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An Investigation of Teachers' Views on Applicability of Modeling in Mathematics Courses*

Emine Özdemir[1], Devrim Üzel[1], Nesrin Özsoy[2]

[1]Department of Mathematics Education, Faculty of Necatibey Education, Balıkesir University, Balıkesir, Turkey

[2]Department of Mathematics Education, Faculty of Education, Adnan Menderes University, Aydın, Turkey

Correspondence: Emine Özdemir, Department of Mathematics Education, Faculty of Necatibey Education, Balıkesir University, Balıkesir, Turkey.

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Abstract

The purpose of this study has been to determine the views of elementary mathematics teachers on the applicability of modeling in mathematics courses. A case study was conducted with 17 elementary mathematics teachers working in various provinces in Turkey. An interview form consisting of open-ended questions was designed for the purpose of collecting data, which was obtained through semi-structured interviews. From the categories constituting the themes developed via the views of the teachers, four major conclusions and one minor conclusion were reached at the end of the study. Study results showed that the elementary mathematics teachers' knowledge of the process and teaching performance had an impact on their views of the applicability of modeling.

Keywords: elementary mathematics teachers, mathematics education, mathematical modeling

1. Introduction

The National Council of Teachers of Mathematics [NCTM] focuses on research-based mathematics learning. In such learning environments, students are encouraged to discover, detect and develop associations, solve problems, and share and discuss their ideas and the conclusion they have reached in small cooperative groups composed of teachers and peers. Under this system, learning is expressed as an active and constructivist activity (NCTM, 1989, 1991, 2000). Mathematics teaching involves a process whereby students are taught to perform mathematical research and interpretation. In this process, teachers are expected to be flexible and adaptive to the responses of students (NCTM, 2000). The objectives of the elementary mathematics curriculum in our country (Turkey) include mathematical model formation, mathematical thinking, problem solving, establishing communication, reasoning, and association skills (Ministry of National Education [MNE], 2005). The attainment of these skills and ensuring their retention throughout life is made possible, not by memorization of basic knowledge and operations, but rather by training individuals to have a working knowledge of technology, be capable of establishing interdisciplinary relations and of solving problems, and have model formation skills (Lesh and Zawojewsky, 2007; Thomas and Hart, 2010). According to Thomas and Hart (2010), primary school mathematics teachers need to have the necessary competencies in order to be able to successfully practice mathematical modeling in their lessons. Furthermore, their understanding of and training in the application of modeling is one of the factors directly influencing their success and motivation in practice. With mathematical modeling, mathematics is applied to real-life cases. Model formation activities are of significance in this process. Blomhoj and Kjeldsen (2006), Yu and Chang (2009), and Thomas and Hart (2010) have argued that because modeling activities require students to engage in a new set of activities, ones that they are unfamiliar with, this may cause some difficulties for them. They added that the role of the teacher in overcoming these difficulties is to create opportunities that enable students to think in a multidimensional manner about the problem, explain and interpret the problem, develop and test hypotheses, review obtained results or models, and rearrange them by eliminating excessiveness (Zawojewski, Lesh and English, 2003). Models are the conceptual systems that students develop in mathematically defining, explaining, interpreting, and representing a case (Lesh and Doerr, 2003). Attention has been

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called to the importance of mathematics teachers being competent in the field and acquiring experience and mathematical aptitude in the preparation of modeling applications that serve to give students the opportunity to formulate mathematical structure and concept systems and to utilize them in the solution of real-life problems. Based on this, the purpose of the study is to evaluate the views that elementary mathematics teachers who have received modeling training have on the applicability of modeling in the mathematics course. To achieve this purpose, the views of elementary mathematics teachers on the applicability of modeling in the mathematics course were researched.

2. Method

2.1 Research Design

The case study approach was employed in this study. Case studies enable an in-depth longitudinal investigation of the studied subject. With this approach, a systematic examination of the relations governing the obtained data is able to be made, and these relations are able to be explained within the framework of cause and effect (Cohen and Manion, 1994).

2.2 Sampling Procedures

The criterion sampling method was used in the determination of the study group. All of the cases that meet a set of criterion are studied in this method (Yıldırım and Şimşek, 2005). Based on this, 17 elementary mathematics teachers participated in the study. These teachers received modeling training in the *School Experience and Teaching Practice* course offered by the elementary mathematics bachelor's degree program, and all had graduated from the program in the 2010-2011 academic year. They are currently working at education institutions affiliated to the MNE. For this study, they were asked to prepare a mathematics lesson plan based on modeling and then to perform modeling-based teaching in their classes.

2.3 Data Collection Procedures

An interview form consisting of four open-ended questions was developed for the purpose of determining the view of elementary mathematics teachers on the applicability of modeling in the mathematics course. For the content validity of the semi-structured interview form used in the study, the opinions of 3 academic staff specialized in the field of mathematics teaching and assessment/evaluation were consulted. The items constituting the interview forms were organized in line with expert opinions and the purpose of the study. The preliminary studies for the testing of the validity of the interview form involved taking the views of 5 elementary mathematics teachers selected through simple random sampling. Being trained in and having practiced the applying of modeling in the mathematics course, and having knowledge on the subject were taken into account in selecting the elementary mathematics teachers who would participate in the preliminary study. Teachers were selected based on their voluntary consent. The answers to the items in the interview forms were analyzed by the researchers and categorized under suitable themes. For the purpose of ensuring internal consistency, the data under the formed themes were looked at to determine whether or not they constituted a meaningful whole. In addition to all of the formed themes being different from each other, it is also necessary that taken together they form a meaningful whole; external consistency was determined by taking this into consideration. The researchers performed scoring independently of each other in determining the themes. In this scoring system, the expression of "inadequate" was applied 1 point, "acceptable" was applied 2 points, and "adequate" was applied 3 points. The percentage of agreement between the researchers' evaluation results were calculated by using the formula of "agreement/ [agreement + divergence] x 100" (Kırcaali-İftar and Tekin, 1997; Tawney and Gast, 1984). Four main titles were obtained in the pilot study: perception of modeling, use of modeling, contributions of modeling to the learning process, and factors influencing the applicability of modeling. The inter-observation agreement as a result of the grading of the themes obtained from the views of 5 elementary mathematics teachers was respectively determined to be .98, .91, .94, and .92. On the basis of the fact that these values were higher than .80, it was decided that the themes used in the pilot study could be employed in the main study (Kırcaali- İftar and Tekin, 1997).The quantification of qualitative data increases reliability (Yıldırım and Şimşek, 2005). In this context, the frequency distribution of the determined themes and of the categories constituting these themes was prepared. According to Weber, there are three types of reliability (Weber, 1985). Since the same results were obtained after repeating the analysis of the data set, invariance was achieved. The analysis of the data set for repeatability involved two mathematics teaching experts, who, it was found, were in agreement on the data analysis, with a consistency of 95%. In the determination of the themes and categories that would constitute the basis of the analysis of the data set, opinions and releveant literature were taken into account to satisfy the criteria of precision.

2.4 Data Analysis

The obtained data were examined through descriptive analysis, wherein data were summarized and interpreted according to the previously determined themes. The stages constituting the analysis process were provided according to the model proposed by Yıldırım and Şimşek (2005). The framework formed for data analysis was based on the study

questions, the conceptual framework of the study and the dimensions in the interview. The themes for which the data are organized and presented under were determined according to this framework, and the data was processed according to the thematic framework. After reading and organizing the data obtained according to the previously formed framework, it was observed that the themes developed from the analysis of the data obtained from the views of the prospective teachers participating in the main study and the themes obtained in the pilot study overlapped. These themes were therefore taken as the basis for the main study. The organized data were identified and supported with direct citations in concerned places, and the findings were explained, associated, and given meanings.

3. Results

Following analysis of the data obtained in the study, thematic coding was performed, where it was determined that the categories could be arranged under four themes: modeling perception, applying of modeling, contributions of modeling to the learning process, and factors affecting the applicability of modeling. A total of 387 views emerged from the analysis of the qualitative data obtained from the opinions of the elementary mathematics teachers. Among these views, 122 (32%) fell under the theme of *contributions of modeling to the learning process*, 118 (30%) under the *perception of modeling*, 104 (27%) under the *factors influencing the applicability of modeling*, and 43 (11%) under the *use of modeling*. For this study, "T" represents "teacher" while the letters that follow represent an abbreviation of the given teacher's name" (e.g. "Teacher Turgut" would be represented as "TTU"). Below are the findings, presented in frequency and percentage form for each category, from the interviews conducted with the mathematics teachers.

Table 1. Percentage and frequency distribution for the categories under the *Modeling Perception* theme

Categories	f	%
Uses real-life problems in the process	17	100
Explains real-life cases with the help of mathematics	17	100
Facilitates formation of mathematical models and their use in problem solving	16	94
Puts mathematizing into focus	15	88
Seen as one of the best instruments used for learning mathematics	15	88
Seen as an innovative approach	13	76
Seen as a process requiring thought	11	65
Conforms with the new curriculum	9	53
Seen as an instrument for converting informal knowledge into formal mathematical knowledge	5	29

It was observed that all of the elementary mathematics teachers developed a positive perception towards modeling in mathematics education. When the categories constituting the perceptions of elementary mathematics teachers on the use of modeling in mathematics education were examined, it was concluded that they had knowledge on the modeling process; a favorable finding. Below are some samples of the views shared by the elementary mathematics teachers in this category.

TTU. *"Instead of the memorization, which is based on the practice-formula relations and had been the primary way in which students learned, it places the student at the center of focus in the development of their mathematics knowledge and skills."*

TF. *"It combines the knowledge of the student with preliminary learning and ensures organizing and construction of one's own knowledge."*

TAY. *"It attempts to translate informal mathematics knowledge into formal mathematics knowledge, and real- life problems are used in the process to achieve this."*

TS. *"I think modeling will ensure the transition from arithmetic generalization to algebraic generalization and it is one of the best tools serving this process."*

The mathematics learning process is dealt with as an active process in the mathematics curriculum implemented in our country. In this process, it is important to prepare an environment that best enables students to research, discover, solve problems using mathematical language, and share and discuss solutions and approaches. Teachers are tasked with directing students to think creatively, to use current mathematical knowledge, to perform mathematical reasoning, and to work actively in the group, and it is emphasized that teachers have knowledge on contemporary approaches to mathematics teaching and utilize them in their lessons. As part of this process, primary school teachers are expected to include modeling, which is one of the contemporary approaches used in mathematics education, in their practices. Thus, based on the conclusion that elementary mathematics teachers have a positive perception regarding modeling, it can be

said that this has a positive impact on their motivation and success in practice.

Table 2. Percentage and frequency distribution for the categories under the *Use of Modeling* theme

Categories	f	%
When starting a new unit/subject	11	65
In cases requiring mathematical reasoning	8	47
After providing basic information on the subject	7	41
At the end of a unit/subject	6	35
To concretize the subject	5	29
To reinforce the subject	4	24
In cases when the subject is not understood	2	12

In the studies conducted by Lesh and Doerr (2003) and English (2006), it was stated that the modeling process puts forward an approach that serves to make complicated systems mathematically meaningful. Based on this, it is understandable why the applicability of modeling is preferred by teachers prior to and during teaching. Mathematics teachers that start new units or subjects with modeling applications stated that it was more suitable to access basic knowledge and concepts regarding the subject through modeling.

TZ. "I generally use it when starting a new subject. And with it, I am able to solve many of the students' questions regarding the subject."

TAR. "I use it to increase the interest of children towards the subject when starting the subject."

TM. "Modeling is a great method for drawing the attention of students when starting a new subject."

TSİ. "I generally use it when starting the subject. It is very effective in drawing attention and including students in the lesson."

These thoughts expressed by the elementary mathematics teachers are supported by the positive effects that the model they use in the lesson have on the students. For instance, one elementary mathematics teacher who taught the subject of perspective through modeling, noted their satisfaction with the outcomes as follows: "It really had positive impacts on the students and developed their perspectives. The activities helped students adopt a new perspective within a very short period of time, and I did not need to administer an additional application to ensure their comprehension of the core subject." There was one other similar case encountered during teaching. The inclusion of modeling applications during teaching was reported by the elementary mathematics teachers to be strongly preferred. Some of the teachers stated that modeling had been used during teaching after introducing basic topics regarding the subject, while others stated that they had preferred using it in circumstances requiring mathematical reasoning.

TAY. "I prefer to use modeling after introducing the subject, once an idea of the new subject begins to form."

TSE. "Rather than using modeling prior to starting a new subject, I prefer using it in the development section of the lesson. Since the level of my students is low, in order for me to be able to use modeling prior to starting the lesson, preliminary knowledge needs to be retained."

TKA. "I use it more to make the subject realistic and comprehensible when starting a new subject, or when the subjects are not understood."

A mathematics teacher who preferred to use it in cases requiring mathematical reasoning summarized his/her views by stating, "At times, when there is a generalization that needs to be provided within the subject, I could consult modeling in future phases of teaching." On the same subject, another teacher stated, "I use modeling, for application purposes, after the core of the subject is comprehended." This particular category constitutes the first two preferences expressed by the teachers to be in favor of the use of modeling during teaching. The views of mathematics teachers who preferred the use of modeling in concretizing the subject, reinforcing the subject, and when the subject is not understood fall under the other categories. Samples of these views are as follows:

TE. "If the subject to be explained is an abstract subject for the students, I use it to concretize the subject. I also use it to teach the logic in subjects that require some memorization, rather than having the students simply memorize formulas. An example would be modeling perfect square expressions when explaining identity…"

TKO. "I use modeling at the end of the subject. From the mathematics exercises book published by the MNE, I select and apply an activity associated with our subject."

In addition to some of the teachers stating that the use of modeling was more suitable at the end of units/subjects,

mathematics teachers preferring the use of modeling prior to and after teaching were encountered in the views of TTU, TAR and TB, shown below.

TTU. "I prefer using it prior to starting the subject and in the general assessment section."

TAR. "I use it to enhance their interest in the subject when starting the subject. Sometimes I use it at the end of the subject in order to have them picture the subject in their minds."

TB. "I use it when starting subjects that students have preliminary knowledge on. If they do not have knowledge on the subject, I use it after their prerequisite learning is completed or at the end of the subject."

Views on the use of modeling in terms of learning domains in the mathematics curriculum were examined as part of this study, and according to these, among the elementary mathematics teachers, 32% preferred using modeling activities in algebra, 29% preferred using it in geometry, 14% preferred using it in measuring with percentages and numbers, and 11% preferred using it in the statistics and probability learning domains. As seen from these percent figures, the areas of algebra and geometry were reported to be the best fit for modeling. In the study conducted by Pollak in 2003, it was reported that certain mathematical models adhered to certain learning domains, like algebra, geometry, and statistics. The reason for this was attributed to the presence of formulas and algorithms in these domains. When the views of elementary mathematics teachers were examined, it is striking that both this case and its positive impacts on students were taken into consideration.

TB. "When I use modeling, I generally use it in the areas of algebra, measurement, probability, and statistics. It helps to create a permanent learning setting for the children."

TE. "It is more suitable for use in the area of algebra. As the terms are more abstract, concretizing them with modeling is more effective in terms of facilitating the students' understanding."

TKA. "I generally use it in geometry. This is because with modeling, the geometry subjects are able to be brought closer to reality and to capture the attention of the students."

When the views of the elementary mathematics teachers were examined, it was concluded that their own experiences were effective in preparing and practicing modeling applications. Other factors shown to have an impact on preparing and practicing modeling applications included the student profile of the class in which the teacher applied modeling and the intensity of the curriculum. The following views of the teachers demonstrate how these factors influence the area selected for modeling application.

Tİ. "I use it more comfortably in the areas of algebra and numbers. I have trouble in applying it to other areas."

TG. "I use it in the areas of algebra, measurement, and numbers, as it is easier to prepare activities in these areas."

TAR. "I use it in the areas of measurement and geometry. It is easier to apply, as these domains are closer to real life."

TF. "I use modeling more often in the areas of numbers and for problems that they may encounter in daily life."

Here it is important to identify which learning domains the elementary mathematics teachers apply modeling, how they use it, and the type of activities they use it for. In examining the responses of the teachers, it was observed that they were able to present sample problem cases for each learning domain. The teachers reported that it could be used more frequently in geometry for the discovery of π, in the field of numbers for finding relations between numbers, and in algebra, for identities by using the squares of Khwarizmi. Furthermore, they stated that they had used social studies and science subjects in association with activities related to measurement concepts. For example, measurement concepts would be taught by conducting activities wherein the students were to determine the area of a map of a region or the area of oil accumulation leaking from a pipeline. It was also found that for the areas of statistics and probability, activities enabling the applying of modeling were used for finding the probability of an event or for determining the rules derived from tree graphs. From these findings, it can be concluded that modeling can be used in a manner suitable for all learning domains by means of these activities.

The application of modeling in learning domains is reflected in the frequency in which the mathematics teachers use the modeling. When examining the frequency of use of modeling, it was revealed that the "sometimes" category had the highest frequency. It was determined that 59% of the elementary mathematics teachers preferred to include modeling in applicable topics or when necessary. Sample views regarding frequency of use are given below.

Tİ. "I could use it 3 times within the year. Other than that, I neither had the time nor the opportunity."

TE. "It does not have a certain frequency. I only use modeling if there is a topic for its application. Sometimes I used it consecutively, and sometimes I did not practice it for a month."

It can be observed that the reasons for including modeling in their lessons have again reflected the views of the elementary mathematics teachers. In examining the views, it can be seen that factors such as student profile, modeling

being a time consuming process, relevance of subjects to modeling, and teaching experiences have an effect on the use of modeling. The teachers' views below demonstrate this.

TKA. "I include it depending on the suitability of the subjects."

TSİ. "I include it sometimes. I say sometimes because the very low level of readiness of the students only allows me to include it sometimes."

TTU. "I did not use it in my first year of teaching. I think that this is due to both the incapability of the students and also my lack of experience. I only started using it recently."

Based on these teachers' views, it is clear that student profile does directly influence the use of modeling to some extent. Nonetheless, it can also be seen that among the teachers faced with similar conditions, there are some that still sometimes include modeling in their lessons. In contrast to this, two mathematics teachers stated that they had not yet included modeling in their mathematics lessons.

TG. "The knowledge of most students is much lower than the level of knowledge expected of a student attending the 6th grade. I could not use modeling due to this."

TSE. "I am unable to use modeling because I did not have a class at a level enabling me to use it."

It was found that 29% of the elementary mathematics teachers included modeling in the unit/subject of their lessons. The views below from TAR, TKO and TM offer insight into this finding.

TAR. "I do not use it much for 6th grade students. But, I use modeling examples frequently in the 5th grade."

TKO. "I include modeling in 2 periods each week."

TM. "I include it once each week."

Today, memorizing mathematical operation processes and applying these to similar problem cases is not enough. It is necessary for students to encounter complicated problem cases in order to help them develop mathematical thinking, create new concepts and gain experience in this (Lesh and Zawojewsky, 2007). Mathematical modeling can be viewed as one of the methods best capable of achieving these aims. Based on this inference, modeling has been accepted as a hypothetical framework in this study. In classes performing teaching with modeling applications, students have had the opportunity to clarify real-life problems through mathematics. The percentage and frequency distributions of the theme, *positive contributions of modeling to learning*, in terms of the views of elementary mathematics teachers and the categories constituting this theme, are provided in Table 3.

Table 3. Percentage and frequency distribution for the categories under the *Positive Contributions of Modeling to Learning* theme

Categories	f	%
Ensures transition to algebraic generalization from arithmetic generalization	11	65
Ensures permanent learning	11	65
Developes problem solving skills	10	59
Developes the students' high level cognitive skills, such as mathematical reasoning	10	59
Structures the students' knowledge	9	53
Draws and maintains attention to the mathematics course	9	53
Enables mathematical achievement	9	53
Encourages research	8	47
Ensures the in-depth development of mathematical knowledge	8	47
Encourages active participation	8	47
Makes mathematics learning more joyful	7	41
Encourages creative thinking	7	41
Does not only focus on memorization	7	41
Promotes mathematization of daily life problems	4	24
Rationalizes the mathematical knowledge of students	4	24

When Table 3 is examined, it is striking that in each category there are expressions related to the skills targeted to be

acquired by the mathematics curriculum. The views of the elementary mathematics teachers show that modeling plays an active role in the acquisition of all the stated skills. Some of the more illuminating views are provided below as examples.

Tİ. *"There were some short and amateur applications that I had developed myself. Even though the application takes longer than I expected, I obtained 80% achievement in internalizing the targeted acquisition."*

TSİ. *"I applied the plan I developed and received very positive results. The entire class was very active. Even a student with a very poor level had an idea about the subject."*

TM. *"More importantly, they start liking mathematics instead of being afraid of it."*

TKO. *"I completely apply modeling particularly in the the 5th grade mathematics practices lesson. Even though the children will not necessarily acquire anything in the short term, I think their problem solving skills will develop in a proper manner."*

When the views of elementary mathematics teachers on the applicability of modeling are examined, the theme of *factors influencing this condition* emerged. The percentage and frequency distributions of the categories related to the theme of *factors influencing the applicability of modeling* are provided in Table 4.

Table 4. Percentage and frequency distribution for the categories under the *Factors İnfluencing The Applicability of Modeling* theme

Categories	f	%
Intensity of the mathematics curriculum	16	94
Readiness of the students	15	88
Time	14	82
Means/infrastructure of the school	13	76
Unsuitability of the program for modeling	13	76
Memorization imposed by the current exam system	12	71
Students not encountering similar applications in the past	12	71
Competency of the teacher	6	35
Workload of teacher	3	18

From Table 4, it can be observed that the categories of *intensity of the curriculum* and of *readiness of the students* proved to be particularly problematic for the teachers in terms of applying the modeling. Below are some sample views presented by the teachers on these categories.

TKA. *"When I became a teacher, I thought the applicability of modeling was possible, but in reality I saw that with its use it was very difficult to complete all of the subjects on time."*

TAR. *"The extreme intensity of the curriculum is causing me difficulties."*

While TKA and TAR pointed to the intensity of the mathematics curriculum as influencing the applicability of modeling, TSE and TE cited the readiness of the students as being an influencing factor. TG expressed views on both cases.

TSE. *"In order to be able to practice modeling, it is very important that the students' level of readiness is suitable."*

TE. *"The level at which students leave their class teachers, in other words their readiness level, is very important."*

TG. *"I have doubts with regards to the applicability of modeling. This is because class size, current level of knowledge of students, and the curriculum are obstacles for the implementation of modeling."*

The lack of time, failure to establish infrastructure, lack of teacher knowledge on modeling, and incompatibility of the curriculum to modeling appeared as additional factors influencing the applicability of modeling.

TTU. *"I believe the only thing missing is the physical condition of the classroom, and this lack may reduce the effectiveness of modeling."*

TF. "*Teachers can be informed about modeling by providing them in-service training."*

TB. "*I think there is a time problem for the application.*"

Regarding the categories of *memorization imposed by the current exam system, students not encountering similar applications in the past*, and *the excessive workload of the teacher*, some of the teachers expressed that these too were factors preventing the effective application of modeling. The factors are summarized below in the views of TZ, Tİ and TE.

TZ. *"The fact that there are some students who come to class after having attended private courses, received tutoring and memorized certain formulas constitutes an obstacle in some practices."*

Tİ. *"The subject focus for each lesson is very extensive, and subjects have to be covered with plain explanations and time has to be set aside for formal works in school."*

TE. *"You are unable to use modeling in some subjects. If the teacher emphasizes this and has developed a perspective in this area, the child is able to perform the application. But, if the class teacher has made memorization a habit for the student, the child does not want to deal with the modeling application or its logic; memorization suits them."*

4. Discussion, Conclusions and Suggestions

The aim of this study has been to investigate and ascertain the views of the elementary mathematics teachers on the applicability of modeling in their lessons. In line with this objective, semi-structured interviews were conducted with teachers, the obtained data were analyzed and their views on the applicability of modeling were gathered together under 4 themes. With the categories constituting these themes, four major conclusions and one minor conclusion were reached at the end of the study. Following are the results obtained in the study, which were evaluated together with the results from studies in the literature.

It was concluded that the modeling perceptions of elementary mathematics teachers had formed based on what they had experienced in the modeling process. Doruk (2010) pointed to certain features of modeling to explain this, including the constant reviewing and rearranging involved in modeling, and the use of metacognitive thinking skills for this in the active problem solving process of modeling activities. In addition to modeling being perceived as a process, a striking conclusion drawn from the study was that the teachers percieved the modeling approach to be one of the contemporary approaches in mathematics education and placed emphasis on its suitability for the new curriculum. When reviewing the literature, it was observed that there were studies in which mathematical modeling was perceived as the use of mathematical models. For instance, Akgün et al. (2013), attempting to determine the mathematical modeling awareness of teachers, whose knowledge of modeling was limited to the theoretic knowledge they received in their undergraduate studies, determined that elementary mathematics teachers did not have adequate knowledge with regards to modeling and confused the concepts of model, modeling, mathematical model, and mathematical modeling. In the study by Özturan-Sağırlı (2010), it was revealed that only one teacher partially held the view that the mathematical modeling method involved finding solutions to real-life problems with mathematical terms, while the others considered mathematical modeling to be the use of mathematical models. In contrast to this, the study of Bukova-Güzel and Uğurel (2010) found that teachers defined modeling as problem cases, outside of mathematics being expressed in a mathematical language, and the investigation of solutions with mathematical approaches. Based on this, it can be said that the elementary mathematics teachers participating in the study developed correct perceptions regarding modeling and had adequate knowledge on modeling.

Results from the present study showed that elementary mathematics teachers included modeling practices prior to, during or after teaching; however, among these 3 times, the use of modeling prior to and during the process was reported to be preferred. The use of modeling prior to teaching was preferred for the purpose of refreshing preliminary knowledge and drawing attention to the lesson when starting a new unit/subject. A similar case to this one was reported in the study by Şandır (2010), where the development of preliminary knowledge on the concept served to prepare the students for the lesson and increase their motivation. When findings on the use of modeling during teaching were examined in the present study, it was determined that modeling was used for concretizing the subject after basic information on the subject was provided, for cases requiring mathematical reasoning, for reinforcing the subject, and for cases when the subject was not understood. In a review of the literature, findings similar to the findings obtained in this study were encountered in those conducted by Şandır (2010) and Tekin-Dede and Bukova-Güzel (2013). In the study by Şandır (2010), models designed and implemented by mathematics teachers and prospective teachers were investigated. The teachers in Şandır's study reported that they had used modeling for the purpose of drawing the attention of students to the lesson, motivating them towards the lesson, having them visualize the concept, facilitating the learning of concepts, having them do exercises, and creating a concept image, as well as to help them learn the concept, eliminate misconceptions and avoid the formation of misconceptions. Accordingly, it was asserted that modeling could be used in various stages of the lesson, such as attention drawing, motivating, and transition to the lesson, and for teaching or reinforcing. In the study conducted by Tekin-Dede and Bukova-Güzel (2013), teachers reported that they could use modeling at the beginning or end of the subject, for term assignments or projects, for the purpose of drawing the attention of the students and integrating different mathematics subjects or interdisciplinary subjects. Lastly, the study by Akgün et al. (2013) reported that teachers used mathematical modeling mostly for the purpose of facilitating better understanding of the lesson, ensuring permanent learning, and visualizing mathematical concepts. Based on these related studies, it can be said that the purpose of the use of modeling directly affected how modeling activities were

included in the process of conducting mathematics lesson.

As a minor conclusion of the study, modeling was found to be used in the learning domains of measurement, numbers, statistics, and probability, with teachers holding the view that modeling was more appropriate for the areas of algebra and geometry. Akgün et al. (2013) reported that in interviews conducted with teachers, the teachers considered the use of modeling to be more suitable for the subjects of geometry, fractions, and numbers. Pollak attributed this finding to the fact that mathematical modelling adhered to certain learning domains (algebra, geometry, and statistics), particularly domains that featured formulas and algorithms.

In this study, it was shown that there were certain factors that influenced the applicability of modeling in mathematics education. The views of elementary mathematics teachers indicated that these factors included the teachers' own experiences, the student profile in the class of practice, and the intensity of the curriculum, in terms of their influence on the preparation and practice of modeling applications. The same conclusion was reached in the study by Tekin-Dede and Bukova-Güzel (2013), where teachers expressed that the frequency in which they applied the modeling depended on the suitability of the subject and timing. Şandır (2010) reported that the experiences that the prospective and seasoned teachers had acquired in the past regarding the modeling concept influenced their decisions to select modeling. Yu and Chang (2009) listed the negative factors influencing applicability as the weak bond between modeling activities and the curriculum, the exam system, modeling being time consuming, lack of knowledge on model formation activities, group discussions causing complications in class, students not being able to concentrate, difficulty in fulfilling activities, and lack of attention grabbing power. In the study of Aydın (2008) conducted with teachers in London, it was revealed that teachers were unable to teach lessons in such a way as to make it applicable to real-life due to style of education and certain obstacles presented by the system of education. The obstacles noted by the teachers included the notions that mathematical modeling was time consuming and made the concepts difficult for students to comprehend. These obstacles were also cited in the study conducted by Blum (1991). Other studies in the literature report similar factors influencing the applicability of modeling.

It was concluded that the use of modeling in mathematics lessons had positive impacts on learning mathematics. There are many studies that have been conducted in Turkey, as well as abroad, that support this finding (e.g. Avilés-Garay, 2001; Durmuş and Yaman, 2002; Ortiz, Castro and Rico, 2001; Özgün-Koca, 1998; Skemp, 1987). These studies have demonstrated that in activities conducted for the purpose of developing the modeling knowledge of prospective mathematics teachers, modeling could be used for creating a bond between concepts and real life and for teaching concepts. Furthermore, it was stated that the multiple demonstrations of the concept, in other words, modeling for the surfacing of the theoretical roof, could be used in mathematical teaching in order to enable students to gain a deeper and more flexible understanding. Yu and Chang (2009) revealed that mathematics teachers perceived modeling to be a problem solving process, and they had the view that such practices in mathematics classes developed the problem solving skills of students. The same study reported that students felt the need to speak to each other in the process, they benefitted from the ideas of their friends when thinking about the problem, they established good relations with their peers, and they understood the importance of respect. Furthermore, the teachers reported that the mathematical content was not difficult for students, modeling taught them to not be afraid of mathematics, and group discussions were beneficial in terms of facilitating thinking on the problem and they enabled students to convey their own ideas. Yu and Chang concluded that modeling activities related to daily living cases resulted in the development of a positive attitude towards modeling. Similarly, Eraslan (2011) reported that modeling activities had positive contributions to mathematics teaching, with the prospective elementary mathematics teachers expressing these contributions in terms of enabling students to '*make interpretations, 'put new ideas forward, 'look from various perspectives', 'think in a different manner', 'express themselves, 'show empathy', 'socialize'*, and '*adopt professional tendencies'*. In the study conducted by Blum (2002), it was asserted that the mathematical modeling method needed to be included in all mathematics curriculums because mathematical modeling could present important contributions in developing the skills of students. Based on these studies in the literature, the importance of the inclusion of the mathematical modeling method in mathematics curriculums and the contributions of the applicability of modeling in lessons have been demonstrated.

Within the last century, there has been a pronounced increase in the number of studies conducted abroad on the field of mathematical modeling and its application. In Turkey, an increased number of these studies have been produced in the last three years. When current studies (Bukova-Güzel, 2011; Eraslan, 2011, 2012; Kertil, 2008; Tekin, Hıdıroğlu and Bukova-Güzel, 2011) are examined, the common point in all of these studies is that they put prospective teachers at the center. In the study conducted by Lange in 1989, the training of teachers in mathematical modeling was especially emphasized. On the basis of this insight, studies on mathematical modeling practices conducted with the participation of teachers were examined, and it was observed that there was only a very limited number of studies that have been conducted on this subject in Turkey. The present study is therefore among the first studies to be performed in the field and has provided valuable contributions, including research on elementary mathematic teachers applying the modeling

process in their field work, where the views obtained by the teachers on the applicability of modeling showed them to have knowledge of the process and of the teaching of it.

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