utilized by Lesh and Doerr (2003) in their study. The present study was a qualitative case study. Following the modeling activity, focus group discussions were conducted with 14 pre-service teachers who attended a primary school mathematics teaching department in the Faculty of Education of a state university. Results of the study showed that because mathematical modeling activities are related to daily life problems, they facilitate the transfer of mathematics to daily life situations, support higher-level thinking and provide tangible experiences.

Keywords: Model, modeling, pre-service mathematics teacher.

INTRODUCTION

One of the main objectives of mathematics teaching programs is to train individuals to develop problem-solving skills and to transfer these skills to daily life problems. The four steps inspired by George Polya (1975) for problem solving in mathematics teaching programs are: understanding the problem, devising a plan to solve the problem appropriately, carrying out the plan, and looking back and assessing the solution (Ministry of National Education-MoNE, 2009). Students solve word or basic operations problems given in mathematics classes. Solving word problems may be effective in acquiring basic skills (four operations), however, this does not ensure the acquisition of mathematical concepts or their sustainability (Van de Walle, 2012). A large number of mathematics instructors claim that traditional word problems do not overlap with real-life situations, do not develop problem-solving skills, nor do they promote mathematical modeling assessments (De Corte, Verschaffel, & Greer, 2000). According to Greer (1997), traditional word or algebra problems do not have any meaning other than allowing students to come up with mechanical and meaningless solutions as they do not require deep mathematical thinking. Problems presented in traditional textbooks are prepared to focus on digital skills and these types of problems do not bring out mathematical thinking skills in students (Lesh & Doerr, 2003).

More flexible, creative personnel with mathematical and technological skills in many fields such as technology, engineering and economics are increasingly needed in today's global world in which the importance of mathematics has increased (English & Watters, 2005; Lesh & Doerr, 2003). Mathematical modeling which involves transferring a real world situation to a model which is then used to comprehend, develop and solve real-life problems has been an indispensable characteristic of engineering, science and technology as well as mathematics because the transition between real-

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State of the literature

- There are many studies related to use of mathematical models and modeling in mathematics teaching. These studies range from pre-service and in-service teacher education to the teaching of special concepts and relations at different levels.
- Main focus of these studies is to develop modeling activities and implement them on selected topics and to investigate the effects of this approach on participants' success and attitudes.
- More studies need to be done in order to obtain a comprehensive understanding of the mathematical models and modeling approach and issues that deserve detailed investigation

Contribution of this paper to the literature

- This paper presents a summary of different approaches related to mathematical models and modeling used in the teaching of mathematics.
- It aims to develop a model eliciting activity in order to give an example of the modeling approach for primary school pre-service mathematics teachers. The participants who had never taken a course related to mathematical modelling were asked to develop a model for the problem that was posed by the researchers.
- The findings of the study show cognitive and social gains in participants.

life problems and models creates the essence and core of these disciplines (Crouch & Haines, 2004). The question of whether educational institutions, teachers and students are sufficiently prepared to meet the needs of the global world is worth investigating.

In principle, mathematics involves abstractions that originate from concrete observations and it is imperative to comprehend the abstract structures in order to develop mathematical thinking. School mathematics should be designed to facilitate the acquisition of this fundamental skill (Bayazıt, Aksoy, & Kırnap, 2011). Teacher competency comes into prominence when transferring knowledge from real-life situations through mathematical modeling and in developing solutions during students' problem-solving processes. Teachers should be effective guides for their students in this respect (Güzel & Uğurel, 2010).

In recent years, issues such as mathematical reasoning, probabilistic thinking and modeling have been the focus of international assessments such as OECD Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). Turkey which participates in comparative research such as PISA (MoNE, 2009, 2010) and TIMSS (MoNE, 1999, 2003) falls in the lower ranks. However students in Germany, one of Europe's highly-developed countries, do not achieve the desired levels of attainment either. The fact that students in Germany are unable to transfer mathematics into daily life is considered to be one of the reasons underlying this lack of achievement (MaaB, 2006).

In this context, the current study aimed to determine primary school mathematics pre-service teachers' views on mathematical modeling activities, to discuss the need for mathematical models and modeling, its contribution to teaching mathematics and its effects on pre-service teachers. We believe that the contribution this study can make toward the relevant literature will be illuminating for other studies in the field.

THEORETICAL FRAMEWORK

In recent years, problem solving, reasoning skills and transferring these skills to daily life have been emphasized in educational programs in countries such as America, England, Australia, Holland, Singapore and Korea (Verschaffel, De Corte, Lasure, Vaerenbergh, Bogaerts, & Ratinckx, 1999).

In America, Principles and Standards for School Mathematics, a document from the National Council of Teachers of Mathematics-NCTM, (2000) emphasized the importance of mathematical reasoning and thinking skills so that students can solve problems by comprehending mathematics. According to NCTM (2000) teaching programs should support students' self-confidence in their conceptual understanding, problem solving and mathematics skills.

Studies undertaken in recent years show that teaching problem solving at school is insufficient for solving real-life problems and that students try to reach solutions quickly instead of thinking over problems and producing strategies for solutions (Verchaffel et. al., 1999). Absence of student-centered teaching at schools, a lack of materials in classroom activities, and provision of one-way feedback from teachers to students are a few of the shortcomings related to associating mathematics with real life (Doruk & Umay, 2011). Different methods can be used in this process to make mathematics more meaningful for students. One of these methods may be mathematical modeling because mathematical modeling expresses an event from daily life in mathematical terms and looks for solutions (Lesh & Doerr, 2003; Spandaw & Zwaneveld, 2009; Doruk & Umay, 2011, Sahin, Yenmez, & Erbas, 2015). Studies on mathematical model and modeling are undertaken in many countries in recent years and they aim to attract the interest and to contribute to teaching (Dolye, 2006; English & Watters, 2004; English, 2003; Spandaw & Zwaneveld, 2009;

Blum & Ferri, 2009; Durmuş, 2011; Keskin, 2008, Doruk, 2010).

In this respect, mathematical modeling includes a multifaceted problem-solving process (Blum & Niss 1989, cited in Doruk & Umay, 2011). Lesh and Doerr (2003) stated that problem-solving techniques and methods are used in mathematical modeling and emphasized the need to create a product (model) at the end of the mathematical modeling process.

A model is an entity rebuilt with abstract symbols. According to Lesh and Doerr (2003), models are conceptual systems that allow comprehension of the rules that govern the elements, relationships, operations and interactions. At the same time, models are the entirety, composed of mental structures necessary to comprehend and interpret complex systems and external representations of these structures. Conceptual systems create representational media, written symbols, computer-based graphics, paper-based diagrams, graphics and experience-based metaphors. All of these aim to generate, define and explain other systems (Lesh & Harel, 2003).

Mathematical modeling can be considered as the simplification or abstraction of real-life problems or situations through mathematical structures; therefore, a model transforms real-life problems into mathematical problems (Spandaw & Zwaneveld, 2009; Ang, 2010; Niss, 1987 cited in Bayazit et.al., 2011).

Mathematical modeling allows students to discover meaningful problem situations and create explanatory models that will empower them to deal with current global problems (Dolye, 2006). In this context, Kaiser (2005), and Kaiser and Sriraman (2006) classified mathematical modeling approaches in literature in their studies. The Contextual Modeling Approach (CMA) and studies by Lesh and Doerr (2003) formed the basis of Kaiser and Sriraman'sresearch.

Although CMA was termed as a solving word problems approach, CMA has extended this approach (Lesh & Doerr, 2003; Kaiser & Sriraman, 2006). Model-eliciting activities are problem-solving activities which help students discover, make sense of, develop and improve different situations by using their own mathematical structures and educational characteristics. The purpose of traditional problem solving is to undertake operations with the given information however, eliciting a model is a process in itself. The purpose of this process is to implement the model with a new problem that the students created while solving the original problem (Kaiser & Sriraman, 2006).

According to Lesh and Doerr (2003, p. 9) modeling is the process of mentally organizing, coordinating and systematizing problem situations to find patterns, and use and generate various schemas and models during the process of interpreting (identifying, explaining or creating) events or problems (Fig. 1).

Mathematical modeling can be defined as a process that represents real-life problems and it is an initiative to comprehend these types of problems and find solutions (Ang, 2010; Spandaw & Zwaneveld, 2009). Mathematical modeling is a cyclical process; Lesh and Doerr (2003, p.17) explain the modeling cycle presented in Figure 1 as:

Description: Forming relationships between real life and the model

Manipulation: Producing solutions to related problems, making predictions

Transformation: Transforming the obtained results back to real-life situations

Verification: Checking the accuracy of the results.

Lesh and Doerr (2003) define the modeling process as a set of activities that aim to develop students' exploration and discovery skills, and these activities include transforming a real-life problem into a mathematical problem and making decisions regarding how problems are solved, how ideas are planned and developed, whether ideas need revision or more comprehensive thinking, and whether the ideas include the conditions and assumptions provided in the problem.

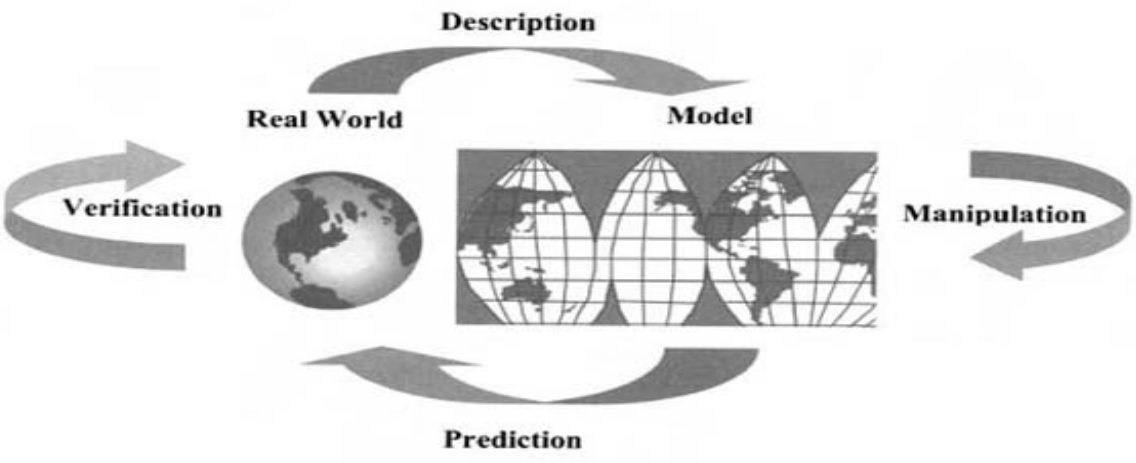

Figure 1. Four-step Modeling Cycles

Lesh and Doerr (2003) base their mathematical modeling studies on model-eliciting activities. Model-eliciting activities include the modeling process. The purpose is to create a model at the end of the process that can be shared with others, used in similar situations and changed for other purposes. Model-eliciting activities can contain various fields of mathematics (quantity, dimensioning, coordination, classification, transformation into algebra, regularity that affects relationships), therefore, students acquire mathematical senses and elicit a more distinct mathematical comprehension from undertaking such activities (Lesh and Doerr, 2003 p. 5).

Mathematical modeling problems reflect real-life content based on other disciplines such as social studies, science and other domains included in the problem. Students faced with mathematical modeling problems have to discuss the content of the problem in order to achieve the aim of the problem-solving task (Dolye, 2006). Usually, groups of three to five students discuss the mathematical modeling activities and information exchange takes place. Individual or group work can be undertaken in mathematical modeling activities.

Situations that require modeling are related to both the teacher and the student. Literature review shows that skills, competences and views of pre-service teacher regarding mathematical modeling are worth investigating (Spandaw & Zwaneveld, 2009). Ferri and Blum's (2009) study emphasized the need to research pre-service teachers' approaches to mathematical modeling problems and their competences to implement the model in the classroom environment. In a study by English and Watters (2005), training was provided to primary school students for three years on mathematical modeling problems and it was observed that students were able to use various different approaches consistent with modeling structures at the end of the period. Modeling is an arduous process however, in which attitudes and skills of teachers and pre-service teachers related to modeling are very important.

The main aim of the current study was to identify the views of "primary school mathematics pre-service teachers on mathematical modeling". Three research questions were identified by examining various studies on mathematical modeling and mathematics included in the literature:

1) What are the views of primary school mathematics pre-service teachers on mathematical modeling problems?
2) What are the views of primary school mathematics pre-service teachers on the benefits of using mathematical modeling activities in teaching mathematics?
3) What are the views of primary school mathematics pre-service teachers on the hardships experienced in the use of mathematical modeling activities in teaching mathematics?

METHOD

Research Model

The current study aimed to identify the views of primary school mathematics pre-service teachers on mathematical modeling. In this context, it was necessary to establish the existing knowledge of the working group. Case studies provide in-depth information and results related to a specific situation. Therefore, qualitative research methods were used in the case study because according to Şimşek and Yıldırım (2008), qualitative research is a research model that includes data collection methods such as observations, interviews and document analysis and in which a qualitative process is used regarding the presentation of perceptions and situations in a realistic and holistic manner in the natural environment. In this context, qualitative research methods were used in the current study to investigate the research questions in a holistic manner. Appropriate data collection tools were selected for the purposes of observation, interview, video analysis and content analysis. Additionally, themes, and relationships among themes, were identified to obtain more explanatory and causal results. Researcher comments were also included and thus, the role of the researcher was also identified in the study.

The current study utilized convenience sampling and maximum variation sampling together.

Participants

Participants were pre-service teachers attending a primary school mathematics teaching department of a state university. However, since it would be difficult to undertake the study with all pre-service teachers, the working group consisted of 14 primary school mathematics pre-service teachers.

The working group was selected from among volunteers from various levels. The prerequisite for selection was that they did not take any classes related to mathematical modeling.

While sharing student views, they were coded S1 through S14 instead of using their names. Since group work was used in modeling activity, pre-service teachers named their own groups. Table 1 presents the group names of pre-service teachers and their classroom levels.

Table 1. Group Names and Years of Pre-Service Teachers

Participants (codes*)	Years
İHA S1 İHA S2 EBU S3 EBU S4	Year 4
EBU S5 GROUP OF SMARTS S6 GROUP OF SMARTS S7	Year 3
GROUP STAR S8 GROUP STAR S9 GROUP STAR S10 IMOS S11	Year 2
IMOS S12 FRIENDS CAFE S13 FRIENDS CAFE S14	Year 1

İHA and EBU stand for initials of first names of studens in the group, S stands for student and IMOS stands for Primary School Mathematics Teachers

Table 2. Skills to be Assessed with the Warm-up Questions

Participants	Years
Warm-up question	Assessing the related column in the table
Warm-up question	Selecting the "most appropriate one" from among the columns in the table
Warm-up question	Assessing the related columns in the table
Warm-up question	Gaining operational skills

Data Collection Tools

The modeling activity used in the research was adapted for the purposes of the study in a similar manner to the modeling activities (e.g., the volleyball problem, the big foot problem) developed by Lesh and Doerr (2003). The developed activities were checked by three experts in the field to ensure the validity of the assessment tool and it was confirmed that the tool had the basic qualities that existed in Lesh and Doeer's activities. The activity asked students to model a house purchase problem, often experienced in daily life, by determining which banks and which conditions were suitable to secure a loan for the selected house (see APPENDIX 1). Selection of the "buying a house" problem was considered relevant as people always plan to buy a house and therefore mortgage options interest them. The first four problems were warm-up problems and the fifth required mathematical modeling. Warm-up problems acted as the preliminary preparation phase for the modeling problem. Although they were structured as open-ended questions, they directed the students toward a single answer. Warm-up questions were asked in order to make participants select modeling options more easily, analyze relations among different parameters and establish connections between these relations. Table 2 presents the skills that were assessed with the help of warm-up questions. In their study, Lesh and Doerr (2003) emphasized that additional work should be provided or problems related to the topic before starting the modeling activity.

The fifth question required the use of modeling. Before taking their views on mathematical modeling activities, pre-service teachers were asked to think about the modeling activity and solve the problem. The modeling question below was designed with the help of experts:

> Question 5. Mr. Ali has a saving of 120.000 Turkish Liras (TL) and can pay a monthly payment of 2500 TL credit at the most. He would like to purchase a house by taking different aspects of a house and its neighborhood into consideration and to receive a loan form a suitable bank for this purpose. You are asked to select a house for Mr. Ali by taking these concerns into consideration and propose 5 bank names by taking bank interest rates for home loans into account. Prepare a payment plan according to bank rates for home loans for

banks that you have selected (present the payment plan by making use of various representations). Convince Mr. Ali by writing a detailed letter with your options and justifications.

Data Collection and Analysis

The activity was held in two sessions. The data collection tool was administered to 3rd and 4th year primary school mathematics pre-service teachers during the first session and it was administered to 1st and 2nd year primary school mathematics pre-service teachers during the second session. The problem paper that included the mathematical modeling activity was distributed to each participant and they were allocated 60 minutes for thinking and solving the problem. At the end of the 60 minutes, the participants were asked to form groups of two or three. Pre-service teachers were then instructed to discuss the problems in the mathematical modeling activity for 15 minutes. After the implementation of the modeling activity, interviews and focus group discussions which lasted between 35 and 40 minutes in total were held with the participants. Interviews were recorded with the permission of the participants. They were asked open-ended questions such as "What do you think of the problem you solved? How was it different from the other problems? In your opinion, what contributions can these types of mathematical modeling activities make to mathematics teaching? Would you like to use these types of activities in your classrooms when you become a teacher? " Open-ended questions aim to identify the views of the participants (Yıldırım & Şimşek, 2008). In addition to pre-prepared questions, the participants were asked additional questions to obtain more detailed information.

Interviews were recorded using audio and video with permission from the pre-service teachers. Audio recordings were documented to confirm accuracy with the video recordings. According to Yıldırım and Şimşek (2008), descriptive analysis is the classification and interpretation of obtained data based on pre-identified themes. In the current study, the themes were elicited in the descriptive analysis from the interview questions prepared to answer the research questions. The themes identified with the descriptive analysis were subjected to more in-depth study with the help of content analysis to reveal the overlooked data in the descriptive analysis. The data obtained through content analysis was combined around specific concepts and themes to be organized and interpreted (Yıldırım & Şimşek, 2008). In the current study, the codes identified for content analysis were adapted from studies by Ferri and Blum (2009) and Lesh and Doerr (2003) in line with the themes. In addition, documents obtained with the help of audio and video recordings were read by the researcher several times to identify themes and codes. These themes and codes were examined by two other researchers who confirmed their suitability. There was a high level of consistency between themes and codes. For instance, the question What do you think of the problem you solved? How it was different from the other problems? asked in the interview to reveal the first research question was identified as a theme. The answers mainly provided by teachers such as "…from daily life (DL)". "…depends on the person (subjectivity) (S)", "….importance of preference (P)", "…uncertainty (U)", "…importance of value judgments (VJ)" made up the codes for the first research question (Table 3). The statements of the pre-service teachers who shared their views in the interview were used to determine the coding ratios for the first research question. The same

Table 3. Codes for the First Research Question

Participants	Codes
İHA S1	S,P, U, VJ
İHA S2	DL, S. VJ, P
EBU S3	DL, VJ
EBU S4	DL
EBU S5	DL, U
GROUP OF SMARTS S6	DL, P
GROUP OF SMARTS S7	S,P
GROUP STAR S8	DL, S, U
GROUP STAR S9	DL
GROUP STAR S10	DL
İMÖ'LER S11	P
İMÖ'LER S12	DL, S, VJ, P
FRIENDS CAFE S13	S
FRIENDS CAFE S14	DL, S, T, VJ

Table 4. Ratio of Codes for the First Research Question

	Daily Life (DL)	Subjectivity (S)	Preference (P)	Value Judgment (VJ)	Uncertainty (U)
Number of Participants	10	6	7	5	3
Percentage	71.4%	42.8%	50%	35.7%	21.4%

operations were repeated by two other researchers to confirm consistency. In this manner, we aimed to establish the reliability of the study. Participant responses to the first question can be seen in Table 3.

The percentage of the pre-service teachers who answered the research questions were calculated while coding ratios were measured. For instance, because a pre-service teacher mentioned more than one feature regarding the first research question, the ratio total was higher than 100. However Table 4 provides total coding ratios lower than 100 because not all of the pre-service teachers gave answers related to the third research question.

FINDINGS AND COMMENTS

This section summarizes answers to the research questions of the study based on the data obtained from the interview records.

Findings and Comments Regarding the First Research Question

The first question of the study was the question "What are the views of primary school mathematics pre-service teachers on mathematical modeling problems?" During the interview following the modeling activity, pre-service teachers were asked the question "What do you think of the problem you solved? How it was different from the other problems?" The answers provided for this question "daily life, subjectivity, preference, uncertainty, value judgments" represent the characteristics of the mathematical modeling activity. Pre-service teachers were divided into groups and each group was coded. Table 4 presents the percentages provided by the pre-service teachers regarding the characteristics of mathematical modeling.

The relationship between mathematical modeling and daily life was mentioned by 71.4% of pre-service teachers: "We encounter it in daily life" (EBU S4), "It is more than seeing mathematics only as four operations, it is something everyone can come across" (IMOS S12),

> It can be reduced to daily life from the real life" (IMOS S12),
>
> They are exactly from daily life but since we are focused on solving the problem directly I tried to create a formula, this is the mathematician mentality, we are still students. My brothers are businessmen they handle these (taking bank loans) without using these types of formulas, hands-on as they say! I did not use the formula. I have never taken a bank loan. Since they (my brothers) have a lot of experience, they will do it more easily, some experience is needed. (İHA Ö2)

With these statements, the pre-service teachers express how experiences in daily life facilitated the solution of the problem.

Table 4 shows that 42.8% of the participants emphasized the subjectivity of mathematical modeling. Statements provided by the participants related to subjectivity are as follows:

> What criteria is he using to select the house? For instance if he doesn't like crowds, he can be away from the center, it is also better for the school to be away from the center as well so that students are not affected from the environment. It says shopping mall near the housing estate, who would go to shopping around his house nowadays? Everyone looks for cheaper places. And I don't think there usually do not exist cheap shopping malls aroundanyone's home. (İHA S1)
>
> Even if I pay 10.000 TL according to my conditions. I can pay 10.000 TL but I may also want to live in a house in Mamak, so it depends on the person" (İHA S1), "there is no definite answer to this problem. There are different answers for each of us. (GROUP STAR S8)

Participants mentioned freedom of choice and emphasized subjectivity. The word "most suitable" in the problem given in the mathematical modeling activity requires a selection from several options. Fifty percent of the participants mentioned the necessity to form a "preference" from many variables:

> You form a preference. (GROUP OF SMARTS S7)
>
> There were many alternatives. (IMOS S11)
>
> You need to form a preference; two to three options are coming from the banks. (İHA S1)
>
> I thought like this: Mr. Ali can pay 2500 TL at the most. If he receives a loan of very large amounts, for instance 100.000 TL, he pays 2500 TL. If he needs 40.000 TL I believe the bank will not have him pay 2500 TL because the payments will be finished quickly and the banks cannot get the desired interest rate from Mr. Ali. That's why they will tell Mr. Ali to pay a monthly installment of 1000 TL but in a longer period. (GROUP OF SMARTS S6)

By using higher-order thinking skills, the pre-service teacher tried to direct our attention to the fact that their preference is not formed by a single individual but the banks also play a part in reaching a decision. In the following statement, a pre-service teacher focused on the importance of value judgments in forming preferences:

> For example, when you compare the two, he will think that which one is more important, their using a school service or not, or proximity to the center or not being close to the center. Later he will think of the interest rate. (IMOS S12)

If we consider that our preferences are formed according to our value judgments, it would not be correct to separate "preference" and "value judgment" codes with a precise boundary; 35.7% of the participants commented on the importance of value judgments in their preferences.

In addition, the pre-service teachers complained about the ambiguity they experienced while solving the problems; 21.4% of the participants had difficulty in determining which bank to accept the loan from or which house to purchase:

> Life conditions in Batıkent are a bit better compared to Yaşamkent but the house features are better in Yaşamkent, the house is new and it is 4 bedrooms plus 1 living room.. There is an enormous difference in terms of prices. You did not say whether we should take the price into account or not to. Only the house and the neighborhood….When we look at these characteristics, it feels like Yaşamkent. (EBU S5)

Later, the participant went on to say:

> The given criteria were sometimes insufficient. There were other things involved; because it is a problem taken directly from real life. When one takes the points I mentioned a while ago, he/she becomes undecided about which one to choose. (EBU S5)

Findings and Comments Regarding the Second Research Question

The second research question was "identifying the views of primary school mathematics pre-service teachers on the benefits of using mathematical modeling activities in teaching mathematics". Percentages of pre-service teachers' answers regarding this research problem are presented in Table 5.

As it can be seen from Table 5, 71.4% of the pre-service teachers asserted that mathematical modeling activity is a daily life practice. The importance of building the information in teaching mathematics on real-life situations and using concrete examples is also stated in the renewed primary school program. The view of the participant that supports the view that mathematical modeling is applicable in daily life is seen below.

> This problem is taken from real life, I believe this example is very difficult for the students but modeling should be used. Modeling examples should be found and used for each topic because children cannot learn the things they cannot see and touch, it will be forgotten. (GROUP OF SMARTS S6)

Views on the benefits of using mathematical modeling in class centered on its support for developing higher-level thinking skills such as critical thinking, comprehensive and detailed thinking and interpreting the obtained results. Over thirty-five percent (35.7%) of the participants thought that mathematical modeling activity would develop higher-order thinking skills:

> Mathematics taught in secondary school level is based on a certain pattern, there are formulas, if you know them you can do the mathematic problems…. When we think of this question (pointing to Question 5), you think more comprehensively, it changes if you think of the situation according to this or that, it changes if you think it based on the house or based on the interest. Also, interest rate of 0.01 can be overlooked. If these are simplified and asked to students, students can think more comprehensively and in more detail. (IMOS S11)
>
> Their thinking skills will develop. I mean they can interpret and think. (IMOS S12).

Using these activities in class will "develop thinking structures, will remove monotony and will help focusing

Table 5. Ratio of Codes for the Second Research Question

	Daily Life Practice (DLP)	Higher Level Thinking (HLT)	Strategy Production (SP)	Cooperation (C)
Number of Participants	10	5	3	12
Percentage	71.4%	35.7%	21.4%	85.7%

Table 6. Ratio of Codes for the Third Research Question

	Difficulty Due to Topic of Activity (DDTA)	Difficulty Due to Its Being a Daily Life Problem (DDDLP)	Difficulty Due to Uncertainty (DDU)
Number of Participants	6	4	1
Percentage	42.8%	28.5%	7.14%

on thinking" (GROUP OF SMARTS S6).

Participants from three groups stated that higher-level thinking skills can be gained in this way: "They will learn other perspectives. Since everyone has a different perspective, students can get new ideas from different viewpoints" (GROUP STAR S10) therefore "by thinking critically" (GROUP STAR S8) "we can at least have students express their own views by taking them out of a set pattern" (IMOS S11).

Findings and Comments Regarding the Third Research Question

The third research question of the study was the "hardships experienced by the primary school mathematics pre-service teachers in the use of mathematical modeling". Percentages of pre-service teachers' answers regarding this research problem are presented in Table 6.

According to Table 6, 42.8% of the pre-service teachers had difficulty in solving the problem due to the topic of the activity being related to interest. They emphasized that the topic of interest was hard.

Considering their statements, it would be true to state that the participants showed that they had difficulty it is because of the fact that problems required mathematical modeling involved interest and interest problems are complex and the answers include remainders:

> It is the first time I became so involved with interest. (GROUP STAR S10)
>
> It is necessary to calculate them one by one, there are fractions all the time. (IMOS S12)
>
> If the formula was a bit easier, we could solve it too. (FRIENDS CAFE S14).

Another difficulty that was experienced by the pre-service teachers was based on the fact that the problem was a real-life problem; 28.5% of the pre-service teachers stated that they had difficulty in this respect, "The problem we encountered is not a problem we are used to, that was difficult enough. The given criteria were sometimes insufficient; other things could play a role because it is a problem taken from real life" (EBU S5).

One pre-service teacher had difficulty due to ambiguity: "There were many banks. It is good to have large variety but then you want to check them all. I had difficulty because of this" (FRIENDS CAFE S13). The pre-service teacher had difficulty selecting the bank and the house and wanted to check all the banks which proved difficult.

DISCUSSION

As a result of examining the views of primary school mathematics pre-service teachers on the characteristics of mathematical modeling, it was observed that they emphasized the difference of mathematical modeling from the problems solved in the class, its reflective real life nature and the importance of preferences, ambiguity and subjectivity. Pre-service teachers who mentioned the fact that selecting a variable in modeling problems could affect other choices stated that the subjectivity characteristic is extremely important. The important question here is whose selections are valuable. Lesh and Doerr (2003) emphasized that students' choices are important since they solve their own problems in mathematical modeling. Studies by Ferri and Blum's (2009) and Lesh and Doerr (2003) also support these views about mathematical modeling activities. Pre-service teachers regarded the mathematical modeling problem as a problem that could be experienced in real life rather than a problem that required the use of the four operations. This finding is in parallel with the studies carried out by De Corte, Verschaffel and Greer (2000) regarding realistic problems.

The second research question in the study was related to the contribution of mathematical modeling activities to teaching mathematics. Pre-service teachers believe that mathematical modeling activities contribute to using mathematics in daily life or awareness of using mathematics in daily life. In addition, pre-service teachers emphasize that modeling problems are effective in the acquisition of higher-level thinking skills, analytical thinking skills and strategy development. Similar to the findings in studies by Dolye (2006), Ferri and Blum (2009), Lesh and Doerr (2003), pre-service teachers mentioned that it would be meaningful to provide mathematical modeling activities as project work as they are related to daily life, require higher-order thinking skills and take extended periods to be completed.

The problems provided in the current study were hard for the pre-service teachers in terms of making decisions due to the uncommonness of the problems. They were used to deal with problems which have certain solutions. Pre-service teachers stated that they spent some time in deciding which choices were accurate. They emphasized that they used various thinking process in the selection and decision phases, that higher-level thinking was necessary for doing calculations and making suggestions and that it was necessary to use analytical thinking and questioning skills to approach the questions. They stressed the importance of having these types of activities in advanced classes because thinking processes would be useful for them when they become teachers.

Pre-service teachers identified that working together by cooperating, collective thinking, creating an environment for discussion and enjoying the work throughout the process were positive characteristics that could be acquired by students. Findings regarding the

importance of group work in Zawojewski, Lesh and English (2003) overlap with the findings of the current study.

While examining the pre-service teachers' views on the hardships of using mathematical modeling, the third research question of the study showed that pre-service teachers experienced difficulties because the problem was related to interest. They stated that operations related to interest were complex. They expressed the view that they had difficulties because they were not used to having problems with more than one correct answer and they could not decide which choice was preferable from among the many options, and which one would be more valuable. Studies by De Corte, Verschaffel and Greer (2000) and Eraslan (2011) also stated that participants had difficulties related to the topic of the modeling problem.

SUGGESTIONS

Results of the semi-structured interview analysis undertaken with primary school mathematics pre-service teachers demonstrate that mathematical modeling includes real-life problems, has more than one option, and subjectivity and value judgments are important elements in solving the problem. Since pre-service teachers were not previously subjected to these types of problems in their training, they experienced feelings of ambiguity in their efforts in problem solving and choice-making and were not sure about the results they obtained. The usual and ordinary problems based on "one correct answer" caused students to perceive mathematics as independent from real life. The fact that the modeling activity in the current study consisted of an interest problem, and included a variety of banks, generated hardships for pre-service teachers. The suggestions based on the findings of the study are provided below:

1) Mathematical modeling activity could be implemented by ensuring problems selected are age-appropriate. The modeling activity used in the current study could be implemented in the classroom environment by simplifying it with fewer bank choices.

2) Since the pre-service teachers who participated in the study had not taken mathematical modeling classes they could not quite comprehend what the modeling process was and how the model was elicited. Mathematical modeling classes could be provided in teacher training institutions.

3) A problem situation which students could use to associate mathematics with real life and a mathematical modeling activity appropriate for the student level could be selected to develop the mathematical modeling competences of primary school level students.

4) Allocating time for modeling activities at primary school level may not be effective in transferring mathematical modeling and mathematics to real-life situations. The reason for this may be related to the lack of knowledge and practice of the teachers who would be responsible for implementing the activities in the classroom. Therefore, in-service training could be provided to existing teachers on this topic.

5) Providing opportunities to carry out mathematical modeling activities by using group work and cooperation and allowing the exchange of models in the classroom may increase students' self-confidence.

Suggestions for future studies on mathematical modeling are as follows:

1) Views of pre-service teachers who attend elective mathematical modeling courses in teacher training institutions on mathematical modeling and their competences could be studied.

2) Relationships between mathematics classes and other content areas could be studied from a modeling view point and important results could be obtained from project and performance work.

3) Positive/negative effects of mathematical modeling activities on student attitudes toward mathematics, their views and their mathematics achievement could be studied for students who use mathematical modeling activities in their training.

Authors' Note

This paper is prepared based on first author's master's thesis

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APPENDIX 1: Mathematıcal Model And Modelıng Actıvıty

Neighborhood	Types of homes	Age of the homes (annual)	Distance to central locations	Distance to school	Mall inside the housing estate	Community clinic inside the housing estate	Day care center, playground etc. inside the housing estate	Swimming pool inside the housing estate	Frequency of public transportation	Value of the house
Yaşam Kent	4+1 ($130m^2$)	1	22 km	2km	5 km	Existent	Existent	Existent	Every 30 minutes	300.000 TL
Batı Kent	3+1 ($110m^2$)	8	12 km	500m	2km	Non existent	Existent	Non existent	Every 10 minutes	160.000 TL
Bahçelievler	3+1 ($100m^2$)	15	3km	200m	Non existent	Non existent	Existent	Non existent	Every 5 minutes	250.000 TL
Mamak	4+1 ($120m^2$)	10	10km	1km	Non existent	Non existent	Existent	Non existent	Every 20 minutes	130.000 TL

Mr. Ali has a family of four with his wife and two children (aged 5 and 10). He goes to a real estate agent. The real estate agent presents him the options provided in the table.

Question 1. Which house should Mr. Ali choose by taking transportation opportunities into account, why?

Question 2. Which house should Mr. Ali choose if he would like his children to sleep in separate rooms, why?

Question 3. Mr. Ali believes that it would be dangerous for his children to take the school service. In your opinion, which house should he select for this reason?

(Month)	12	18	24	36	48	60	72	84	96	108	120	144	180	240	300	360	VRI.*
AnadoluBank	0.84	0.84	0.84	0.84	0.84	0.84	0.85	0.85	0.85	0.87	0.87	-	-	-	-	-	Yes
Akbank	0.89	0.92	0.92	0.92	0.92	0.95	1.05	1.05	1.05	1.05	1.05	-	-	-	-	-	No
Denizbank	0.80	0.80	0.80	0.80	0.80	0.80	0.83	0.83	0.83	0.83	0.83	1.00	1.00	-	-	-	No
Finansbank	0.69	0.69	0.69	0.74	0.77	0.79	0.80	0.80	0.80	0.80	0.80	1.04	1.09	-	-	-	No
Fortis	0.74	0.74	0.74	0.74	0.79	0.79	0.81	0.81	0.81	0.81	0.81	-	-	-	-	-	No
Garanti	0.47	0.64	0.64	0.70	0.76	0.76	0.79	0.79	0.79	0.81	0.81	0.85	0.85	0.85	-	-	No
HSBC	0.76	0.76	0.76	0.77	0.79	0.80	0.83	0.83	0.85	0.85	0.85	-	-	-	-	-	No
İş Bankası	0.74	0.74	0.74	0.79	0.79	0.79	0.81	0.81	0.83	0.83	0.83	-	-	-	-	-	No
Vakıfbank	0.87	0.87	0.87	0.87	0.87	0.87	0.92	0.92	0.92	0.92	0.92	-	-	-	-	-	No
ING Bank	0.50	0.65	0.65	0.75	0.78	0.78	0.81	0.81	0.81	0.81	0.81	-	-	-	-	-	No
Yapı Kredi	0.74	0.75	0.75	0.75	0.75	0.75	0.79	0.79	0.79	0.79	0.79	-	-	-	-	-	No
TEB	0.74	0.74	0.74	0.74	0.89	0.89	0.95	0.95	0.95	0.95	0.95	-	-	-	-	-	No
BankPozitif	1.19	1.19	1.19	1.19	1.24	1.24	1.24	1.24	1.24	1.33	1.33	-	-	-	-	-	No
Şekerbank	0.84	0.84	0.97	0.97	0.97	0.97	0.99	0.99	0.99	0.99	1.02	-	-	-	-	-	No
DD Mortgage	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	1.02	1.02	-	-	-	No
Halkbank	0.88	0.88	0.88	0.88	0.92	0.92	0.95	0.95	0.95	0.95	0.95	-	-	-	-	-	No
EurobankTekfen	0.90	0.90	0.90	0.95	0.95	0.98	-	-	-	-	-	-	-	-	-	-	No
Ziraat	0.89	0.89	0.89	0.89	0.94	0.94	0.95	0.95	0.95	0.95	0.95	-	-	-	-	-	No

(VRI: Variable Rate of Interest)

Question 4. In your opinion, which interest rate from Garanti is suitable for Mr. Ali to purchase the house in Bahçelievler, why? (He has a saving of 120.000 TL).

Question 5. Mr. Ali has a savings of 120.000 TL and can pay a monthly payment of 2500TL credit at the most. He would like to purchase a home by taking the features of the house and its neighborhood into consideration and to receive a loan form a suitable bank for this purpose. You are asked to select a house for Mr. Ali by taking the features of the house and its neighborhood into consideration and propose 5 banks by taking bank rates for home loans into account. Prepare a payment plan according to bank rates for home loans for the banks that you have selected (present the payment plan by making use of various representations). Convince Mr. Ali by writing a detailed letter with your options and their justifications

Note: Calculations in loan use are found in the formula:
a: Amount to be received, k: monthly interest rate, n: number of installments
C: Amount of installments

$$a = \frac{C}{k} \times \left(1 - \frac{1}{(1+k)^n}\right)$$

Amount of monthly payment

$$C = \frac{a.k}{\left[1 - \frac{1}{(1+k)^n}\right]}$$