INVESTIGATION OF PRE-SERVICE ELEMENTARY MATHEMATICS TEACHERS' SELF-EFFICACY BELIEFS ABOUT USING CONCRETE MODELS IN TEACHING MATHEMATICS

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INVESTIGATION OF PRE-SERVICE ELEMENTARY MATHEMATICS TEACHERS' SELF-EFFICACY BELIEFS ABOUT USING CONCRETE MODELS IN TEACHING MATHEMATICS

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ABSTRACT

INVESTIGATION OF PRE-SERVICE ELEMENTARY MATHEMATICS TEACHERS' SELF-EFFICACY BELIEFS ABOUT USING CONCRETE MODELS IN TEACHING MATHEMATICS

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The main purpose of the study was to investigate pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. Data were collected from the pre-service teachers in the middle of the spring semester of 2008-2009. Pre-service teachers were junior students enrolled in elementary mathematics teaching program at a public university. Six instructional sessions based on using concrete models in teaching mathematics were carried out during a three week period. In this study, the researcher was also the teacher of the instruction at the same time. A survey on pre-service mathematics teachers' efficacy beliefs about using concrete models was administered to the students before and after the instruction to evaluate the contribution of the instruction on pre-service teachers' efficacies. After the instruction, semi-structured interviews were conducted.

The present study demonstrated that the instruction based on using concrete models had positive contributions on the pre-service elementary mathematics teachers' self-efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. In addition, results revealed that pre-service elementary mathematics teachers had confidence in themselves about using concrete models both as learners and as teachers. Moreover, they believed that using concrete models in teaching mathematics would have positive consequences in teaching process and students' learning. However, the interview data indicated that, pre-service teachers had relatively low personal efficacies and outcome expectancies about classroom management, when the concrete models were involved in the instruction.

Keywords: Mathematics Education, Concrete Models, Pre-service Elementary Mathematics Teachers, Self-efficacy Beliefs, Teachers' Sense of Efficacy.

ÖZ

İLKÖĞRETİM MATEMATİK ÖĞRETMEN ADAYLARININ SOMUT MODELLERİ MATEMATİK ÖĞRETİMİNDE KULLANMAYA YÖNELİK ÖZ-YETERLİK İNANÇLARININ İNCELENMESİ

PİŞKİN, Mutlu

Yüksek Lisans, İlköğretim Fen ve Matematik Alanları Eğitimi

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Bu çalışmanın temel amacı, ilköğretim matematik öğretmen adaylarının somut modelleri matematik eğitiminde kullanmaya yönelik öz yeterliklerini ve sonuç beklentilerini incelemektir. Çalışmanın verileri, 2008–2009 bahar dönemi ortasında, öğretmen adaylarından toplanmıştır. Öğretmen adayları, bir devlet üniversitesinde, matematik öğretmeni yetişme programına devam eden üçüncü sınıf öğrencileridir. Üç haftalık bir zaman dilimi içerisinde, somut modellerin kullanımına yönelik altı saatlik bir eğitim yürütülmüştür. Yapılan uygulamada, araştırmacı aynı zamanda eğitim görevlisi olarak görev almıştır. Matematik öğretmen adaylarının somut model kullanımına yönelik öz-yeterlik inançlarını ölçmeye yönelik bir ölçek eğitimden önce ve sonra uygulanmıştır. Eğitiminden sonra yarı-yapılandırılmış mülakatlar yapılmıştır.

Veri analizi sonucunda somut modellerin kullanımına yönelik verilen eğitimin, ilköğretim matematik öğretmen adaylarının öz-yeterlik inançlarına ve sonuç beklentilerine olumlu katkıları olduğu bulunmuştur. Bunun yanında, sonuçlar, ilköğretim matematik öğretmen adaylarının somut modelleri öğrenen ve öğreten olarak kullanmakta kendilerine güvendiklerini ortaya koymuştur. Ayrıca, öğretmen adayları, somut modellerin öğrencilerin öğrenmelerine ve öğretim sürecine olumlu katkılar sağlayacağını düşünmektedirler. Buna karşın, görüşmelerde, sınıf yönetimiyle ilgili öğretmen adaylarının kişisel yeterliklerinin ve sonuç beklentilerinin düşük olduğu görülmüştür.

Anahtar Kelimeler: Matematik Eğitimi, Somut Modeller, İlköğretim Matematik Öğretmen Adayları, Öz-Yeterlik İnançları, Öğretmenlerin Öz-Yeterlik Algıları.

To The Head Teacher Mustafa Kemal Atatürk and All Teachers

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LIST OF ABBREVIATIONS

EUCM: The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models

PECMU: Personal Efficacy Beliefs about Concrete Model Use

OECMU: Outcome Expectancies Regarding Concrete Model Use

PRE_PE: Pretest Personal Efficacy Scores

PRE_OE: Pretest Outcome Expectancy Scores

POST_PE: Posttest Personal Efficacy Scores

POST_OE: Posttest Outcome Expectancy Scores

DIF_PE: Differences of Personal Efficacy Scores

DIF_OE: Differences of Outcome Expectancy Scores

PT: Pre-service Teacher

CHAPTER I

INTRODUCTION

"If I have the belief that I can do it, I shall surely acquire the capacity to do it even if I may not have it at the beginning."

Mahatma Gandhi

Achieving goals, changing things, and performing tasks are all about one's belief in his or her ability to do them. The belief in one's capability to succeed in a particular situation is described as self-efficacy by Bandura (1997). Self-efficacy beliefs provide the foundation for human motivation, well-being, and personal accomplishment (Pajares, 2002). Moreover, these beliefs affect the choices individuals make because people engage in tasks in which they feel competent and confident and avoid those in which they do not feel so (Pajares, 1997, 2002). Bandura (1994) argued that people's self-efficacy beliefs play a major role in how they feel, think, motivate themselves and behave. In particular, self-efficacy beliefs of teachers partly determine their choices and instructional behaviors in the classroom. However, teachers' efficacies differ from self-efficacy in such a way that a person who has high self-efficacy about a specific task can still have a low sense of efficacy when it comes to teaching the task (Pajares, 1996). In this sense, both in-service and pre-service teachers' self-efficacy beliefs are important areas of research focus. Moreover, besides their general teaching efficacy beliefs, their content specific efficacy beliefs have also been investigated in various research studies. This study is parallel to such research in that its main aim is to investigate a specific efficacy belief of pre-service teachers that is their efficacy beliefs about concrete models.

Mathematics is a subject that is composed of abstract concepts, which are difficult to comprehend for many children. In this sense, dealing with concrete representations of abstract mathematical concepts is important for children if they are to develop an understanding of these concepts. The use of concrete models in teaching and learning mathematics has been an important field of research for years. Van de Walle (2007) defined a concrete model as any object, picture, or drawing that is designed to represent abstract mathematical concepts. Sowell (1989) defined a concrete model learning environment as one where students worked directly with concrete models under the supervision of a teacher. Considerable studies have supported the idea that using concrete models enhance learning of mathematics (Bayram, 2004; Moyer, 2001; Silver, Mesa, Morris, Star, & Benken, 2009; Sowell, 1989; Suydam, & Higgins, 1977). The strongest theoretical arguments in favor of concrete models were developed by Piaget (1950), Bruner (1961), and Dienes (1967). Piaget (1950) stated that children, especially young ones, learn mathematics best from concrete activities. Moreover, he suggested that learning environments should include both concrete and symbolic models of the concepts. Another theoretician, Bruner (1966) claimed that when children learn new mathematics concepts, they need, firstly, concrete objects, secondly, pictorial ones and lastly, abstract symbols. Similarly, Dienes (1967) supported the use of concrete models and stressed the importance of learning mathematics by means of direct interaction with the environment. In short, each theoretician strongly suggested active student involvement in the learning process and proper use of concrete models in mathematics classrooms. However, there are also other studies indicating that concrete models are not always necessarily more effective than traditional methods. The main reason for possible ineffectiveness of models is a lower quality of instruction. Thus, teachers' knowledge, practices, and beliefs have an important role on the effectiveness of instruction with concrete models (Moyer, 2001; Post, 1981; Suydam, & Higgins, 1977). In Turkey, the majority of the teachers was taught through lecture and did not learn mathematics with the help of concrete models. Furthermore, their experiences with concrete models are limited throughout their education. Since teachers tend to teach as they were taught (Bauersfeld, 1998), teachers in Turkey do not prefer to use concrete models in mathematics classrooms, and their competencies about the models are problematic (Dede, 2007; Temizöz, & Koca, 2008; Toptaş, 2008). However, the recent curriculum reform in Turkey strongly suggested the use of concrete models in mathematics classrooms (Ministry of National Education, 2004). The current emphasis on proper use of the concrete models requires that teachers have strong skills and knowledge about using concrete models. Hence, another important goal of the study is giving the pre-service teachers the chance of using the models as learners and becoming familiar with the models. In addition, since teacher efficacy beliefs is an important construct that influence their behavior, the study aims to explore how pre-service teachers' familiarities and practices with concrete models contribute their efficacy beliefs about using them in teaching mathematics.

1.1 Main and Sub-problems, and Associated Hypothesis of the Study

MP 1 What are the contributions of the instruction based on concrete models to the pre-service elementary mathematics teachers' self-efficacy beliefs about using concrete models in teaching mathematics?

The first main problem has been divided into two sub-problems:

SP 1.1 Is there any statistically significant mean difference between pre-test and post-test personal efficacy scores of pre-service elementary mathematics teachers about using concrete models?

SP 1.2 Is there any statistically significant mean difference between pre-test and post-test outcome expectancy scores of pre-service elementary mathematics teachers about using concrete models?

Before studying the first and second sub-problems SP 1.1 and SP 1.2, the following two hypotheses (H1.1 and H 1.2) were stated:

H1.1 There is no statistically significant mean difference between pre-test and post-test personal efficacy scores of pre-service elementary mathematics teachers about using concrete models.

H.1.2 There is no statistically significant mean difference between pre-test and post-test outcome expectancy scores of pre-service elementary mathematics teachers about using concrete models.

MP 2 What are the pre-service elementary mathematics teachers' self-efficacy beliefs about using concrete models after the instruction based on concrete models?

SP 2.1 What are the pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models after the instruction based on concrete models?

SP 2.2 What are the pre-service elementary mathematics teachers' outcome expectancies about using concrete models after the instruction based on concrete models?

1.2 Significance of the Study

Until recently, the national mathematics curriculum in Turkey did not have recommendations for the use of concrete models in mathematics instruction. The recent curriculum reform in Turkey, however, emphasized the use of concrete models in the teaching of mathematics (Ministry of National Education, 2004). In such a context, the role of teachers becomes critical, since they have an important function in the quality of mathematics instruction at the school level. Most of the pre-service mathematics teachers in Turkey have almost no experience in the use of concrete models as learners of mathematics. In this sense, preparing pre-service teachers to meaningfully use concrete models in Turkish schools is an important issue. Moreover, based on research from several countries, teachers' usage of models is generally problematic (Moyer, 2001; Puncher, Taylor, O'Donnell, & Fick, 2008; Van de Walle, 2007). In this sense, it is critical to investigate future mathematics teachers' self-efficacy beliefs about concrete models to understand the reasons for ineffective use of models, or worse, possible disuse. One important factor of teachers' use of instructional strategies is their efficacy beliefs (Moyer, 2001). In this respect, as future practitioners, pre-service teachers are critical stakeholders whose self-efficacy beliefs need to be studied.

In Turkey, while there are some studies about teachers' opinions on using concrete models, there are not sufficient studies on teachers' self efficacy beliefs about using concrete models. Even though teachers' views are related with their self-efficacy beliefs, their personal efficacy and outcome expectancy beliefs also should be investigated. Therefore, the major objective of the study is to investigate pre-service elementary mathematics teachers' personal efficacies and outcome expectancies about using concrete models in teaching mathematics.

1.3 Definitions of Important Terms

In this section, some of the terms that were used in this study are defined to prevent any misunderstandings.

Pre-service Elementary Mathematics Teachers

Prospective teachers in elementary mathematics education department in education faculties are called as pre-service elementary mathematics teachers. They are teacher candidates who are going to teach mathematics from sixth grade to eighth grade in elementary schools after their graduations. In the present study, pre-service elementary mathematics teachers are junior students majoring in mathematics education department.

Concrete Models

Concrete models refer the tools that are constructed for educational purposes (base-ten blocks, algebra tiles, pattern blocks, unit cubes, etc.), and real life objects (water, glass, paper).

Personal Efficacy about Concrete Model Use

Personal efficacy is called as perceived self-efficacy by Bandura (1997) and he defined it as a judgment of one's ability to organize and execute given types of performances (Bandura, 1997). As an extension of this definition, in this study, personal efficacy about concrete model use is defined as pre-service mathematics teachers' judgments about their capability to use concrete models as both learners and teachers.

Outcome Expectancy about Concrete Model Use

Outcome expectancy is a judgment of the likely consequence of a specific performance will produce (Bandura, 1997). Based on this definition, in the current study, outcome expectancy about concrete model use is described as pre-service mathematics teachers' judgments about likely consequences of using concrete models to teach mathematical concepts.

The definitions of the concrete models that were used in the study are in Appendix A.

CHAPTER II

REVIEW OF THE LITERATURE

The primary purpose of this study was to investigate pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. This chapter describes the underlying theory that comprises the conceptual framework for this study, as well as previous studies that form the empirical framework of this study. The chapter includes two parts: a review of self-efficacy beliefs and concrete models literature.

2.1 Self Efficacy Beliefs

Within this part, first, the meanings of self-efficacy and outcome expectancy are stated. Then, sources of self-efficacy are presented. Finally, teachers' sense of efficacy is described in detail.

2.1.1. The Meaning of Self-Efficacy and Outcome Expectancy

The concept of self-efficacy comes from Bandura's social learning theory. Bandura (1997) defined perceived self-efficacy as "beliefs in one's capability to organize and execute the courses of action required to produce given attainments" (p.3). Similarly, Tschannen-Moran, Woolfolk Hoy and Hoy (1998) defined self-efficacy as "a future-oriented belief about the level of competence a person expects he or she will display in a given situation" (p.207). Self-efficacy beliefs affect how people feel, think, motivate themselves and behave (Bandura, 1994). In addition, they provide the foundation for human motivation, well-being, and personal accomplishment (Pajares, 2002). Moreover, these beliefs affect the choices individuals make because people engage in tasks in which they feel competent and confident and avoid those in which they do not feel so (Pajares, 1997, 2002).

The other important concept in Bandura's social learning theory is outcome expectancy that is distinct from perceived self-efficacy. Bandura (1997) argued that "perceived self-efficacy is a judgment of one's ability to organize and execute given types of performances, whereas outcome expectancy is a judgment of the likely consequences such performance will produce" (p.21). According to Tschannen-Moran et al. (1998), while the efficacy question is, "Do I have the ability to organize and execute the actions necessary to accomplish a specific task at a desired level?" (p.210), the outcome expectancy question is, "If I accomplish the task at that level, what are the likely consequences?" (p.210). Bandura (1997), on the other hand, suggested that there is a causal relationship between beliefs of personal efficacy and outcome expectancies. In such a way that the outcomes people expect depend mostly on their judgments of how well they will be able to perform in given situations.

In this study, personal efficacy was defined as pre-service mathematics teachers' judgments about their capability to use concrete models as both learners and teachers. In addition, the meaning of outcome expectancy was pre-service mathematics teachers' judgments about likely consequences of using concrete models to teach mathematical concepts.

2.1.2. Sources of Self-Efficacy

According to Bandura (1994, 1997), people's beliefs in their efficacy are developed by four main sources of influence: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states. Mastery experiences depend on the personal experiences of human and they are the most effective way of creating a strong sense of efficacy. While successful experiences enhance personal efficacy, failures reduce it, especially if failures occur before a strong sense of efficacy is established. The second source of self-efficacy is vicarious experiences that depend on observations of others' behaviors. This source of information alters efficacy beliefs through transmission of competencies and modeled attainments. The impact of modeling on self-efficacy is strongly influenced by perceived similarity between model and observer. Furthermore, Schunk (2001) suggested that if the model performs the task successfully, there is a high probability that the observer's self-efficacy level increases and he or she is motivated to try the task. However, if the model fails to perform the task, the observer's self-efficacy level probably decreases. In addition, Pajares (1997, 2002) argued that self-efficacy is particularly affected by vicarious experiences when people are uncertain about their own abilities or have limited prior experience. The third source of self-efficacy is verbal persuasion that depends on given feedbacks for a specific behavior. While positive feedbacks may increase the efficacy beliefs, negative feedbacks may decrease. According to Bandura (1997), although verbal persuasion alone may be limited to increase self-efficacy beliefs, it can contribute to self-change if the feedbacks are given within realistic bounds. The fourth source of self-efficacy is physiological and affective states such as anxiety, stress, encouragement, exhaustion, and mood states (Pajares, 1997). In judging their capabilities, people rely partly on physical and emotional information conveyed by these states. For instance, positive mood increases perceived self-efficacy, whereas despondent mood decreases it. Besides, self-efficacy beliefs influence how emotional and physical reactions are perceived and interpreted by individuals. In this respect, Bandura (1994) argued that "People who have a high sense of efficacy are likely to view their state of affective arousal as an energizing facilitator of performance, whereas those who are beset by self-doubts regard their arousal as a debilitator." (p. 73).

In mathematics, as in general, students and teachers have different levels of efficacy beliefs and outcome expectations. Since current study is about pre-service teachers' self-efficacy beliefs about using concrete models, teachers' sense of efficacy are considered more detailed in the following section.

2.1.3. Teachers' Sense of Efficacy

Several studies indicate that teachers' beliefs in their instructional efficacy partly determine how they structure academic activities in their classrooms (Bandura, 1997). Therefore, teacher efficacy has been an important field of research for years. According to Bandura (1997), teacher efficacy is a type of self-efficacy. However, it differs from self-efficacy in such a way that a person who has high self-efficacy about a specific task can still has a low sense of efficacy when it comes to teaching the task (Pajares, 1996).

Tschannen-Moran et al. (1998) defined teacher efficacy as "the teacher's belief in his or her capability to organize and execute course of action required to successfully accomplish a specific teaching task in a particular context" (p.233). Alternatively, Wheatley (2005) described it as "teachers' belief in their ability to influence valued students outcomes" (p. 748).

In a study by Gibson and Dembo (1984), the researchers examined the relationship between teacher efficacy and observable teacher behaviors. They suggested that teachers with high efficacy beliefs about teaching tend to devote more classroom time to academic activities, praise students' academic accomplishment, and work longer with difficult students. In contrast, teachers with low efficacy beliefs about teaching tend to spend more time on nonacademic activities, criticize students for their failures, and have lack of persistence in failure situations. Similarly, Bandura (1994) also argued that people with high sense of efficacy can resist the difficulties more than people with low efficacy beliefs.

Because of the importance of teacher efficacy on their instructional behaviors, many attempts have been made to measure it. The first instrument that measure a teacher's sense of efficacy in the context of the classroom was *Rand Measure* developed in 1976 by Armor, et al.; the other instruments were the *Teacher Locus of Control* developed by Rose and Medway in 1981; the *Responsibility for Student Achievement* developed in 1981 by Guskey; the *Webb Efficacy Scale* and the *Ashton Vignettes* developed in 1982 by Ashton, Olejnik, Crocker, and McAuliffe; the *Teacher Efficacy Scale* developed in 1984 by Gibson and Dembo; an undated, unpublished scale developed by Bandura, and the *Teachers' Sense of Efficacy Scale* developed by Tschannen-Moran and Woolfolk Hoy in 2000 (Tschannen-Moran, & Woolfolk Hoy, 2001). Certainly, many other instruments have been developed for measuring teachers' sense of efficacy. However, since in the current study *The Instrument of Preservice Mathematics Teachers' Efficacy Beliefs about Using Manipulatives (EBMU)* developed by

Bakkaloğlu (2007) was used, only the instruments which provide basics for it are considered.

In 1990, Enochs and Riggs developed the *Science Teaching Efficacy Belief Instrument* (STEBI), to measure efficacy of teaching science. They have found two separate factors that were based on Bandura's (1997) self-efficacy theory and consistent with Gibson and Dembo's (1984) instrument (TES). The first factor was *Personal Science Teaching Efficacy* (PSTE) and the second factor was *Science Teaching Outcome Expectancy* (STOE). The two factors were uncorrelated. The STEBI has a Likert scale format in which there were both positively and negatively-written 25 items. Items were stated to measure only self-efficacy or outcome expectancy rather than combination of self-efficacy and outcome expectancy. Responses were in five categories: 'strongly agree', 'agree', 'uncertain', 'disagree', 'strongly disagree'. Enochs and Riggs (1990) reported that the STEBI was a valid and reliable instrument with the alpha reliability coefficients of 0.91 and 0.76 for the PSTE, and STOE, respectively.

A modification of STEBI (Enochs, & Riggs, 1990) was developed by Enochs, Smith and Huinker (2000), named as the *Mathematics Teaching Efficacy Belief Instrument* (MTEBI). The MTEBI consisted of 21 items, 13 items on the Personal Mathematics Teaching Efficacy (PMTS) subscale and 8 items on the Mathematics Teaching Outcome Expectancy (MTOE) subscale. Reliability analysis produced an alpha coefficient of 0.88 for the PMTS scale and an alpha coefficient of 0.75 for the MTOE scale. Similar to STEBI (Enochs, & Riggs, 1990), it was found to be a valid and reliable instrument for areas of research related to efficacy about mathematics teaching.

An adaptation of MTEBI (Enochs et al., 2000) that is named as *The Instrument of Preservice Mathematics Teachers' Efficacy Beliefs about Using Manipulatives* (EBMU) developed by Bakkaloğlu (2007). She developed the instrument to investigate pre-service elementary mathematics teachers' efficacy beliefs about using concrete models in teaching mathematics. EBMU, which was also used in the current study for quantitative data collection, was administered to 77 senior pre-service elementary mathematics teachers at 2 different universities. EBMU had two factors consistent with previous studies (Enochs et al., 2000; Enochs, & Riggs, 1990) and Bandura's (1997) self-efficacy theory. These were personal efficacy beliefs about manipulative use (PEMU) and outcome expectancies regarding manipulative use (OEMU). EBMU consisted of 15 items, 9 items on PEMU subscale and 6 items on OEMU subscale. Reliability analysis produced an alpha coefficient of 0.81 for the PEMU and an alpha coefficient of 0.79 for the OEMU, which were considered reasonable values for the study. The results suggested that gender differences did not affect pre-service elementary mathematics teachers' efficacy beliefs about using concrete models. Yet, according to the research findings, the university had a significant effect on their efficacy beliefs. In addition, the gender and university differences had significant effect on pre-service elementary mathematics teachers' outcome expectancies. As a result, it was concluded that generally pre-service elementary mathematics teachers have high self-efficacy beliefs about using concrete models.

In Turkey, although there are a lot of studies about general teacher efficacy, there are very limited numbers of studies about pre-service teachers' self-efficacy beliefs about using concrete models. However, studies about mathematics efficacy beliefs and mathematics teaching efficacy beliefs of pre-service and in-service mathematics teachers can also give us clues about their content specific efficacy beliefs. In this respect, these studies are presented below.

Işıksal and Çakıroğlu (2006) examined pre-service mathematics teachers' mathematics and mathematics teaching efficacy beliefs in terms of the differences with respect to the university attended and university grade level. *Mathematics Self-Efficacy Scale (MSES)* developed by Umay (2001) and *Mathematics Teaching Efficacy Belief Instrument (MTEBI)* developed by Enochs et al. (2000) were administered to 358 freshmen, sophomore, junior, and senior pre-service mathematics teachers. The results suggested that there is a positive correlation between pre-service teachers' self-efficacy beliefs toward mathematics and mathematics teaching. While there is no significant effect of the university being attended and university grade level on pre-service teachers' teaching efficacy beliefs, there is a significant effect of these variables on pre-service teachers' self-efficacy beliefs toward mathematics. In addition, the research findings indicated that senior pre-service teachers have significant higher mathematics efficacy scores compared to the freshman pre-service teachers.

Another study was conducted by Umay (2001). She investigated the effect of the primary school mathematics teaching program on the mathematics self-efficacy of pre-service mathematics teachers. *Mathematics Self-Efficacy Scale (MSES)* developed by the researcher was administered to 127 freshman and senior pre-service mathematics teachers. Similar to findings in Işıksal and Çakıroğlu's study (2006), the results revealed that senior students' mathematics self efficacy was significantly higher than freshman students. As a result, the researcher suggested that the primary school mathematics teaching program had positive effects on the mathematics self-efficacy of pre-service mathematics teachers.

On the other hand, İşler (2008) examined primary school and mathematics teachers' efficacy beliefs and perceptions in the context of the new primary mathematics curriculum and identify differences, if any, in teachers' efficacy beliefs and perceptions based on their area of certification, gender, experience and number of students in classroom. The participants of the study were 696 primary and 105 mathematics teachers. The questionnaire administered to participants was adapted from two different instruments; *Teachers Assessment Efficacy Scale (TAES)* by Wolfe, Viger, Jarvinen, and Linksman (2007) and *Turkish Teacher' Sense of Efficacy Scale (TTSES)* by Çapa, Çakiroglu, and Sarıkaya (2005). The results suggested that primary teachers had significantly stronger efficacy beliefs about the new curriculum than mathematics teachers. Furthermore, similar to Bakkaloğlu's findings (2007), results revealed that teachers' efficacy beliefs scores was considerably high and they mostly feel competent about general teaching situations. Moreover, teachers' sense of efficacy beliefs was found to increase when teaching experience increased, although this increase was not found to be significant. In addition, the numbers of students in the classroom and gender differences were found to have no significant effect on teachers' sense of efficacy beliefs.

In addition to the study of İşler (2008), Dede (2008) investigated mathematics teachers' self-efficacy beliefs about teaching mathematics. The *Self-Efficacy Beliefs toward Mathematics Teaching Scale,* which was adapted by the researcher from STEBI (Enochs, & Riggs, 1990), was administered to 60 mathematics teachers. According to findings of the study, the mathematics teachers had high levels of self-efficacy beliefs regarding teaching mathematics.

In addition, the majority of teachers believed that they taught mathematics effectively and had efficacy in teaching.

To sum up, research studies in Turkey show that pre-service and in-service mathematics teachers have high efficacy beliefs about teaching mathematics and mathematics itself. Most importantly, as seen in the above studies, teacher sense of efficacy has generally been measured quantitatively. However, quantitative measures of self-efficacy commonly give superficial information about the efficacy beliefs of a large number of teachers at a particular point in time (Tschannen-Moran et al., 1998). Furthermore, qualitative measures such as teacher observations and interviews, which can provide more rich description about the growth of teacher efficacy, are extremely rare in the teacher efficacy literature (Tschannen-Moran et al., 1998; Wheatley, 2005). This study, therefore, aims to investigate efficacy of pre-service teachers by utilizing both quantitative and qualitative techniques. Furthermore, majority of the instruments measure all aspects of teaching (e.g., teacher efficacy scale) or all aspects of teaching for specific subjects (e.g., mathematics teaching efficacy belief instrument). However, the current study investigates a specific efficacy belief of pre-service teachers that is pre-service teachers' efficacy belief about using concrete models. For this reason, the following section is about concrete models.

2.2 Concrete Models

This part of the study focuses on the meaning of concrete models, strengths and limitations of using concrete models, and pre-service and in-service teachers' views about using concrete models in teaching mathematics.

2.2.1 The Meaning of Concrete Models

The concrete mathematical tools have been defined and named in different ways. While some researchers called them as manipulative or material, others called them as models.

Moyer (2001), Karol (1991), Heddens (1997), and Uttal, Scudder and Deloache (1997) are the researchers who called the mathematical tools manipulatives or materials. Here are their definitions for concrete models. Moyer (2001) defined concrete models as objects designed to represent abstract mathematical ideas clearly and concretely. She also added that they had both visual and physical attraction for learners. Similarly, Karol (1991) defined them as objects that students are able to see, feel, touch, rearrange and move. Both Moyer (2001) and Karol (1991) emphasized concrete models' attraction for several senses of students. Otherwise, Heddens (1997) pointed out that they were objects from the real world using to show mathematics concepts. Besides, Uttal et al., (1997) suggested that they were designed specifically to help children learn mathematics.

On the other hand, Van de Walle (2007) and Sowell (1989) called the mathematical tools concrete models. Van de Walle (2007) defined a concrete model as any object, picture, or drawing that is designed to represent abstract mathematical concepts. In addition, Sowell (1989) defined a concrete model learning environment as one where students worked directly with models such as based-ten blocks, algebra tiles, geoboards, paper folding, or other concrete models under the supervision of a teacher.

In the current study, the researcher refers to both mathematical tools and real life objects as "concrete models", since there were activities with not only educational materials (base-ten blocks, algebra tiles, pattern blocks, unit cubes, etc.) but also real life objects (water, glass, paper).

2.2.2 Strengths of Using Concrete Models in Teaching Mathematics

The effects of concrete models in learning of mathematics have been investigated for years (Sowell, 1989). The strongest arguments in favor of concrete models were developed based on the ideas of Piaget (1950), Bruner (1961), and Dienes (1967).

Piaget (1950) studied the stages of intellectual development and their relations to the development of cognitive structures. Piaget's four stages of intellectual development (sensorimotor, preoperational, concrete operations, and formal operations) give clues to educators about students' cognitive structures in different age intervals (Post, 1981). Piaget believed that conceptual knowledge could not be transferred from one person to another; in contrast, he argued that it was developed by knower's own experiences (Steffe, 1990). Piaget (1950) also stressed the importance of concrete actions in learning mathematics. He stated that children, especially young ones, learn mathematics best from concrete activities. Therefore, he indicated that teachers could help students to develop more powerful ways of thinking by concrete activities. As a result, Piaget suggested that learning environments should include both concrete and symbolic models of the concepts.

The other theoretician, Bruner (1966), studied on general nature of conceptual development. He provided additional evidence suggesting the need for firsthand student interaction with the environment. Moreover, in terms of concrete models, he tried to explain teacher's role and effective instruction by using them. According to Bruner (1961), "The devices themselves cannot dictate their purpose." (p.88). Therefore, the effectiveness of any technique or tool depends on teacher's skill and the instruction that is implemented. He also argued that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (Bruner 1966, p. 33). Moreover, he (1966) described three modes of representational thought. That is, an individual can think about a particular idea or concept at three different levels; enactive (involves hands-on or direct experience), iconic (based on the use of the visual medium), and symbolic (based on the use of abstract symbols to represent reality). In the same way, he suggested that when children learn new mathematics concepts, they need, firstly, concrete objects, secondly, pictorial ones and lastly, abstract symbols.

Unlike Piaget and Bruner, Dienes mostly studied on mathematics learning. Dienes (1967) supported the use of concrete models and stressed the importance of learning mathematics by means of direct interaction with the environment. He believed that a child should recognize symbols as representations of concrete experiences before he or she uses the symbols in a mathematical system (Flener, 1980). In addition, like Piaget and Bruner, Dienes strongly suggested active student involvement in the learning process (Post, 1981). In brief, each theoretician represented the cognitive view points of learning and they suggested proper use of concrete models in mathematics classrooms.

To date, different mathematical concepts have been taught to students of different age groups by using concrete models. In USA, the Standards of National Council of Teachers of Mathematics (2000) recommend using mathematical concrete models at all grade levels. Similarly, the recent curriculum reform in Turkey emphasizes the use of concrete models in mathematics classrooms (Ministry of National Education, 2004). Bulut (2004) suggested that new mathematics curriculum aims to facilitate students' meaningful understanding of mathematics by using concrete models and other mathematical materials. Accordingly, many studies emphasized the importance of using concrete models in teaching mathematics (Aburime, 2007; Balka, 1993; Bayram, 2004; Heddens, 1997; Howard, Perry, & Lindsay, 1996; Karol, 1991; Martelly, 1998; Moyer, 2001; Nevin, 1993; Silver et al., 2009; Sowell, 1989; Suydam, & Higgins, 1977).

Several studies support the idea that concrete models have positive effects on mathematics achievement of students of different age groups (Aburime, 2007; Bayram, 2004; Fuson, & Briars, 1990; Martelly, 1998; Suydam, & Higgins, 1976).

A study with primary school students was conducted by Fuson and Briars (1990). They investigated the effects of base-ten blocks on first and second grade students' performances with multi-digit addition and subtraction. The results suggested that on all tests and interview measures, performance of students using the base-ten blocks was considerably higher than performance of students receiving traditional instruction. As a result, they reported that students achieved high levels of skills with multi-digit addition and subtraction through the use of base-ten blocks.

On the other hand, Bayram (2004) investigated the effect of instruction with concrete models on eighth grade students' geometry achievement. A total of 106 eighth grade students participated in her quasi-experimental design. She found that students who received instruction with concrete models had higher scores on geometry achievement test than those who received instruction with traditional method. In short, she suggested that concrete models were beneficial for achievement of students.

Similarly, Aburime (2007) investigated the effects of geometric models on mathematics achievement of high school students. The models in the study were eighteen different geometrical shapes constructed from cardboard paper. The sample for the study was 185 high school students. An experimental design was carried out. Experimental group students were taught with models while control group students were taught without models during ten weeks. The results suggested that students taught with geometric models had higher performance on mathematics achievement than students taught without models. In brief, like Bayram (2004), it was argued that geometric models had positive effect on achievement of students.

Another study was conducted by Martelly (1998) with college students. She investigated the effects of using algebra tiles and other concrete models on college remedial mathematics students' achievement. The sample for the study was 253 college students. A quasi experimental design was carried out with five experimental groups and five control groups during a semester. An achievement test was conducted as pretest and a final exam was conducted as posttest. The analyses of achievement measure revealed a significant difference in favor of the concrete models groups. Therefore, the researcher suggested that concrete models fostered college students' algebra achievement.

A review of research was conducted by Suydam and Higgins (1976) from Kindergarten through Grade 8. Among 40 studies, that were examined, 24 favored concrete models, 4 favored traditional methods and 12 showed no significant difference. The results of the report were consistent with the studies above, it is concluded that the use of models at every grade level is generally effective in promoting students' achievement.

The reasons for increase in achievement have been another concern of researchers; in this sense, different positive effects of concrete models on students' cognitive learning were suggested. These are presented below.

Concrete models help students in bridging the gap between their own concrete environment and abstract levels of mathematics (Karol, 1991). Besides, they play an important role in making and realizing the mathematical relationships between mathematics concepts (Balka, 1993; Nevin, 1993). Moreover, they connect work done in the mathematics classroom to other subjects and to the real world (Heddens, 1997; Silver et al., 2009). Concrete models also increase students' flexibility of thinking and creativity to solve new mathematics problems

(Karol, 1991; Parsley, 2006). Furthermore, they provide settings, in which students can explain and justify their solutions, and also create and extend patterns. Students' analytical and spatial reasoning are also developed in these concrete model environments (Heddens, 1997; Balka, 1993). By this way, the models increase students' meaningful understanding of mathematical concepts and enable them to have meaningful experiences (Balka, 1993; Karol, 1991; Silver et al., 2009).

In addition, the use of concrete models in instruction increases students' scores on retention and problem solving tests (Clements, 1999; Keller, 1993). They help students in visualizing and organizing information in their minds to solve problems. According to Keller (1993), visualization skills, which are beneficial at problem solving process, developed through concrete experiences.

There are also studies suggesting that concrete models enable students to develop positive attitudes toward mathematics and enable students to enjoy solving math problems (Johnson, 1993; Sowell, 1989). Moreover, several studies argued that concrete models motivate students to explore, investigate and learn mathematics (Balka, 1993; Gürbüz, 2007; Johnson, 1993; Karol, 1991). Bayram (2004), Martelly (1998), and Fuson and Briars (1990) investigated the effects of concrete models on students' attitudes besides on their achievement. They suggested that concrete models are also beneficial for students' attitudes.

Concrete models' role on the development of students' social skills cannot be left untouched. The use of concrete models in teaching mathematics help students learn to discuss mathematical ideas and concepts, to verbalize their mathematics thinking and to make presentations in front of a large group (Heddens, 1997). Moreover, using concrete models in mathematics classrooms foster communication and interaction among students (Karol, 1991; Silver et al., 2009).

Another important role of concrete models is to make students active participants in their own learning process (Karol, 1991; Nevin, 1993). In addition, they increase students' engagement with mathematical tasks (Silver et al., 2009). According to Nevin (1993), understanding can only take place when students have been actively involved in their own learning. An old Chinese proverb, "I hear and

I forget, I see and I remember, I do and I understand" also emphasized the importance of active participation.

As a result, with the increased use of concrete models, students' cognitive and affective skills are positively developed and more importantly they come to see mathematics as a way of thinking rather than a set of rules.

2.2.3 Limitations of Using Concrete Models in Teaching Mathematics

Some studies suggested that using concrete models enhance students' achievement, conceptual understanding, motivation and attitudes (Aburime, 2007; Balka, 1993; Bayram, 2004; Heddens, 1997; Howard et al., 1996; Karol, 1991; Martelly, 1998; Moyer, 2001; Nevin, 1993; Silver et al., 2009; Sowell, 1989; Suydam, & Higgins, 1977). However, there are also other studies indicating that concrete models are not always necessarily more effective than traditional methods (Clements, 1999; Fennema, 1972; McNeil, & Jarvin, 2007; Van de Walle, 2007). Besides, several studies have suggested that concrete models sometimes may not only be inefficient but also harmful for students' learning (Kaminski, Sloutsky, & Heckler, 2006; Szendrei, 1996; Uttal et al., 1997). In other words, while concrete models have lots of advantages, they have also some limitations. These limitations might cause many in-service and pre-service teachers to be hesitant in using them during instruction.

Limitations of using concrete models in teaching mathematics can be classified into three parts based on the source of the limitation. These are: limitations arising from students, teachers and concrete models themselves.

Based on several studies, a reason for the ineffectiveness of concrete models is students' difficulty on achieving dual representations (Kaminski et al., 2006; McNeil, & Jarvin, 2007; Uttal et al., 1997). Students generally see models only as an object not a representation of a mathematical concept. Achieving dual representation means not only recognizing concrete model as a concrete object itself, but also as an abstract referent to a mathematical concept (Uttal et al., 1997). Realizing the underlying concepts of models, namely the relation between model and its intended referent is difficult for students (McNeil, & Jarvin, 2007; Uttal et al., 1997; Van de Walle, 2007). Imposing the mathematical relationship on the model is easy for adults. However, for children who have not yet constructed mathematical concepts, the model does not illustrate the intended concept (Van de Walle, 2007). If the model is an object, which is used in real world or students' games such as toys; it is more difficult for students to see the object as a representation of a mathematical concept (McNeil, & Jarvin, 2007; Uttal et al., 1997). Moreover, increasing models' attractiveness as an interesting object decrease the degree to which students see the model as a representation of the concept because if students care too much about the objects themselves, and they may be distracted from mathematical context (Uttal et al., 1997). Models' attractiveness for students is also related with students' familiarity with models. In this sense, Uttal et al. (1997) suggested that long term usage of models eases students' understanding of models as representations of mathematical concepts and also increases their performance. The suggestion is consistent with Sowell's (1989) meta-analysis, which revealed that concrete instructional models were most effective when they were used consistently over extended periods of time.

Another common difficulty that students encounter is transferring their knowledge from a concrete environment to an abstract environment (Fuson, & Briars, 1990; Johnson, 1993; Kaminski et al., 2006; Uttal et al., 1997). Students generally succeed in solving problems by using concrete models, but they can not transfer their mathematical knowledge that was learned by models to an abstract environment (Uttal et al., 1997). Therefore, they fail to solve problems without models unless they are reminded to think about the models (Fuson, & Briars, 1990). For example in the study by Uttal et al. (1997) a student could solve a problem such as 103+52 by using concrete model, but had difficulty in solving a written problem such as 12+14 without using the model although the second one was easier than the other. Because of this reason, Johnson (1993) recommended that a connection must be established in the activities that help the transition from concrete to abstract.

Transferring their knowledge from a learned instance to an unlearned instance is another difficulty that students encounter when models were used (Fennema, 1972; Sowell, 1989). For example, Fennema (1972) compared concrete and symbolic models in learning basic multiplication facts that used repeated addition with a strategy based on the manipulation of Cuisenaire rods. A total of 95 second graders were randomly assigned to either the concrete model instructional approach or the symbolic approach based on addition. After fourteen instructional sessions, during which one teacher was responsible for both groups' instruction, students' learning was evaluated by means of two transfer tests. When solving the tests, students were allowed to use concrete models or symbols; but the problems in the test had never been seen before by students. The difference in mean scores between the groups favored the symbolic method in both tests. In conclusion, students had difficulties on thinking independently from models and transferring their knowledge, which was learned by models, to more traditional forms of mathematical expressions or unlearned situations.

On the other hand, the effectiveness of concrete models might differ in terms of students' achievement and aptitude level. Threadgill-Sowder and Juilfs (1980) examined interactive effects between mathematical achievement and concrete model versus symbolic instruction with junior high school students. The sample for the study was 147 seventh-grade students from two junior high schools. An experimental design was carried out during three 40-minute periods. Findings suggested that students with very low scores on the Mathematics Concepts and Mathematics Problem Solving Tests received higher scores on the achievement posttest when instruction included concrete models, whereas students with high scores on the Mathematics Concepts and Problem Solving Tests found the symbolic approach more beneficial.

Another major source of limitations regarding the use of concrete models is the teacher. Teachers have an important role on the effectiveness of instruction with concrete models (Balka, 1993; Post, 1981; Uttal et al., 1997; Suydam, & Higgins, 1977). The common reasons for limitations arising from teachers are teachers' misinterpretation of instruction with models, the role of models, and students' learning processes when the models are used.

The foremost reason for ineffectiveness of concrete models is teacher directed usage of models. Teachers do not allow students to make meaning from their experiences with models because of their traditional teaching habits (Moyer, 2001; Puncher et al., 2008; Thompson, 1992). They want students to follow them step by step while implementing the procedure for solving a problem with models. Because of this manner, students sometimes use models in a rote manner. The correct steps are performed, but little is learned (Clements, & McMillen, 1996; Szendrei, 1996; Van de Walle, 2007). The other teacher directed misuse of concrete models is instruction with models which include only demonstration of models by teacher. In this instruction, teachers do not allow students to manipulate models independently (Heddens, 1997). However, each student needs to manipulate models independently because teacher directed usage of models does not contribute to students' meaningful understanding (Heddens, 1997; Moyer, 2001; Puncher et al., 2008).

Teachers' misinterpretation of the role of concrete models in mathematics instruction is another reason for limitation (Moyer, 2001; Puncher et al., 2008). They regard models as motivating tools rather than constructing meaning. In a study by Moyer (2001), the researcher investigated how and why 10 middle school mathematics teachers used concrete models in their classrooms. The results suggested that teachers consider concrete models as tools that are used for fun or reward, but not necessarily for teaching and learning. On the other hand, according to Van de Walle (2007) teachers mostly consider concrete models' attractiveness and colorful design while selecting a model for teaching a mathematical concept. Although a concrete model may be interesting and attractive, but this is not enough to enhance students' mathematical knowledge (Uttal et al., 1997).

Another reason is that teachers haven't got a clear idea about how students learn with models and their difficulties on learning with models. Some teachers believe that the only presence of models guarantee conceptual understanding and success (Hall, 1998). Furthermore, they even believe that using an appropriate model to teach a certain mathematical concept will automatically form the desired meaning in the students' mind (Puncher et al., 2008). However, a concrete model's physical nature does not carry the meaning of a mathematical idea (Clements, 1999). Moreover, using models alone can not constitute a necessary and sufficient condition for effective learning (Post, 1981; Puncher et al., 2008; Szendrei, 1996). The majority of teachers believe that students make the connection between concrete and abstract on their own. Furthermore, teachers can not imagine how students would not easily understand the underlying concepts of the models (Puncher et al., 2008). Realizing the relationship with model and mathematics may be easy for a teacher. However, it may be difficult for students, since their concepts are not yet sufficiently constructed (Clements, & McMillen, 1996; Van de Walle, 2007). Van de Walle (2007) explained the dilemma with these words:

> To 'see' a concept in a model, you must have some relationship in your mind to impose on the model. This is precisely why models are often more meaningful to the teacher than to students. The teacher already has the correct mathematical concept and can see it in the model. A student without the concept sees only the physical object or perhaps an incorrect concept (p.32).

Teachers should help students to achieve dual representations, which mean realizing the connection between the models and their intended referents. In fact, students may not construct the connections unless these connections are specifically highlighted by teachers (Clements, 1999; Uttal et al., 1997). In addition, teachers tend to ignore the need of students to see written version of operations expressed with the models (Fuson, & Briars, 1990; Nevin, 1993; Uttal et al., 1997). According to Nevin (1993), students do not realize the relationship between models and written symbols unless they record their actions with models. For example, in a study by Fuson and Briars (1990), while students solved the addition and subtraction problems with base-ten blocks, they needed to see written symbols of the same problems in order to give meaning to both the models and the symbols and to master symbolic relations.

The characteristics of the concrete models themselves are another source of the limitations of the concrete models. Because, some models might do more harm than good (Kaminski et al., 2006; McNeil, & Jarvin, 2007; Szendrei, 1996). Szendrei (1996) argues that some educational models come on the market for only commercial purposes. Therefore, some of them not only have little relationship to mathematical concepts, but also require memorization for proper use (Moyer, 2001; Szendrei, 1996). For this reason, some kind of concrete models may be more effective than others. For instance, models which are similar to concepts that they represent may be more effective such as base-ten blocks (Balka, 1993; Fuson, & Briars, 1990; Uttal et al., 1997). According to Heddens (1997), with base-ten blocks students easily realize and conceptualize the idea of tenness because while one stick is placed on a place value chart in the ones place, ten sticks are placed in the tens place. However, models with colorful and attractive design or familiar to students in outside of school contexts -such as toys- may lead students to see the activity as game and make it more difficult for students to achieve dual representations (McNeil, & Jarvin, 2007; Uttal et al., 1997). Besides these pedagogical limitations, concrete models may also have physical limitations such as lack of durability, difficulty to store, difficulty to use and manipulate, and expensive cost (Heddens, 1997; Karol, 1991).

2.2.4 Pre-service and In-service Teachers' Views about Using Concrete Models in Mathematics Classrooms

The recent curriculum reform in Turkey emphasizes the use of concrete models in mathematics classrooms (Ministry of National Education, 2004). However, studies in Turkey generally concluded that teachers do not prefer to use new instructional approaches and specifically concrete models in mathematics classrooms (Dede, 2007; Temizöz, & Koca, 2008; Toptaş, 2008).

The main reason is that most of the concrete models are novel for Turkish Mathematics Curriculum and therefore, for Turkish mathematics teachers. As it is well known, teachers tend to teach as they were taught (Bauersfeld, 1998). In Turkey, the majority of teachers was taught through lecture and did not learn mathematics with the help of concrete models. Furthermore, teachers have taught mathematics in the same way for years. Changing those teaching habits is difficult, especially for experienced teachers (Wilson, & Goldenberg, 1998). In brief, both experienced and pre-service teachers are likely to teach through lectures, even if such instruction is not consistent with the current curriculum.

Mathematics method courses in undergraduate education of pre-service teachers have a major role on pre-service teachers' future school experiences (Çakıroğlu, & Yıldız, 2007; Yenilmez, & Can, 2006). Therefore, pre-service teachers' experience with concrete models in undergraduate education is necessary for their future teaching carrier. In-service education about concrete models is also important for increasing in-service teachers' usage of models in mathematics classrooms (Moyer, 2001).

Çakıroğlu and Yıldız (2007) investigated the influence of method courses and field experiences on pre-service elementary mathematics teachers' attitudes toward the use of concrete models. The participants of the study were 9 senior pre-service elementary mathematics teachers. The participants were asked to teach to a group of students in a real classroom setting using concrete models. Interviews were conducted before and after the field experience. The results suggested that the factors that affect pre-service teachers' decision on whether or not to use models in teaching mathematics were: strict curriculum, students' learning styles, their familiarity with the models and group work, the compatibility of the concrete models with curriculum expectations, availability of the models, time constrains and finally the reaction to the models of parents, school administrators, and students. According to pre-service teachers in the study, compared to direct instruction, teaching with concrete models was more complex and the role of the teacher was more difficult. Furthermore, they believed that regular use of concrete models would not contribute to success in traditional multiple choice tests.

Bal (2008) investigated the opinions of primary teachers about new mathematics curriculum in Turkey. The sample for the study was 23 primary teachers who teach 1st, 2nd, and 3rd graders. Interviews were conducted about new mathematics teaching program. The research findings showed that teachers had positive attitudes toward new mathematics program. However, the majority of teachers in the study complained about implementation problems of models due to crowded classes and difficulty of designing activities with models.

Gürbüz (2007) explored elementary school students' and their teachers' opinion on an instruction with concrete models. The instruction was conducted with grade 8 students to teach probability subject. The sample of the study was 2 mathematic teachers and their own classes with 44 students in total. Interviews were conducted with both the teachers and 16 students. The results suggested that teachers had positive opinions about instruction with concrete models. Similar to the findings in Bal's study (2008), teachers complained about difficulty of designing activities with models.

Ersoy (2005) investigated the views of secondary mathematics teachers about mathematics teaching environment and constraints that they encounter while teaching mathematics. The sample was 47 secondary mathematics teachers. As found in Bal's study (2008), teachers complained about crowded classes, but generally had positive views about new instructional materials. Additionally, like the pre-service teachers in the study by Çakıroğlu and Yıldız (2007), teachers complained about insufficiency of instructional tools in mathematics classrooms.

Considering the studies that investigate in-service mathematics teachers' views about new instructional materials in Turkey, it could be concluded that teachers have generally positive views and they agree about the effectiveness of these materials on students' achievement, motivation and attitudes toward mathematics (Bal, 2008; Ersoy, 2005; Gürbüz, 2007; Toluk, & Olkun, 2003). Similarly, pre-service teachers also have generally positive views about concrete models and want to use models in their future experience (Çakıroğlu, & Yıldız, 2007; Yetkin-Özdemir, 2008). However, both pre-service and in-service teachers lack a clear idea about how models help students to understand mathematical concepts (Çakıroğlu, & Yıldız, 2007; Moyer, 2001; Yetkin-Özdemir, 2008). They regard concrete models as motivating or reinforcing tools instead of tools to construct meaning (Çakıroğlu, & Yıldız, 2007; Howard, Perry, & Tracey, 1997; Moyer, 2001). Therefore, they usually want to use models at the beginning of the lesson to introduce new concepts or after finishing an instructional unit to practice procedural skills or only for entertainment (Çakıroğlu, & Yıldız, 2007; McNeil, & Jarvin, 2007; Moyer, 2001; Nevin, 1993). Based on the research from several countries, opposite results might be obtained. For example, in a study by Howard et al. (1997), teachers' views about mathematics and concrete models were investigated. Data was collected from 603 primary and 336 secondary teachers. The results suggested that over half of the primary teachers reported that they used the models in each mathematics lesson. Additionally, almost all teachers felt confident in the use of models available to them. However, these findings can not reflect the situation in Turkey. Therefore, mostly studies in Turkey were considered in this section.

To sum up, it can be concluded that teachers in Turkey generally have positive views about concrete models. However, they do not prefer to use them in mathematics classrooms and their competencies about models are problematic. In addition, there are limited numbers of studies that investigate teachers' competencies about concrete models. Thus, the primary purpose of this study was to investigate pre-service elementary mathematics teachers' self efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics.

CHAPTER III

METHOD

Within this chapter, first, the design and procedure of the study are presented. Then, the participants, data collection tools, and the process of instruction are described in detail. Finally, data analysis, assumptions and limitations of the study are stated.

3.1 Research Design and Procedure

The main purpose of the study was to investigate pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. In this study, mainly one-group pretest-posttest research design was utilized. In this design, single group is measured twice; the first one before the treatment and the second one after the treatment (Fraenkel, & Wallen, 1996). Since this design does not have a control group, there is a serious limitation of ensuring that the change between the pretest and posttest is due to the treatment. To minimize such limitations of the design, quantitative findings were supported and mixed with qualitative methods.

For the quantitative part of the study, *The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models* (EUCM) developed by Bakkaloğlu (2007) was administered both before and after the instruction. The treatment consisted of six instructional sections based on using concrete models in teaching mathematics was carried out during a three week period. The treatment part is explained with detailed in the following parts.

The study was conducted in the middle of the spring semester of 2008-2009. In order to get in-depth information from the pre-service teachers, different data collection procedures, mainly questionnaires and interviews, were used.

Creswell (1998) referred this type of data collection as ‘multiple source of information’. After the treatment, semi-structured interviews were conducted with 13 pre-service teachers during two weeks. For each interview, first, the researcher explained the aim of the interview. Then, the students were asked questions prepared previously. After the pre-service teachers’ explanation, general inquires were made, such as, “explain”, “clarify”, or “give details” and continued to ask more specific questions until a response was obtained. Interviews lasted approximately 45 minutes. Each interview was conducted in a quite area of the university such as meeting room or an empty classroom.

Since the instructor who provided the treatment was also the researcher of the present study, the current study was a first-person research as defined by Ball (2000). Ball argued that in a first-person research, “the teacher is also the principal investigator of the research” (p.365). First-person research is distinguished from other types of research in such a way that “it deliberately uses the position of the teacher to ground questions, structure analysis, and represent interpretation” (Ball, p.365). However, in other research, the researcher and the teacher are different individuals and therefore, the work of practice is separated from the work of inquiry. The researcher attempts to understand, and analyze the lesson by observing it from outside. However, Ball claimed that first-person research enables the researcher to look from inside. The researcher can see, realize and analyze the things happened during the lesson from inside. As a result, this provides the researcher with a look into some aspects of teaching and learning that are often invisible to outsiders.

Considering the current study, being the instructor of the treatment and the researcher at once provided some advantages and disadvantages. For instance, the researcher became aware of the students’ views and beliefs about using concrete models during the instruction and recognized them. As an advantage, this enabled the researcher to understand the participants’ ideas better and to make more sensitive analysis of the data. Moreover, since the participants knew the researcher earlier; they were willing to participate in the interview and explained their views without hesitation and thus, the interviews were conducted in a sincere atmosphere. Yet, the responses of the interviewees could not always reflect the reality because of the sincere relationship with the researcher. It is also worth noting that as the researcher knew the participants before the interviews, she might tend to be subjective while asking the interview questions (Coghlan, & Brannick, 2001).

3.2 Participants

The subjects of the first phase of the study were 31 junior pre-service elementary mathematics teachers. As Fraenkel and Wallen (2006) recommended, a minimum number should be 30 individuals per group for experimental studies. The sample size was appropriate for the study because in the present study, data was collected only from one group of students. In this study, convenience sampling was used. Junior pre-service elementary mathematics teachers enrolled in elementary mathematics teaching program at a public university, where the researcher is a research assistant, were selected. There were 22 girls and 9 boys that took part in the study. The average age of the students was 21.

For the second phase of the study, a total of 13 (9 female, 4 male) interviewees were selected from the participants of the study regarding their self-efficacy gain scores. In order to select a group of participants that reflect a diverse range of opinions about concrete models, they were selected among the pre-service teachers with highest and lowest gain scores. Firstly, participants were ordered according to their gain scores from high to low. Secondly, they were divided into three groups in such a way that ten participants with highest gain scores were the first group, following eleven participants were the second group, and the last ten participants were the third group. Finally, 60% (6 out of 10) of the participants in the first group, 10% (1 out of 11) of them in the second group, and 60% (6 out of 10) of them in the third group were invited to participate to the interviews. All of these invited participants were agreed to participate in the interviews. From 13 junior pre-service teachers, three graduated from Anatolian Teacher Education High School, five from Anatolian High School, and five from high school. All of the interviewees took “Mathematics Method Course I” and they passed the course successfully. In addition, all of them were taking the “Mathematics Method Course II” during the study. By the time of data collection, the interviewees had not taken the course of school experience and they had not had any teaching experience with the concrete models.

3.3 Data Collection Tools

In order to get deep information from the pre-service teachers, both quantitative and qualitative data collection procedures were used. Quantitative data were collected from a survey that consisted of two parts (Appendix C). In the first part, pre-service teachers' age, gender, and their familiarity with concrete models before the instruction were asked. The first familiarity question was "Do you have any knowledge about the concrete model?" and the second one was "Have you ever used the concrete model in learning or teaching mathematics?" There were 23 concrete models which were chosen from the Ministry of National Education's elementary mathematics curriculum document for grades 6 to 8. The participants were informed if their answer was 'yes' to a given question; mark the space under the column that the answer 'yes' was located, if their answer was 'no', mark the space under the column that the answer 'no' was located. The second part of the survey was *The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models* (EUCM) that was administered both before and after the instruction. Besides, qualitative data were collected through semi-structured interviews that were conducted after the instruction. In the next sections, EUCM and interviews are presented in detail.

3.3.1 The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models

In the study, *The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models* (EUCM) developed by Bakkaloğlu (2007) was used to measure the pre-service mathematics teachers' efficacy beliefs about using concrete models in teaching mathematics. The original instrument's name was *The Instrument of Preservice Mathematics Teachers' Efficacy Beliefs about Using Manipulatives* (EBMU) and it contains 15 items. Yet, in the current study, one more item about pre-service teachers' personal efficacy beliefs was added with the recommendation of one mathematics education professor, so a 16-item-instrument was applied to the pre-service teachers. EBMU had two factors, personal efficacy and outcome expectancy. There were 9 items on personal efficacy beliefs about manipulative use (PEMU) subscale and 6 items on outcome expectancies regarding manipulative use (OEMU) subscale. Similarly, EUCM had two factors consistent with previous instruments (Bakkaloğlu, 2007; Enochs et al., 2000; Enochs, & Riggs, 1990) and Bandura's (1997) self-efficacy theory. These are personal efficacy beliefs about concrete model use (PECMU) and outcome expectancies regarding concrete model use (OECMU). EUCM consisted of 16 items, 10 items on PECMU subscale and 6 items on OECMU subscale. The distribution of the items into these two factors is given in Table 3.1. In addition, Appendix C displays the EUCM.

Table 3.1 The Distribution of the Survey Questions

The Items about Concrete Model Use Personal Efficacy Beliefs	The Items about Concrete Model Use Outcome Expectancies
1,2,3,4,5,6,11,14,15,16	7,8,9,10,12,13

Items in the EUCM have a five-point Likert scale ranging from 1 to 5; 1 indicating 'strongly disagree', 2 indicating 'disagree', 3 indicating 'neutral', 4 indicating 'agree', and 5 indicating 'strongly agree'. Negatively worded items were reversed while scoring so that high scores on both subscales were the indicator of positive efficacy beliefs toward using concrete models in teaching mathematics. In addition, each mean score was calculated by dividing total scores by the number of participants.

In order to determine the internal consistency of the scale Cronbach alpha coefficient was used. In the Bakkaloğlu's study (2007), EBMU had satisfactory internal consistency, with Cronbach alpha coefficient reported of .81 for PEMU and .79 for OEMU. Similarly, in the current study, both the pre and post administration of the EUCM yielded Cronbach alpha coefficients of .74 for the subscale PECMU. In addition, for the subscale OECMU, pre and post administrations of the EUCM yielded Cronbach alpha coefficients of .7 and .8, respectively. Moreover, the Cronbach alpha coefficients for the total scale were .78 for pretest and .84 for posttest. Since the Cronbach alpha coefficient of a scale should be above .7 (Pallant, 2001), the Cronbach alpha coefficients were considered reasonable values for this study.

The content validities of both scales were already ensured by Bakkaloğlu (2007). However, since one item, which was the 16th item in EUCM, was added to EBMU, it was essential to determine whether the added item was consistent with the construct being investigated. For this reason, two mathematics education professors reviewed the scale and the content validity of EUCM was established.

3.3.2 Interviews

Interview was another important data collection tool for this study because it enabled the researcher to investigate pre-service teachers' efficacies in a more detailed way. After administering the EUCM to pre-service teachers as pre-test and post-test, semi-structured interviews were conducted with 13 junior pre-service mathematics teachers. The interview questions' main aim was to get additional information on the pre-service teachers' perceived self-efficacy beliefs about using concrete models and judgments about likely consequences of using them to teach mathematical concepts (See Table 3.2).

To ensure the validity of the interview questions, two mathematics education professors were asked to determine whether the interview questions were matched with the research questions and the purpose of the study. Then, interview questions were revised until there was an agreement among the mathematics education professors on interview questions. All the interviews were tape recorded and transcribed.

Table 3.2 Interview Questions

1. Do you believe that you have enough knowledge and skills about using concrete models? Why?
2. Do you believe that you could use the concrete models effectively in your future mathematics classroom? Why?
3. What are the difficulties that you might encounter while teaching the concepts by using the concrete models? Why?
4. Have you ever used the concrete models during your own education? Which one(s)? How?
5. What do you think about using concrete models in teaching mathematics? a. What are the advantages of using concrete models? Why? b. What are the disadvantages of using concrete models? Why?
6. What are the effects of the concrete models on students' learning?
7. What are the differences between the lesson with concrete models and the lesson without concrete models? Why?
8. How did the instruction based on concrete models contribute to your knowledge of concrete models?

3.4 The Process of Instruction

During six sessions, instruction based on using concrete models in teaching mathematics that is as a component of method instruction was given to the junior pre-service mathematics teachers. It consisted of a variety of activities with the models (Appendix B). The activities were developed through a process of reviewing of resources from literature and the Ministry of National Education' elementary mathematics curriculum document for grades 6 to 8. In Table 3.3, the used concrete models and the concepts that might be taught by using the concrete models are presented for each session.

Table 3.3 Concrete Models Used in Instruction and Corresponding Concepts

Sessions	Concrete Models	Concepts	Duration (minutes)
Session 1	Pattern blocks, Transparent fraction cards, Fraction bars, Triangular dot paper	Fractions	50
Session 2	Tens card, Hundreds card, Square paper, Based-ten blocks	Decimals, Percents	50
Session 3	Algebra tiles, Paper, Transparent counters, Glass	Algebraic expressions, Equations	50
Session 4	Hundred table, Transparent counters, Square dot paper, Based-ten blocks,	Natural numbers, Integers, Square numbers	50
Session 5	Symmetry mirror, Geometry strips, Unit cubes, Square paper, Isometric dot paper	Two and three-dimensional shapes	50
Session 6	Squares set, Cubes set, Tangram, Square dot paper, Square geoboard, circular geoboard, Solid figures, Paper	Perimeters, areas and volumes of geometric shapes	50

The sessions were conducted in the mathematics laboratory of the university during a three week period without interfering in the participants' university class hours. Since there were not enough concrete models, the participants of the study were divided into two groups; 14 participants were in one group and 17 of them were in the other one. As a result, each participant had chance to use the all concrete models.

The researcher started each session by distributing the models to the participants and then, she gave general information about the concrete models used in the session. Afterwards, activities with the models were carried out. Finally, the pre-service teachers had a discussion on the usage of the models in a real classroom.

The first session consisted of the concrete models that can be used for teaching fractions. These models were pattern blocks, transparent fraction cards, fraction bars, and triangular dot paper. To begin with, pre-service teachers were asked to model a fraction by using these concrete models. Then, the activities about equivalent fractions, comparing and ordering fractions, and operations with fractions were carried out by using the concrete models.

The second session included two parts. The first part was about the concrete models that can be used for teaching decimals. In this part of the session, tens card, hundreds card, square paper and based-ten blocks were used to model decimals and activities with these models were carried out for the subjects of comparing and ordering decimals, and operations with decimals. The second part of the session was about modeling percents by using hundreds card and based-ten blocks.

The third session contained two parts. In the first part, the concrete models that can be used for teaching algebraic expressions were considered. At first, algebra tiles were introduced by giving details. Secondly, pre-service teachers were asked to model algebraic expressions and operations with these expressions. Thirdly, they were expected to factor algebraic expressions by using algebra tiles. Finally, paper cutting activities were completed for modeling the identities. The second part of the session was solving linear equations by using transparent counters and glasses.

The fourth session included three parts. In the first part, the hundred table was used for the concepts: divisibility, prime numbers, and multiples of natural numbers. In the second part, pre-service teachers were required to model operations with integers by using transparent counters. Finally, in the third part, based-ten blocks and square dot paper were used to find out square numbers.

In the fifth and sixth sessions, the concrete models used in geometry concepts were considered. The fifth session covered four parts. Firstly, the pre-service teachers were expected to obtain different two-dimensional shapes from an unordered polygon by using symmetry mirror. Secondly, pattern blocks and colored papers were used for the concepts in the transformation geometry. Thirdly, by using geometry strips, the participants were asked to discover the relationships between not only a triangle's edges but also a parallelogram and a quadrangle. Eventually, the pre-service teachers were expected to draw two-dimensional views (top, front, and sides) of the three-dimensional buildings. In addition, they were asked to construct three-dimensional buildings by using the unit cubes and draw these buildings on isometric dot paper.

In the last session, there were activities about perimeter, area and volume. At first, the participants were asked to construct different shapes by using squares set, cubes set and tangram and to calculate the areas and perimeters of these shapes. Moreover, they were expected to construct some polygons on geoboard and estimate the areas of these polygons. Secondly, pre-service teachers were supposed to construct cube, rectangular prism, and square prism with unit cubes and then they were expected to discover the volumes of these three-dimensional shapes. Thirdly, by using solid figures, the participants were expected to discover the relationship between a square based pyramid and a rectangular prism, and also the relationship between a circular cone and a circular cylinder. Finally, paper folding and cutting activities were carried out to discover the area of a circle, the surface area and the volume of a sphere.

3.5 Data analysis

The pre-service elementary mathematics teachers' self-efficacy beliefs about using concrete models in teaching mathematics were evaluated through self-efficacy's personal efficacy and outcome expectancy dimensions. For the quantitative data, first descriptive and inferential analyses carried out for the data obtained from the survey. Descriptive statistics were used to evaluate pre-service elementary mathematics teachers' familiarity with concrete models, and their self-efficacy beliefs before and after the instruction. Since data collected from one group on two different occasions, paired-samples t-test was used to determine whether there was a significance mean difference among pre-test and post-test scores (Pallant, 2007).

For the analysis of data collected by the interviews, the interviews were tape recorded and transcribed. They were coded on the basis of self-efficacy's personal efficacy and outcome expectancy dimensions. Then, categories and subcategories for each theme were formed by using the recurring patterns. In order to establish validity and reduce bias, coding of the data was independently conducted by the researcher and a mathematics teacher who was informed about the dimensions of self-efficacy and data analysis framework of the study. Both coders analyzed the transcribed data with pseudonym names for the participants in order to eliminate the bias for the credibility of the research study. Once coding was completed individually, eighty percent agreement on the codes was reached by the coders in the first round. Then, the codes were revised until there was a hundred percent agreement among the coders.

3.6 Internal Validity

Internal validity refers to the degree to which observed differences on the dependent variable are directly related to the independent variable, not to some other uncontrollable variable (Fraenkel, & Wallen, 1996). In the current study, there are some threats to internal validity that might also explain the results on the posttest. One of them was mortality that was some subjects might probably drop out of the study because pre-service teachers in the study were not familiar with concrete models. This threat was controlled by encouraging all subjects to participate and continue to the study. Another threat is instrumentation that means unreliability or lack of consistency in measuring instruments that can result an invalid assessment of performance (Gay, & Airasian, 2000). In the present study, the instrument was administered twice to the participants but the researcher used consistent procedures during both administrations. In addition, taking "Mathematics Method Course II" during the treatment could lead the participants to change their self-efficacy beliefs about concrete models in the posttest. Yet, as the pre-service teachers used limited number of concrete models in the method course, they might not experience major changes in their self-efficacies.

3.7 Assumptions and Limitations of the Study

It is assumed that the administrations of the scales were completed under standard conditions. Moreover, all the responses of the pre-service teachers to the surveys were obtained sincerely. In addition, all the participants answered interview questions in a serious way.

This study was limited to 31 junior pre-service elementary mathematics teachers enrolled at a public university, during spring semester of 2008-2009. Another limitation of the study was that the selection of the subjects for the study did not comprise a random sampling. The researcher selected them from the university where she is a research assistant. Furthermore, the instruction lasted for three weeks which was a limited time to change self-efficacy beliefs of the pre-service teachers and there were only six sessions for considering all concrete models recommended from Ministry of National Education' elementary mathematics curriculum document for grades 6 to 8.

As mentioned earlier, being the teacher of the instruction and the researcher at once might also lead some limitations. For example, the responses of the interviewees could not always reflect the reality because of the sincere relationship with the researcher. However, the participants were stated that they were able to express comfortably their doubts and negative judgments on using concrete models in teaching mathematics. Moreover, this kind of research is open to be subjective (Coghlan, & Brannick, 2001), but the researcher paid attention to this point and tried to be as objective as possible in the interviews.

CHAPTER IV

RESULTS

Within this chapter, the collected data was analyzed using both quantitative and qualitative methods to answer the research questions. This study was designed to investigate pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. This chapter is about the results obtained from data analysis. The chapter includes four sections. The first section presents descriptive statistics about pre-service elementary mathematics teachers' familiarity with concrete models before the instruction. The second presents descriptive statistics about their self-efficacy beliefs and outcome expectancies before and after the instruction. The third deals with the effect of the instruction based on the pre-service elementary mathematics teachers' self-efficacy beliefs and outcome expectancies. The fourth presents in depth analysis of interview data.

4.1 Pre-Service Elementary Mathematics Teachers' Familiarity with Concrete Models before the Instruction

In order to evaluate pre-service elementary mathematics teachers' knowledge about concrete models and the kind of the concrete models they used in learning or teaching mathematics before the instruction, descriptive statistics were used. Although the statistics give limited information about real situation; it is important in terms of indicating participants' perceived familiarity about concrete models.

Table 4.1 Frequency Table about Knowledge and Usage of Concrete Models

Concrete Models	Total Participants	Frequency of Knowledge	Frequency of Usage
Base-ten blocks	31	17 (55 %)	7 (23%)
Unit Cubes	31	29 (94%)	16 (52%)
Pattern blocks	31	11 (36%)	3 (10%)
Tens card	31	11 (36%)	1 (3%)
Symmetry mirror	31	11 (36%)	3 (10%)
Tangram	31	29 (94%)	22 (71%)
Square geoboard	31	12 (39%)	5 (16%)
Circular geoboard	31	5 (16%)	1 (3%)
Fraction bars	31	24 (77%)	16 (52%)
Transparent fraction cards	31	12 (39%)	10 (32%)
Geometry strips	31	4 (13%)	1 (3%)
Squares set	31	4 (13%)	0 (0%)
Cubes set	31	6 (19%)	0 (0%)
Algebra tiles	31	24 (77%)	15 (48%)
Solid figures	31	8 (26%)	2 (7%)
Transparent Counters	31	12 (39%)	2 (7%)
Hundred table	31	12 (39%)	2 (7%)
Hundreds card	31	12 (39%)	4 (13%)
Square dot paper	31	22 (71%)	10 (32%)
Isometric dot paper	31	13 (42%)	3 (10%)
Triangular dot paper	31	5 (16%)	2 (7%)
Carton/colored paper	31	25 (81%)	13 (42%)
Real life objects	31	26 (84%)	20 (65%)

Table 4.1 shows frequency table about knowing and using concrete models. Interestingly, none of the participants used squares and cubes sets in teaching or learning mathematics before the instruction. Moreover, tens cards, circular geoboard and geometry strips were only used by one participant. On the other hand, real life objects and tangram were used by the majority of the participants because there were 20 participants for real life objects and 22 participants for tangram. In general, while the rate of the frequencies of usage of the models was very low, the rate of the frequencies of knowledge about concrete models was fairly well. Almost all of the participants (29 out of 31) knew unit cubes and tangrams; 26 participants have knowledge about real life objects; 25 participants knew carton/colored paper, 24 participants knew algebra tiles and fraction bars, 22 participants knew square dot paper and 17 participants knew base-ten blocks. However, the knowledge of the participants was not enough for other models because with the rest of the models, the frequencies of familiarity were under 15 participants, namely fewer than 50 % of the participants. The least known models were geometry strips and squares set because there were only four participants for each model.

4.2 Pre-Service Elementary Mathematics Teachers' Self-Efficacy Beliefs Before and After the Instruction

In order to assess pre-service elementary mathematics teachers' self-efficacy beliefs and outcome expectancies before the instruction, descriptive statistics and histograms were used. A histogram is a visual representation used to display where most of the measurements are located and how they are spread out (Fraenkel, & Wallen, 2005). Possible scores in both PRE_PE and PRE_OE were ranged from 1 to 5. PRE_PE scores ranged from 1.90 to 4.10 and PRE_OE scores ranged from 2.83 to 4.33. As shown in the Figure 4.1, most of the measurements located in the middle of the histogram and the scores were not closer together; that is to say, they were much more spread out. In contrast, in the Figure 4.2, most of the measurements located in the right part of the histogram, the scores were closer together and tend to cluster around the mean. In addition, Figure 4.1 and 4.2 showed that the scores on the PRE_PE and PRE_OE were normally distributed.

Figure 4.1 Histogram of PRE_PE

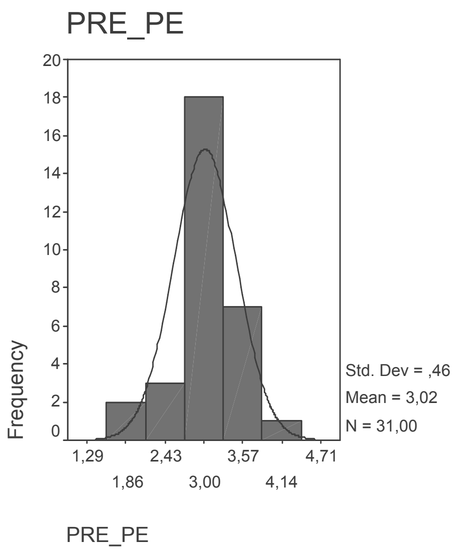
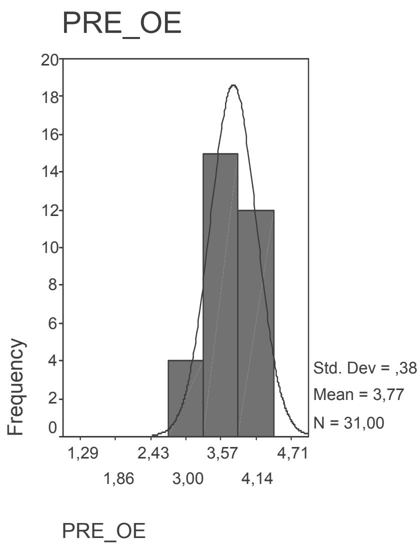
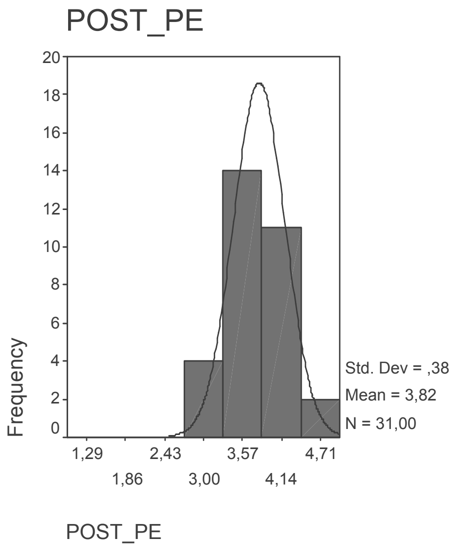


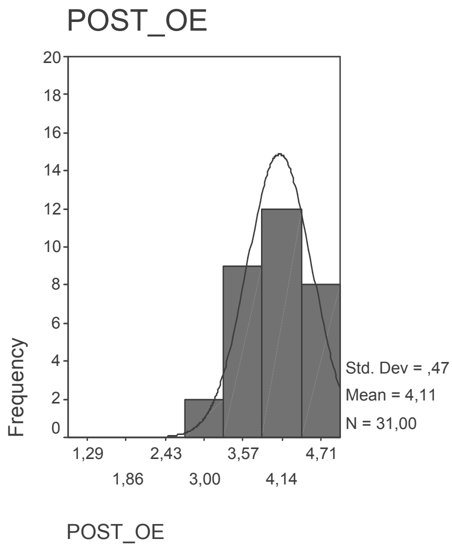
Figure 4.2 Histogram of PRE_OE



Regarding to post-test results possible scores in both POST_PE and POST_OE were ranged from 1 to 5. POST_PE scores ranged from 3.10 to 4.50 and POST_OE scores ranged from 2.83 to 5.00. As shown in the Figure 4.3, most of the measurements located right part of the histogram; the scores were closer together and tended to cluster around the mean. Similarly, in the Figure 4.4, most of the measurements located in the right part of the histogram; but the scores were much more spread out. In addition, Figure 4.3 and 4.4 showed that the scores on the POST_PE and POST_OE were normally distributed.

Figure 4.3 Histogram of POST_PE **Figure 4.4 Histogram of POST_OE**





4.3 The Contribution of the Instruction to the Pre-Service Elementary Mathematics Teachers' Personal Efficacy Beliefs and Outcome Expectancies

In this section, the findings of the analyses to answer the first main problem are presented. The sub-problems of the first main problem are as follows:

"Is there any statistically significant mean difference between pretest and posttest personal efficacy scores of pre-service elementary mathematics teachers about using concrete models?"

"Is there any statistically significant mean difference between pretest and posttest outcome expectancy scores of pre-service elementary mathematics teachers about using concrete models?"

In order to find out the differences between pretest and posttest efficacy scores, data were analyzed by using paired-samples t-test at the .05 significance level. Paired-samples t test has two assumptions which are the difference variable should be normally distributed and the difference scores should be independent of each other (Green, Salkind, & Akey, 2000). Before conducting the analyses, the assumptions were checked.

As seen in the Table 4.2, the kurtosis of differences of personal efficacy beliefs scores is -.808 and skewness is .122 and the kurtosis of differences of outcome expectancy scores is -.288 and the skewness is -.178.

Table 4.2 Descriptive Statistics of the DIF_PE and DIF_OE

	N	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
DIF_PE	31	-.10	1.90	.80	.51	0.122	-0.808
DIF_OE	31	-.50	1.17	.33	.41	-0.178	-0.288

Because of the values of kurtosis and skewness in table 4.2 were between -1 and 1 (George, & Mallery, 2003), the differences variables were normally distributed in the population**.** Moreover, Kolmogorov-Smirnov and Shapiro-Wilks statistics were examined and they revealed non-significant result (Sig value of more than .05) indicating normality (Pallant, 2007). On the other hand, the difference scores were independent of each other. Since the assumptions were met, the analyses were carried on.

4.3.1 A Comparison of Pretest-Posttest Personal Efficacy Scores

The first null hypothesis was as follows: There is no statistically significant mean difference between pre-test and post-test personal efficacy scores of pre-service elementary mathematics teachers about using concrete models.

A paired-samples t-test between pre-test and post-test personal efficacy scores was conducted to evaluate this null hypothesis. There was a statistically significant increase in PECMU scores from pre-test (M=3.02, SD=.46) to post-test (M=3.82, SD=.38), ($p<.05$), t (30) = -8.80, as shown in Table 4.3.

Table 4.3 Measures Obtained from the Testing of Significance of the Difference between PRE_PE and POST_PE

	Mean	N	Std. Deviation	Std. Error Mean	T	df	P	η2
PRE_PE	3.02	31	.462	.083	-8.803	30	.000	.72
POST_PE	3.82	31	.379	.068				

As seen in the Table 4.3, the eta squared statistic was .72 that indicated a large effect size (Cohen, 1988). This means that 71 % of the variance in the personal efficacy scores could be explained by the instruction based on concrete models.

4.3.2 A Comparison of Pretest-Posttest Outcome Expectancy Scores

The second null hypothesis was as follows: There is no statistically significant mean difference between pre-test and post-test outcome expectancy scores of pre-service elementary mathematics teachers about using concrete models.

A paired-samples t-test between pre-test and post-test outcome expectancy scores was conducted to evaluate this null hypothesis. There was a statistically significant increase in OECMU scores from pre-test (M=3.77, SD=.38) to post-test (M=4.11, SD=.47), ($p<.05$), t (30) = -4.57, as shown in Table 4.4.

Table 4.4 Measures Obtained from the Testing of Significance of the Difference between PRE_OE and POST_OE

	Mean	N	Std. Deviation	Std. Error Mean	T	df	P	η2
PRE_OE	3.77	31	.379	.068	-4.572	30	.000	.41
POST_OE	4.11	31	.474	.085				

As seen in the Table 4.4, the eta squared statistic was .41 that indicated a large effect size (Cohen, 1988). This means that 41% of the variance of the outcome expectancy scores could be explained by taking instruction based on concrete models.

4.4 In Depth Analysis of Interview Data

In this section, the findings of the analyses of the interview data to answer the third and fourth research questions are presented. The questions are as follows:

"What are the pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models after the instruction based on concrete models?"

"What are the pre-service elementary mathematics teachers' outcome expectancies about using concrete models after the instruction based on concrete models?"

In order to answer the research questions, semi-structured interviews were conducted with 13 pre-service elementary mathematics teachers. The interviewees were selected from the participants of the study regarding their gained self-efficacy scores. 6 interviewees were selected within the participants with high gained scores, 1 interviewee was selected within the participants with medium gained scores and 6 interviewees were selected within the participants with low gained scores. After the interview data were transcribed verbatim, they were coded on the basis of self-efficacy's dimensions which were personal efficacy and outcome expectancy. Then, categories and subcategories for each theme were formed by using the recurring patterns. Following quotes of the pre-service teachers are indicated by codes that consist of letters and numbers given in parentheses at the end of each quote. For example PT1 indicates the quote by pre-service teacher number 1 from the interview.

4.4.1 Pre-service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models after the Instruction

Pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models in teaching mathematics were classified under two major categories emerging from the interview data. The major categories were personal efficacy beliefs about using concrete models as learners and personal efficacy beliefs about using concrete models as teachers. The participants' views, which were coded under these categories, are explained elaborately and they are summarized for a clear explanation (See Figure 4.5).

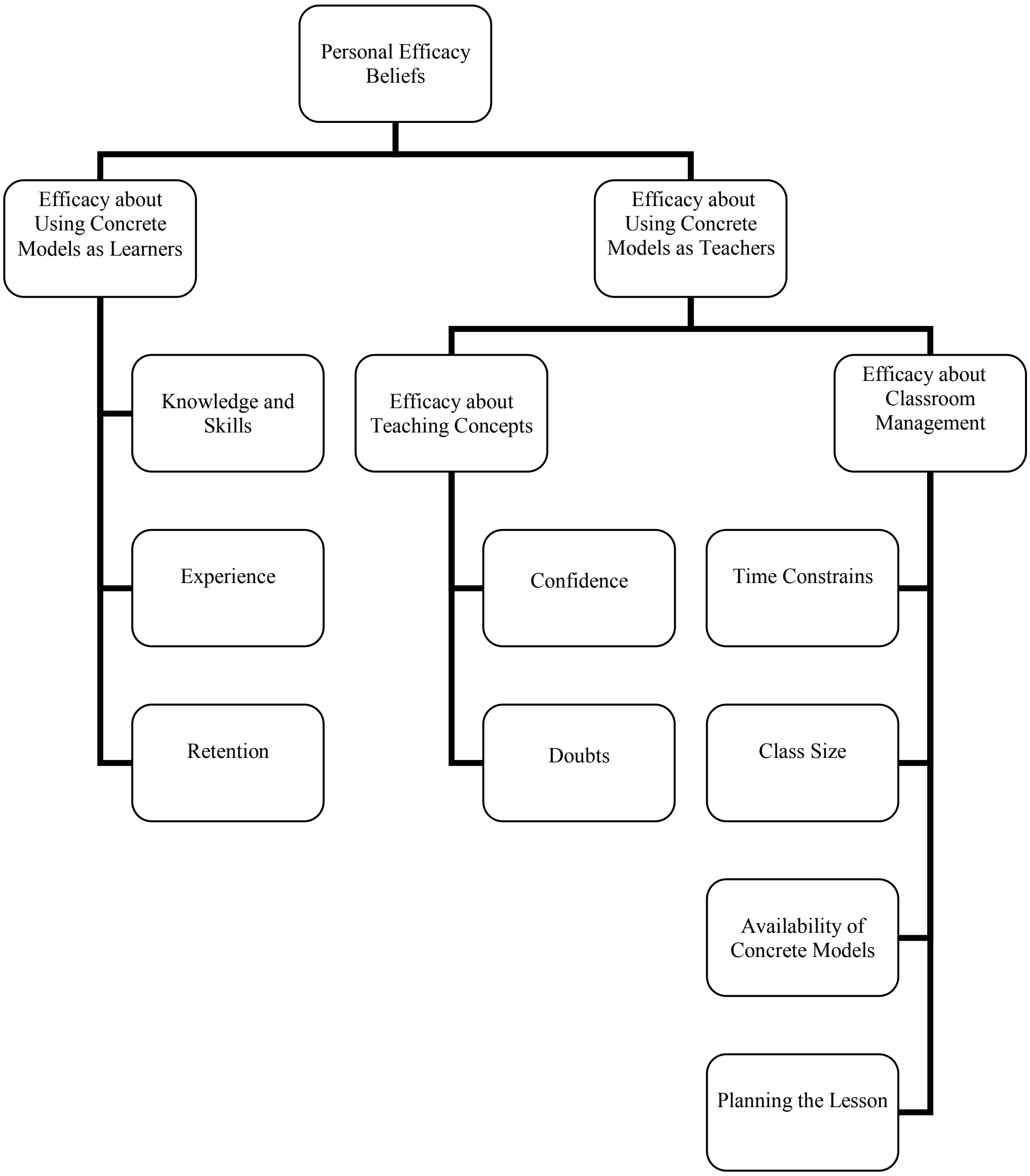


Figure 4.5 A summary for Pre-service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models in Teaching Mathematics

As given in the literature, Bandura (1997) defined perceived self-efficacy as a judgment of one's ability to organize and execute specific performances. In the current study, by using the term personal efficacy, the researcher mentioned about pre-service elementary mathematics teachers' perceived self-efficacy beliefs about using concrete models as learners and as teachers. The first category -efficacy about using concrete models as learners- was concerned with pre-service mathematics teachers' judgments about their capability in using concrete models as learners. The second category -efficacy about using concrete models as teachers- was referred to as pre-service mathematics teachers' judgments about their capability to organize and execute a lesson with concrete models.

4.4.1.1 Pre-service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models as Learners

The first main category of personal efficacy was pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models as learners. It consisted of pre-service teachers' knowledge and skills about using concrete models, their own experiences with concrete models as learners, and their retention of concrete models.

According to interview results, almost all of the pre-service teachers (12 out of 13) believed that they had enough knowledge about using concrete models. Similarly, when they were asked to express their overall skills about using concrete models, most of them (10 out of 13) indicated that they had enough skills in using these models. However, when the same questions were asked to the interviewees specifically about each model, seven of the interviewees indicated that they had difficulties on using some models. For instance, three of them said:

> *"If I have to tell the truth, I cannot draw three-dimensional shapes on isometric dot paper because it is very confusing (PT6)."*

> *"I want to use base-ten blocks; but I am confused which block I will call ones or which block I will call tens. It is really difficult*

because the value of blocks differ for integers and decimals (PT12)."

"I am concerned about the use of transparent fraction cards for multiplication and division because I did not exactly understand how they are used for these operations (PT4)."

As seen in the first quote above, some pre-service teachers (2 out of 13) pointed out that they had difficulty on using the concrete models requiring spatial thinking skills such as drawing three-dimensional shapes on isometric dot paper or forming these shapes with cubes. In addition, as explained in the second quote, some participants (2 out of 13) were concerned about confusing the values of blocks while using base-ten blocks for integers and decimals. As stated in the last quote, some of them (3 out of 13) specified that they had difficulty in using transparent fraction cards for multiplication and division.

To conclude, generally pre-service teachers believed that they had enough knowledge and skills about using concrete models. Likewise, posttest results were consistent with this interview result because in the posttest, the mean of the question 3, which was about pre-service teachers' knowledge, was 4.26 over 5 and the mean of the question 4, which was about pre-service teachers' skills, was 4.13 over 5 (See Appendix D).

Furthermore, all of the pre-service teachers in the interviews indicated that they had more knowledge and skills about concrete models than they had had before the instruction. For instance, an interviewee stated:

"I think the instruction is very beneficial for me. Before the instruction, I really wanted to use concrete models; but I did not have any knowledge about them. However, in this instruction, I learned how to use concrete models. Even though I do not have enough experience about using them, I know what they are (PT 1)."

Pre-service teachers had consensus on the benefits of the instruction. However, as noted before, some of them indicated that they lacked experience on using concrete models (8 out of 13). Another interviewee said:

> *"...Before this instruction I had little knowledge about concrete models. For example, at high school only some solid figures were shown, apart from that nothing was shown to us. We generally learned mathematics by paper and pencil methods (PT 10)."*

Like the pre-service teacher in the above quote, all of the interviewees stated that they did not use the models during their own education. Since they did not learn concepts by the models, they had some doubts about using them. These doubts were about retention of concrete models. While some pre-service teachers (4 out of 13) were concerned about forgetting the names of the models, some of them (5 out of 13) were concerned about forgetting how to use the models. For instance, two of them stated:

> *"...I have not used the concrete models much. For instance, even now I cannot exactly remember them. There are lots of models; so it is difficult to keep them in mind (PT 8)."*

> *"My biggest problem with concrete models is that I cannot remember the names of them (PT 2)."*

4.4.1.2 Pre-service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models as Teachers

The second main category of personal efficacy was pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models as teachers. It had two subcategories that were pre-service teachers' personal efficacy beliefs about teaching the mathematical concepts by using the models and their personal efficacy beliefs about classroom management. The first subcategory consisted of pre-service teachers' confidence and doubts about teaching the concepts by using concrete models.

Some pre-service teachers in the interview (7 out of 13) believed that they could effectively teach mathematical concepts by using concrete models. Moreover, some of them (6 out of 13) claimed that they could better explain mathematical concepts by using the models. In general, it can be concluded that tolerable amount of interviewees have confidence about effectiveness of their instruction with models. Likewise, the means of the posttest questions 6 and 14, which were about pre-service teachers' effectiveness and confidence about teaching concepts by using concrete models, were 3.13 and 2.97 over 5 (Appendix D).

However, when pre-service teachers were asked to explain their opinions elaborately about teaching process with the models, the majority of them (8 out of 13) indicated doubts about effectiveness of their instruction with concrete models. Interestingly, all of these interviewees reported that lack of experience on teaching with concrete models was the foremost reason for their doubts. Two of them stated:

> *"I have never taught a concept by using these models; therefore, I have some doubts. For example, each model has a main aim and you should not distract from this aim. If you distract from this aim, you might teach wrong things. I have doubts about this, but if I have enough experience about teaching, I can teach things that I desire to teach (PT 8)."*

> *"…When a student only learns how to use algebra tiles or fraction bars at the end of the lesson, the student does not learn much because the main aim of the teacher should be teaching operations on fractions by using fraction bars or teaching multiplication with algebraic expressions by using algebra tiles. On the other hand, the main aim is not teaching how to use these models. However, I think it is difficult to achieve this. Thus, I need more experience on teaching with concrete models (PT 10)."*

As explained in the above quotes some of the pre-service teachers expressed their doubts in a more detailed way. For example, like the interviewee in the first quote, some pre-service teachers (4 out of 13) indicated that they had doubts about distracting from the main subject. In addition, as stated in the second quote, some of them (3 out of 13) put forward that they had doubts about using concrete models as an end not as a means to an end. Furthermore, they believed that they need more experience in order to gain confidence on teaching with the models.

The second subcategory of personal efficacy about using concrete models as teachers was pre-service elementary mathematics teachers' personal efficacy beliefs about classroom management while teaching the mathematical concepts with concrete models. It consisted of pre-service teachers' opinions about time constrains, class size, availability of concrete models and planning the lesson with concrete models.

The majority of the interviewees believed that management was the most important difficulty they might encounter while teaching the mathematical concepts by using concrete models (9 out of 13). In contrast, the mean of the posttest question 1, which was about pre-service teachers' confidence in classroom management, was 3.65 over 5 (See Appendix D). In the posttest, the majority of the participants indicated that they can cope with difficulties about management. However, in the interviews, most of the interviewees expressed their doubts about management. For example, two interviewees stated:

> *"I can cope with difficulties about management unless the class is too crowded because when class size is large, I may ignore some students and there will be so much noise (PT 2)."*

> *"I want to use concrete models but I have doubts about how to cover curriculum in a limited time because using the models is time consuming (PT 10)."*

Like these interviewees, some others had doubts about the instruction with concrete models in a crowded class (3 out of 13), and some of them had doubts about time constrains (4 out of 13). In addition, availability of concrete models was another doubt of pre-service teachers (5 out of 13). On the other hand, some pre-service teachers had confidence in supplying these models (3 out of 13). For instance, a pre-service teacher said:

> *"Supplying concrete models will not be a problem for me because I can make most of the models by myself. Moreover, I can use materials from daily life (PT 2)."*

Another doubt of pre-service teachers was about planning the lesson where concrete models were used (8 out of 13). They did not have any clear idea about when and how they use the models. For instance, an interviewee reported:

> *"I do not know how I will plan the lesson. Should I use them at the beginning of the lesson? How should I start? How much time should I spend on the models? These are the questions whose answers are not clear for me… (PT 3)"*

In summary, pre-service teachers generally had high level of personal efficacies about using concrete models both as learners and as teachers. However, they have low level of efficacy beliefs about specific management problems that they might encounter in a classroom environment.

4.4.2 Pre-service Elementary Mathematics Teachers' Outcome Expectancies about Using Concrete Models in Teaching Mathematics

Pre-service elementary mathematics teachers' outcome expectancies are classified under two major categories emerging from interview data. The major categories were outcome expectancies about students' learning and outcome expectancies about teaching process. The participants' views, which were coded under these categories, are explained elaborately and they are summarized for a clear explanation (See Figure 4.6).

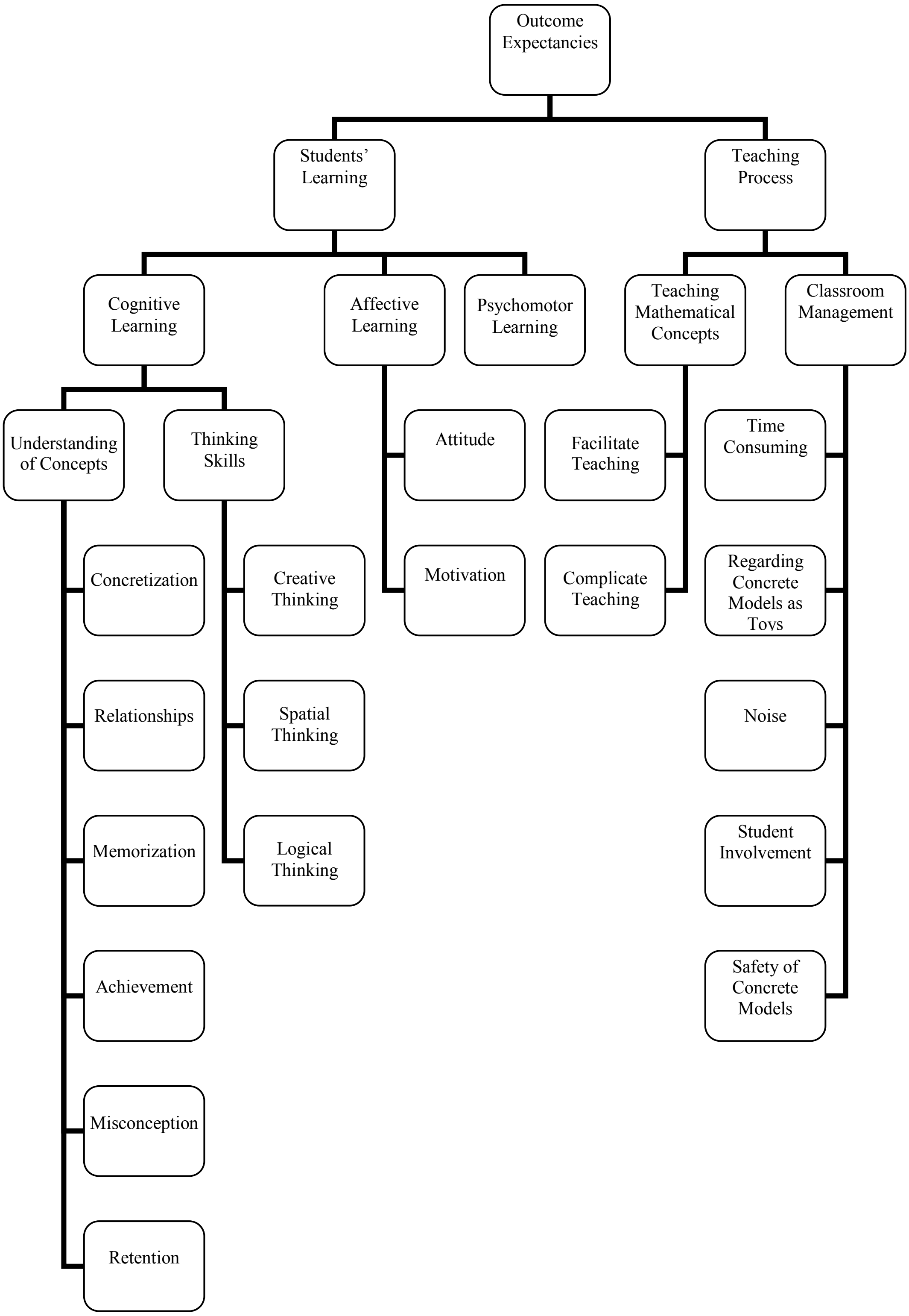


Figure 4.6 A Summary for the Pre-service Elementary Mathematics Teachers' Outcome Expectancies about Using Concrete Models in Teaching Mathematics

As given in the literature part, Bandura (1997) defined outcome expectancy as a judgment about the likely consequences of a performance. In the current study, by using the term outcome expectancy, the researcher mentioned pre-service elementary mathematics teachers' outcome expectancies about using concrete models in teaching mathematics. In other words, the meaning of outcome expectancy in the study was pre-service mathematics teachers' judgments about likely consequences of using concrete models to teach mathematical concepts on students' learning and teaching process.

4.4.2.1 Pre-service Elementary Mathematics Teachers' Outcome Expectancies Regarding Students' Learning

The first main category was pre-service elementary mathematics teachers' outcome expectancies regarding students' learning. It was referred to as pre-service mathematics teachers' judgments about likely consequences of using concrete models on students' learning. It consists of three subcategories: outcome expectancies about cognitive learning, affective learning and psychomotor learning of students.

Under the cognitive learning category, participants seemed to be concerned about two major types of student outcomes: understandings of concepts and thinking skills. The first outcome expectancy about cognitive learning was about the effects of teaching mathematical concepts by using the models on students' understandings of these concepts. Both the interview and posttest data indicated that pre-service teachers generally had positive expectancies about the likely consequences of the models on students' cognitive learning. The mean of the posttest question 10, which was about the positive effect of concrete models on students' mathematical knowledge, is 4.13 over 5 (See Appendix D). Similarly, all interviewees pointed out using concrete models enabled students to better understand the mathematical concepts. Four of them stated:

> *"…Concrete models enable students to better understand the concepts because students will find the formulas by themselves*

instead of memorizing them. I think the most important advantage of the models is that (PT 2). "

"... When the teacher directly gives students the formulas or properties of concepts, it is easily forgotten. However, if students themselves find the rules by using the models, they are never forgotten (PT 6)."

"... When students form shapes with tangram pieces, any shape may be ... for example a cat, they can see the relationships between shapes. For instance, they can realize that a trapezoid may be constituted of a square and a triangle. Additionally, they can also find the area of the trapezoid by adding the areas of the square and the triangle. Consequently, they do not need to memorize the formula (PT 7)."

"... If I teach equivalent fractions by using fraction bars, for example, let's consider 1/2 and 2/4, students can easily see the equivalence between 1/2 and 2 pieces of 1/4. Generally, students can not imagine it in their minds, the models make it concrete and it becomes easier to learn (PT 5)."

As seen in the above quotes, pre-service teachers indicated some advantages of using concrete models for students' understandings of concepts. Firstly, like the pre-service teachers in the first and third quote, some of them (10 out of 13) believed that the models prevent memorization. Secondly, as indicated in the second quote, most of them (11 out of 13) supposed that the models increase retention of the concepts. Thirdly, as seen in the third quote, some of them (9 out of 13) considered that the models enabled students to make and realize relationships. Lastly, like the interviewee in the last quote, all of them believed that one of the most important advantages of the models was concretization of the concepts.

In addition, the majority of the pre-service teachers (10 out of 13) thought that the models increased achievement of students. Similarly, the means of the posttest questions 8, 9, 12, which were about the effects of concrete models on students' achievement, are 4.42, 3.65 and 4.13 over 5, respectively, which indicated high outcome expectancies (See Appendix D). On the other hand, few interviewees reported that the models would not have any effect on students' achievements (3 out of 13). An interviewee said:

> *"If I have to tell the truth, I do not believe that concrete models every time increase the achievement of students because the effect of the models highly depends on teachers. For example, if a teacher uses the models in a wrong way such as only for showing, there will not be any success (PT 7)."*

This interviewee was aware of the limitations of the models emerging from the teacher. In addition, some pre-service teacher put forward other limitations of the models. For example, two of them stated:

> *"If concrete models are used too much, students can have difficulties about abstraction, at this time; the models negatively affect their learning of mathematics because mathematics actually is an abstract subject itself (PT 4)."*

> *"Even though we use the concrete models, children still have to memorize some things. At this time, they should memorize the rules of the models because some models really require memorization for proper use (PT 13)."*

Like the interviewee in the first quote, some pre-service teachers believed that concrete models may prevent abstraction (4 out of 13). In addition, as indicated in the second quote, some of them thought that several models require memorization (4 out of 13). Moreover, some interviewees pointed out that some concrete models led to confusion in students' mind and even led to misconception (10 out of 13). Similarly, the mean of the posttest question 7, which was stated that using concrete models led to confusion in students' minds, was 4.10 over 5.

The second outcome expectancy about cognitive learning was effects of teaching mathematical concepts by using the models on students' thinking skills. The majority of pre-service teachers claimed that concrete models improved logical thinking skills of students (10 out of 13). For example, an interviewee reported:

> *"Teaching a mathematical concept by using a model requires students to think so much and therefore, develops their logical thinking skills because students should find formulas, rules or properties by themselves. However, in the traditional method, teacher gives those readily, students only put the numbers in the formulas and find the answer, and there is not so much need to think or create (PT 3)."*

In addition to logical thinking, the majority of the interviewees believed that concrete models developed students' spatial thinking (10 out of 13) and creative thinking skills (7 out of 13). For instance, two interviewees said:

> *"... Forming three-dimensional shapes with cubes or drawing these shapes on isometric dot paper develops students' spatial thinking (PT 6)."*

> *"Tangram gives students the opportunity to be creative. For example, students can form different types of shapes by using tangram pieces that do not even come to our minds… (PT 11)"*

According to these interviewees especially geometric models such as tangram, unit cubes, cubes sets or square sets developed students' spatial and creative thinking skills.

The second subcategory of students' learning was pre-service teachers' outcome expectancies about students' affective learning. It consisted of the likely consequences of teaching concepts by using concrete models on students' attitude and motivation.

The majority of the interviewees claimed that using concrete models in mathematics lessons enabled students to develop positive attitudes toward mathematics (8 out of 13). They explained the reasons in various ways. For instance:

"...because the models enable students to better understand mathematical concepts (PT 1)."

"...because students do not need to memorize (PT 9)."
"...because the models increase students' achievements (PT 6)."

"...because the models make mathematics an enjoyable course instead of a frightening course (PT 5)."

As seen in the first three quotes above, same of the reason they envision for attitudinal impact were the same as their expectancies about cognitive learning. In other words, the pre-service teachers believed that if students understand the concepts clearly and complete the tasks successfully, they develop positive attitudes toward mathematics (4 out of 13). In addition, as indicated in the last quote, the interviewees believed that the models enabled students to enjoy the lesson, and therefore, students developed positive attitudes toward mathematics (8 out of 13). Furthermore, some pre-service teachers indicated that concrete models enabled students to develop positive attitudes not only toward mathematics, but also toward the teacher (3 out of 13).

In addition, nearly all of the interviewees (12 out of 13) believed that using concrete models in mathematics lessons increases students' motivation. Two interviewees stated:

"The models' attractive and colorful design increases students' motivation during the lesson (PT 3)."

"The models increase students' motivations in the lesson. For instance, some activities with models are so easy that all students

can understand them and therefore, not only successful students want to participate in these activities, but also unsuccessful students want to participate in them (PT 12)."

As indicated in the above quotes, pre-service teachers believed that the concrete models gained students' attention (10 out of 13) and increased their willingness to attend the lesson (11 out of 13).

The last subcategory of students' learning was pre-service teachers' outcome expectancies about students' psychomotor learning. The majority of the participants claimed that concrete models positively affected students' psychomotor learning (10 out of 13). For instance, an interviewee said:

"Of course, the concrete models affect psychomotor learning of the students positively. For instance, let's consider the drawing or cutting activities; all of them develop students' psychomotor skills (PT 5)."

As mentioned in the above quote, pre-service teachers believed that activities with concrete models that required drawing, cutting, or combining pieces developed students' psychomotor skills, and therefore, they positively affected their psychomotor learning.

4.4.2.2 Pre-service Elementary Mathematics Teachers' Outcome Expectancies Regarding Teaching Process

The second main category of outcome expectancy was pre-service elementary mathematics teachers' outcome expectancies regarding teaching process. It consisted of outcome expectancies about teaching mathematical concepts and classroom management.

Outcome expectancies about teaching mathematical concepts that was the first subcategory was referred to as pre-service mathematics teachers' judgments about likely consequences of using concrete models on teaching concepts.

The majority of the pre-service teachers believed that concrete models helped teachers to teach mathematical concepts in an effective way (8 out of 13). For example, an interviewee reported:

> *"… For instance, when I say 1/2, children can imagine it in their minds because it is half, thus it is easy to teach. But if I say 1/6 or 4/5, children cannot imagine these fractions in their minds. However, if I use fraction bars or pattern blocks, I can easily show 1/6 or else, I can show the fractions' relationships with the whole, and therefore, children can simply imagine them. In short, the models make my job easier (PT 4)."*

This interviewee indicated that concrete models facilitated the process of teaching concepts. Some of them explained their claim by giving more details. For instance, they believed that concrete models facilitated the representation of mathematical concepts, figures and properties (6 out of 13). In addition, some interviewees suggested that concrete models answer questions in students' mind such as why, how, etc. in an easy way (8 out of 13). For instance, one of them stated:

> *"… For example, by using geometry strips, students clearly see that in a triangle the addition of 2 edges' lengths can not be longer than the 3rd edge's length and the subtraction of 2 edges' lengths can not be shorter than the 3rd edge's length. If we teach this to students as a rule, they may ask why it is true (PT 9)."*

As noted in the above quote, pre-service teachers had generally positive outcome expectancies about teaching mathematical concepts by using the models. However, few pre-service teachers indicated that concrete models might also complicate the process of teaching concepts (3 out of 13). Interestingly, all of these interviewees stated negative expectancies about transparent fraction cards. An interviewee said:

"It is easier to teach multiplication and division with paper and pencil than the transparent fraction cards because they complicate the subject and also require memorization of lots of rules for using them in multiplication and division (PT 9)."

In brief, the majority of the pre-service teachers believed that some concrete models facilitated the process of teaching concepts; on the other hand, some others, especially the transparent fraction cards, could cause frustration in learning and lead to memorization.

The second subcategory of outcome expectancy was pre-service elementary mathematics teachers' outcome expectancies regarding classroom management. It was referred to as pre-service mathematics teachers' judgments about likely consequences of using concrete models on classroom management. It consisted of pre-service teachers' outcome expectancies regarding time, students' reactions, safety of concrete models and noise.

Pre-service teachers believed that concrete models cause some management problems (9 out of 13). Some of them explained their claim by giving more details. For example, four interviewees stated:

"…. It is a great deal of time consuming because all of the students in the class will try to make the activities with the models. Moreover, I should wait for all of them and check their work (PT 13)."

"…children can regard the models as toys and they might play with them. It is possible because some models really look like toys. At this time, the children are getting out of control (PT 11)."
"…For instance, students might break the fraction bars because they are so delicate. In addition, they might rend the models that are made by paper or carton (PT 3)."

"Since most of the models are used in group work activities, students might speak with each other. Therefore, there might be so much noise in the classroom (PT 7)."

Like the pre-service teacher in the first quote above, the majority of the participants (8 out of 13) indicated that concrete models were time consuming. Similarly, the mean of the posttest question 13, which was about time consuming, was 4.23 over 5 (See Appendix D). As indicated in the second quote, most of the participants (9 out of 13) believed that the students might regard the models as toys instead of mathematical tools. In addition, like the interviewee in the third quote, few participants (3 out of 13) specified that students might damage or lose models. Lastly, some interviewees (3 out of 13) indicated doubts about noise like the interviewee in the last quote.

Pre-service teachers indicated only one positive outcome expectancy regarding management. Moreover, the majority of them had consensus on the outcome expectancy. It was that concrete models increased students' involvement in lesson (11 out of 13).

> *"Teaching concepts by using concrete models enables all students to attend the lesson because all of them must be involved in the activities, and they also must share their opinions with the whole class (PT 6)."*

As indicated in the above quote, pre-service teachers suggested that in a concrete model environment, students were at the center of the lesson; in other words, they would do the activities and find the rules by themselves, and share their ideas with each other. Therefore, they believed that concrete models increased students' involvement in class activities.

4.5 Summary of the Results

To sum up, the instruction based on concrete models positively affected the pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. It can be concluded that pre-service mathematics teachers had confidence in themselves about using concrete models both as learners and as teachers.

Moreover, they had positive judgments about likely consequences of the concrete models on students' learning and teaching process. However, interview results revealed that pre-service mathematics teachers' perceived self-efficacy beliefs about classroom management were low and also their judgments about likely consequences of the concrete models on classroom management were negative.

CHAPTER V

CONCLUSIONS AND DISCUSSION

The primary purpose of this study was to investigate pre-service elementary mathematics teachers' personal efficacy beliefs and outcome expectancies about using concrete models in teaching mathematics. In this chapter, first, conclusions of the study are summarized respectively, and then these conclusions are discussed under the related headings. Finally, recommendations are presented.

5.1 Pre-service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models in Teaching Mathematics

In this part, the conclusions about pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models in teaching mathematics are stated briefly. To begin with, the contributions of the instruction on the pre-service mathematics teachers' personal efficacy beliefs about using concrete models are discussed. Then, their personal efficacy beliefs about using concrete models as a learner of mathematics and as a teacher of mathematics are discussed. In the literature, there was a lack of attention to the studies that dwelt on personal efficacies of teachers about concrete models. Therefore, the unique contribution of the study is taking pre-service teachers' personal efficacies about concrete models as both learners and teachers into consideration.

5.1.1 The Contribution of the Instruction on the Pre-Service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models

The quantitative and qualitative analyses suggested that the instruction based on concrete models positively affected the pre-service elementary mathematics teachers' personal efficacy beliefs about using concrete models. Likewise, the findings of the studies by Işıksal and Çakıroğlu (2006), and Umay (2001) suggested that pre-service teachers' self-efficacy beliefs were increased by teacher education teaching program. In the current study, as mentioned in the method chapter, qualitative data were collected from interviews that were conducted after the instruction. On the other hand, quantitative data were collected by a survey that consisted of two parts. The first part of the survey was about pre-service elementary mathematics teachers' familiarity with concrete models before the instruction. Generally, pre-service teachers indicated relatively low level of knowledge about the concrete models before the instruction. The second part of the survey was *The Instrument of Pre-service Mathematics Teachers' Efficacy Beliefs about Using Concrete Models* that was administered both before and after the instruction. The paired-samples t-test between pretest and posttest personal efficacy scores concluded that there was a statistically significant increase in personal efficacy scores from pre-test to post-test. Moreover, the interview results demonstrated that the pre-service teachers believed that they had more knowledge and skills about concrete models than they had had before the instruction. In conclusion, pre-service teachers indicated high levels of efficacy about using concrete models both as learners and as teachers after the instruction based on using concrete models.

The reason for the increase in pre-service teachers' personal efficacies may be that the instruction enabled them to have knowledge and skills about most of the models. In addition, not only they learned how the models can be used for teaching mathematical concepts, but also they used the models as learners. Therefore, they had chance to examine their competencies about using the models and to determine the models' likely consequences in a more objective way.

5.1.2 Pre-Service Elementary Mathematics Teachers' Personal Efficacy Beliefs about Using Concrete Models as Learners

According to both quantitative and qualitative results of the study, pre-service teachers had confidence in their performances to be effective in using concrete models as learners. Yet, in the interview, when pre-service teachers were asked to explain their thoughts in a more detailed way, they indicated some difficulties in using several models. In addition, they maintained some doubts about using the models such as forgetting the names of the models or how to use them. The difficulties and doubts that the pre-service teachers had may be due to the limited experience in using the models as learners. In fact, interview results suggested that all of the interviewees did not use the models during their own education. In addition, the survey's first part showed that the rate of the frequencies of usage of the models was very low before the instruction. Although the pre-service teachers used the models in the instruction as learners, there was not enough time for being competent users of the models. Therefore, in undergraduate education, especially in mathematics method courses, pre-service teachers should be given the chance of using the models as learners. Similarly, Çakıroğlu and Yıldız (2007), and Yenilmez and Can (2006) underlined the importance of mathematics method courses in undergraduate education.

5.1.3 Pre-Service Elementary Mathematics Teachers' Efficacy about Using Concrete Models as Teachers

The literature includes many studies concluding that pre-service teachers had confidence about the effectiveness of their instruction. For example, Bakkaloğlu (2007), İşler (2008), and Dede (2008) found that mathematics teachers had high efficacy beliefs about teaching mathematics. The results in the current study similarly found that pre-service teachers had high personal efficacy beliefs about using concrete models as teachers. However, teachers might declare that they feel confident even though they do not really feel confident at all (Wheatley, 2005). For this reason, in the interview, pre-service teachers were asked to express their ideas about themselves by giving more details. For instance, when they were asked to explain their judgments elaborately about teaching with the models, some of their doubts were revealed. According to the pre-service teachers, the foremost reason for their doubts was their lack of experience about teaching with the models. This might be a reason because pre-service teachers really have limited experience about teaching with models. In mathematics method courses, pre-service teachers are asked to prepare a short lesson (usually 20 minutes) by using the concrete models for a small group of learners who are their colleagues. However, it is very different from teaching concepts to students in a real classroom environment. Moreover, in the school experience, they may not find enough opportunities to teach mathematics by using the models. In short, each pre-service teacher has a chance of using only limited numbers of models as a teacher. Therefore, in the mathematics method courses and school experience, they should be provided more opportunities to practice teaching with models.

Another conclusion of the study was that there was an inconsistency with quantitative and qualitative results about pre-service teachers' personal efficacy about classroom management. In the post-test, they had high efficacy beliefs about classroom management whereas in the interview they demonstrated low level of efficacy about it. Furthermore, in the interview, they stated that management was the most important difficulty that they might encounter while teaching the mathematical concepts by using the models. The reason for the inconsistency may be that pre-service teachers had confidence in general classroom management; however, they had some doubts about specific management problems such as time constrains, class size, availability of concrete models, and planning the lesson. In the interview, they had a chance to explain their doubts about these specific management problems; yet, in the post-test they had to think about the general situation. The specific management problems that pre-service teachers mentioned were similar to the views of pre-service and in-service teachers about using concrete models in the literature. For instance, Çakıroğlu and Yıldız (2007) found that time constrains and availability of the models were two of the factors affecting pre-service teachers' decision on whether or not to use models in teaching mathematics. Similarly, the in-service teachers in Ersoy's (2005) study complained about insufficiency of instructional tools in mathematics classrooms. Moreover, the in-service teachers in both Ersoy's (2005) and Bal's (2008) studies complained about implementation problems of models due to crowded classes.

5.2 Pre-service Elementary Mathematics Teachers' Outcome Expectancies Regarding Using Concrete Models in Teaching Mathematics

In this part, the conclusions about pre-service elementary mathematics teachers' outcome expectancies regarding using concrete models in teaching mathematics are summarized and discussed. First, the contributions of the instruction on the pre-service teachers' outcome expectancies about using concrete models are discussed. Later, their outcome expectancies regarding students' learning and teaching process are discussed.

5.2.1 The Contribution of the Instruction on the Pre-Service Elementary Mathematics Teachers' Outcome Expectancies about Using Concrete Models

The quantitative and qualitative analyses suggested that the instruction based on concrete models positively affected the pre-service elementary mathematics teachers' outcome expectancies about using concrete models. The paired-samples t-test between pretest and posttest outcome expectancy scores concluded that there was a statistically significant increase in outcome expectancy scores from pre-test to post-test. In addition, in the interview, pre-service teachers indicated high levels of outcome expectancies about using concrete models. However, their pre-test outcome expectancy scores were also not low ($M=3.77$). Similarly, in a study conducted by Bakkaloğlu (2007), the results showed that outcome expectancy scores of pre-service mathematics teachers were considerably high, even though they did not take any specific instruction about concrete models. Nevertheless, in the current study, after the instruction, there was an increase on pre-service teachers' outcome expectancies. The reason may be that before the instruction, although they had had little knowledge about the models, they had mostly positive outcome expectancies, which means they generally held the belief that the use of concrete models in instruction would result in improved student learning. On the other hand, after the instruction, they learned how the models facilitated learning and teaching process and therefore, their outcome expectancies further increased.

5.2.2 Pre-Service Elementary Mathematics Teachers' Outcome Expectancies Regarding Students' Learning

Both quantitative and qualitative results showed that the pre-service teachers had generally positive expectancies about the likely consequences of the models on students' learning. The results concluded that, in general, pre-service teachers believed that using concrete models positively affected students' learning. On the other hand, they were aware of some negative effects of the models. Their thoughts could be grouped under three different learning domains that were cognitive, affective and psychomotor learning. While they expressed only positive expectancies about affective and psychomotor learning, they indicated both positive and negative expectancies about cognitive learning.

To begin with, pre-service teachers believed that using concrete models enabled students to have a better understanding of mathematical concepts. In the same manner, they indicated some advantages of using concrete models for students' understanding such as concretization, preventing memorization, increasing retention, and making connections among ideas. Their views were parallel to the strengths of the models mentioned in the literature. For example, Piaget (1950) argued that children learn mathematics best from concrete activities. In addition, Dienes recommended that a child should recognize symbols as representations of concrete experiences before using the symbols in a mathematical system. Besides, according to Karol (1991), concrete models help students in bridging the gap between their own concrete environment and abstract levels of mathematics. Moreover, Balka (1993) and Nevin (1993) claimed that concrete models played an important role in making and realizing the mathematical relationships between mathematics concepts. The Sowell's (1989) meta-analysis concluded that the use of concrete models in instruction increased students' retention.

Pre-service teachers also believed that the models increased the achievement of students. Likewise, the literature includes many studies that focus on the positive effects of concrete models on students' achievement. For instance, Fuson and Briars (1990) found that performance of students using the base-ten blocks was considerably higher than performance of students receiving traditional instruction. In addition, the findings of Bayram (2004) and Aburime (2007) suggested that geometric models had positive effects on the achievement of students. Moreover, according to a review of research by Suydam and Higgins (1976), the use of models at every grade level was generally effective in promoting students' achievement.

Lastly, pre-service teachers claimed that concrete models developed thinking skills of students such as creative thinking, spatial thinking, and logical thinking. They believed that especially geometric models such as tangram, unit cubes, cubes sets or square sets developed students' spatial thinking skills. The reason why they particularly indicated these models may be that the activities with these models included three-dimensional tactile processes. According to Keller (1993), three-dimensional tactile processes developed students' visualization skills.

In addition, pre-service teachers believed that using concrete models developed students' affective learning such as attitude and motivation. The literature includes many studies that supported the same idea. For example, the studies by Bayram (2004), Martelly (1998), and Fuson and Briars (1990) suggested that concrete models are beneficial for students' attitudes. When the pre-service teachers' responses in the interview were considered in a more detailed way, it was concluded that their positive expectancies about affective learning were caused by their positive expectancies about cognitive learning. In other words, the pre-service teachers believed that if students understand the concepts clearly and complete the tasks successfully, they develop positive attitudes toward mathematics and are motivated to learn mathematics. Furthermore, they claimed that concrete models positively affected students' psychomotor learning although a study to support this claim could not be found in the literature.

As aforementioned, pre-service teachers not only indicated the advantages of the models on students' learning, but also stated some limitations of them such as preventing abstraction, requiring memorization, and leading to misconception.

Although the participants did not receive an explicit instruction about such limitations, they seemed to develop ideas about possible weaknesses about the materials they had been learning. These limitations were similar to the limitations stated in the literature. For example, Uttal et al. (1997) found that students generally succeeded in solving problems by using concrete models, but they could not transfer their mathematical knowledge that was learned by models to an abstract environment. For this reason, teachers should help students to make transition from concrete to abstract by using both concrete and symbolic representations of concepts. Johnson (1993) also recommended that a connection must be established in the activities that help the transition from concrete to abstract. In addition, Moyer (2001), and Szendrei (1996) indicated that some concrete models required memorization for proper use. Therefore, teachers should carefully select the models that they will use in their classrooms. Having critical thoughts about concrete models and developing awareness should be interpreted as a positive aspect of pre-service teaches' development. Especially, considering that the participants' critiques to the models demonstrated a similarity to the ones raised in the literature, we can see that they had been through an intense thinking process about the concrete models. In this sense such explicit training about concrete models are likely to trigger pre-service teachers' thinking process and help them to develop a critical perspective.

5.2.3 Pre-Service Elementary Mathematics Teachers' Outcome Expectancies Regarding Teaching Process

Pre-service elementary mathematics teachers' outcome expectancies regarding teaching process were divided into two parts that were outcome expectancy regarding teaching mathematical concepts and classroom management. Although the majority of the pre-service teachers believed that concrete models facilitated teaching mathematical concepts, some of them indicated that the models might complicate teaching. Interestingly, all of these pre-service teachers stated negative expectancies about the same model: transparent fraction cards. The reason might be that the pre-service teachers tried to memorize the operations with transparent fraction cards instead of using the operations' meanings. They developed rules such as "for multiplication put the cards upside down" or "for division put the cards right side up". The pre-service teachers sometimes confused the rules and had difficulties in using the models for multiplication and division. Therefore, they believed that transparent fraction cards could complicate the process of teaching multiplication and division of fractions. This result indicates that the pre-service teachers had been actively thinking about the concrete models they were studying. In this sense, teacher education courses or seminars should enable pre-service teachers to do explicit reflections about the models they are studying. In addition, in the undergraduate education, pre-service teachers should be able to learn how to use models by using the meanings of the concepts instead of learning them in a rote manner.

According to both quantitative and qualitative results of the study, pre-service teachers generally had negative expectancies about the likely consequences of the models on classroom management. For instance, they thought that using concrete models would be time consuming and cause noise in the class. As mentioned earlier, time constrain was also one of their difficulties in using the models as teachers. It can be concluded that when considering time, not only their personal efficacy beliefs were low, but also their outcome expectancies were negative. In addition, pre-service teachers believed that the students might regard the models as toys instead of mathematical tools. This may be explained by some of the limitations arising from concrete models themselves that were mentioned in the literature. For instance, McNeil and Jarvin (2007), and Uttal et al. (1997) argued that models with colorful and attractive design or familiar to students in outside of school contexts -such as toys- may lead students to see the activity as a game and see the models as toys. Furthermore, pre-service teachers indicated a physical limitation of the models that was lack of durability. It can be concluded that they were aware of some limitations arising from the characteristics of the concrete models themselves. However, the pre-service teachers were not so much aware of the limitations arising from the teacher. They mostly indicated the limitations arising from students or concrete models themselves. On the other hand, although pre-service teachers had mostly negative expectancies about classroom management, they believed that the models increased students' involvement in the lesson. Similarly, Karol (1991) and Nevin (1993) put forward that concrete models are to make students active participants in their own learning process. In addition, Nevin (1993) argued that understanding can only take place when students have been actively involved in their own learning.

5.3 Recommendations

Most of the concrete models are novel for Turkish mathematics teachers. As a well known fact, teachers tend to teach as they were taught (Bauersfeld, 1998). Besides, in Turkey, the majority of the teachers was taught through lecture and did not learn mathematics with the help of concrete models. Therefore, in undergraduate education, pre-service teachers should be given the chance of using the models as learners. Also, pre-service teachers have limited experience about teaching with the models, thus, in the mathematics method courses and particularly in the school experience, they should be provided with more opportunities to practice teaching with models.

Concrete models should be used in mathematics lessons at especially elementary level. Similarly, Piaget (1950) argued that children, particularly young ones, learn mathematics best from concrete activities. However, using concrete models in a mathematics classroom gives teachers some responsibilities. For instance, teachers should help students to make transition from concrete to abstract by using both concrete and symbolic representations of the concepts. Furthermore, teachers should carefully select the models to be used in their classrooms and they should carefully plan the lesson.

To conclude, for increasing both pre-service and in-service teachers' self-efficacy beliefs about using concrete models in teaching mathematics, they should be taught the concrete models' both strengths and limitations, and also they should be given the opportunities to practice using concrete models both as learners and as teachers. In the same way, not only pre-service education should be reinforced, but also in-service education should be given the necessary importance.

In order to achieve the intended changes in pre-service mathematics teachers' self-efficacy beliefs about using concrete models, their personal efficacies and outcome expectancies on the subject of concrete models should continue to be analyzed well. Moreover, further studies should be conducted not only with the pre-service mathematics teachers, but also with the in-service mathematics teachers. Besides, further research need to be done to explore how in-service mathematics teachers' efficacies about using concrete models affect students' learning in various topics. In addition, the continuum of development process of self-efficacy beliefs of pre-service and in-service teachers' beginning from early stages of teacher training program and during their classroom practices should be examined and also the effect of experience or other related factors on the self-efficacy construct should be investigated.

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APPENDICES

APPENDIX A

The Definitions of Concrete Models

Base-ten blocks are a mathematical model used to teach basic mathematical concepts including addition, subtraction, number sense, place value and counting. Generally, the three-dimensional blocks are made of a solid material such as plastic or wood and come in four sizes to indicate their individual place value: Units (one's place), Longs (ten's place), Flats (hundred's place) and Blocks (thousand's place).

Unit cubes are cubes all of whose sides are 1 unit long. They used to teach counting, patterns, number comparisons, addition, subtraction, and three-dimensional shapes.

Pattern blocks allow children to see how shapes can be decomposed into other shapes. The pattern blocks have six shapes in different colors: square in orange, equilateral triangle in green, regular rhombus in blue, small rhombus in beige, hexagon in yellow, and trapezoid in red.

Tens card is the chart which is divided into 10 portative squares, used to help students visually see how many "ten" is.

Symmetry mirror is a kind of mirror that is used to teach line symmetry.

Tangram is a dissection puzzle consisting of seven flat shapes which are five triangles, one parallelogram and one square. The objective of the puzzle is to form a specific shape using all seven pieces, which may not overlap. Tagram pieces enable students to form different shapes, explore geometric properties, and identify congruent and similar shapes.

Geoboard is often used to explore basic concepts in plane geometry such as perimeter, area or the characteristics of triangles and other polygons. Consisting of a physical board with a certain number of nails half driven in, in a symmetrical square five-by-five array, students are encouraged to place rubber bands around the pegs to model various geometric concepts.

Fraction bars are constituted of eight pieces which are shown the fractions 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/8 and 1/10. They are used to visualize and teach the basic fractions concepts.

Transparent fraction cards are colored transparent area models of fractions. They are used with overhead projector.

Geometry strips are used to construct geometrical shapes. They are used as a skeleton of the constructed shapes.

Squares set are plastic two dimensional shapes which have different numbers of unit squares.

Cubes set are plastic three dimensional shapes which have different numbers of unit cubes.

Algebra tiles are rectangular shaped, colored concrete models of variables and integers to which we can attach the language of polynomials.

Solid figures are 12 transparent geometric models such as pyramids, cone, cylinder, hemisphere, rectangular prism, triangular prism and square prism.

Transparent Counters are colored transparent plastic objects. There are blue counters for positive integers and orange counters for negative integers. They help developing integer concept.

Hundred table is the chart which is divided into 100 squares numbering from 1 to 100.

Hundreds card is the chart which is divided into 100 portative squares, used to help students visually see how many "hundred" is.

APPENDIX B

Activities with the Concrete Models

Ders I

Konu: Kesir Öğretiminde Kullanılabilecek Somut Modeller

Kullanılan Somut Modeller: Örüntü blokları, şeffaf kesir kartları, kesir çubukları, üçgensel kâğıt.

Etkinlik 1: Farklı Kesir Gösterimleri

Öğretmen adaylarından $\frac{2}{3}$ kesrini örüntü blokları, üçgensel kâğıt, şeffaf kesir kartları ve kesir çubuklarını kullanarak göstermeleri istenir.

Etkinlik 2: Denk kesirler

Örnek: Öğretmen adaylarından, $\frac{3}{4}\ ve\ \frac{6}{8}$ kesirlerinin denkliğini kesir çubukları ve şeffaf kesir kartlarını kullanarak göstermeleri istenir.

Etkinlik 3: Kesirlerde Sıralama

Öğretmen adaylarından aşağıdaki ilk kesir grubunu, kesir çubuklarını kullanarak ve bütüne yakınlığı düşünerek büyükten küçüğe doğru sıralamaları istenir. Daha sonra, ikinci kesir grubunu örüntü bloklarını kullanarak ve birim kesir cinsinden düşünerek küçükten büyüğe doğru sıralamaları ve üçüncü kesir grubunu ise şeffaf kesir kartlarını kullanarak ve kesirlerin bölme anlamını düşünerek büyükten küçüğe doğru sıralamaları istenir.

a) $\frac{9}{10}, \frac{2}{3}, \frac{7}{8}$ **b)** $\frac{2}{6}, \frac{5}{6}, \frac{3}{6}$ **c)** $\frac{1}{6}, \frac{1}{10}, \frac{1}{5}$

Etkinlik 4: Kesirlerle Toplama İşlemi

Öğretmen adaylarından $\frac{2}{3}+\frac{1}{2}$ işlemini somut modelleri kullanarak çözmeleri istenir. İşlemi çözmeden önce, "Sizce hangi modeller bu işlem için daha uygun olabilir?" sorusu yöneltilir ve öğretmen adaylarının fikirleri alınır.

Etkinlik 5: Kesirlerle Çıkarma İşlemi

Öğretmen adaylarından aşağıdaki çıkarma işlemlerini somut modelleri kullanarak çözmeleri istenir.

a) $\frac{1}{2}-\frac{1}{3}=?$ **b)** $1\frac{2}{3}-\frac{1}{6}=?$

Etkinlik 6: Kesirlerle Çarpma İşlemi

Öğretmen adaylarından $\frac{1}{2}\times\frac{2}{3}$ işlemini somut modelleri kullanarak çözmeleri istenir. İşlemi çözmeden önce, "Sizce hangi modeller bu işlem için daha uygun olabilir?" sorusu yöneltilir ve öğretmen adaylarının fikirleri alınır. Daha sonra $\frac{2}{6}\times\frac{3}{4}$ işlemini şeffaf kesir kartlarını kullanarak çözmeleri istenir.

Etkinlik 7: Kesirlerle Bölme İşlemi

Öğretmen adaylarından aşağıdaki ilk iki bölme işlemini kesir çubukları, örüntü blokları ve şeffaf kesir kartlarını kullanarak yapmaları istenir. Daha sonra üçüncü bölme işlemini şeffaf kesir kartlarını kullanarak çözmeleri istenir.

a) $\frac{1}{2}\div\frac{1}{3}=?$ **b)** $\frac{1}{2}\div\frac{1}{6}=?$ **c)** $\frac{2}{3}\div\frac{4}{5}=?$

Ders II

Konu: Ondalık Kesirlerin ve Yüzdelerin Öğretiminde Kullanılabilecek Somut Modeller

Kullanılan Somut Modeller: Onluk kart, yüzlük kart, kareli kâğıt, onluk taban blokları.

Etkinlik 1: Farklı Ondalık Kesir Gösterimleri

Öğretmen adaylarından öncelikle 1,26 ondalık kesrini yüzlük kart ve onluk taban bloklarını kullanarak modellemeleri istenir. Daha sonra, 1,254 ondalık kesrini somut modelleri kullanarak modellemeleri istenir. Modellemeden önce "Yüzlük kart ve onluk kart bu ondalık kesri modellemek için kullanılabilir mi? Kaça kaçlık karesel bölgeye ihtiyaç vardır?" soruları yöneltilir. Son olarak, $\frac{12}{100}$ kesrini onluk taban bloklarını kullanarak modelleyip ondalık açılımını bulmaları istenir.

Etkinlik 2: Ondalık Kesirlerde Karşılaştırma ve Sıralama

Öğretmen adaylarının 1,26; 1,234; 1,2; 1,23 ondalık kesirlerini onluk taban bloklarını veya kareli kâğıdı kullanarak büyükten küçüğe doğru sıralamaları istenir. Ayrıca, yüzlük kart veya onluk kartın kullanılamayacağı; çünkü 1,234'ün modellenmesi için 1000 parçaya bölünmüş bir modele ihtiyaç olduğu vurgulanır.

Etkinlik 3: Ondalık Kesirlerle Toplama İşlemi

Öğretmen adaylarından 0,134 + 1,082 işlemini onluk taban bloklarını kullanarak çözmeleri istenir. Bu soruda, yüzde birler basamağındaki 10 tane onluk onda birler basamağına 1 tane yüzlük olarak geçer. Bu şekilde, onluk taban bloklarını kullanarak elde kavramını öğretebilecekleri vurgulanır.

Etkinlik 4: Ondalık Kesirlerle Çıkarma İşlemi

Öğretmen adaylarından 1,114 – 1,105 işlemini onluk taban bloklarını kullanarak çözmeleri istenir. Bu soruda, binde birler basamağındaki 4 tane birlikten 5 tane birlik çıkamayacağı için yüzde birler basamağından bir tane onluk alınır ve bu şekilde onluk bozmanın onluk taban bloklarını kullanarak öğretilebileceği vurgulanır.

Etkinlik 5: Ondalık Kesirlerle Çarpma İşlemi

Öğretmen adaylarından 3 x 0,04 işlemini çarpmanın tekrarlı ardışık toplama anlamından yararlanarak onluk taban bloklarıyla çözmeleri istenir. Daha sonra, 1,2 x 0,8 işlemini alan modelinden yararlanarak yüzlük kartlarla çözmeleri istenir.

Etkinlik 6: Ondalık Kesirlerle Bölme İşlemi

Öğretmen adaylarından 0,6 ÷ 0,2 işlemini onluk kartları kullanarak çözmeleri istenir. Bu işlemini yaparken bölmenin ölçme anlamını kullanmaları gerektiği yani ilk ondalık kesrin içinde ikinci ondalık kesir ne kadar var sorusuna cevap arandığı vurgulanır.

Etkinlik 7: Yüzdeler

Öğretmen adaylarının 1,25 ondalık kesrini yüzde sembolüyle yazmaları istenir. Bunun için öncelikle yüzlük kartları kullanmaları istenir. Yüzlük kartlarla 1,25 modellenir, bu modelde 1,25'in içinde 125 tane 1/100 olduğu fark ettirilir ve aşağıdaki işlemler yapılarak ondalık kesir yüzde sembolüyle yazılır.

$$1,25 = 125x\frac{1}{100} = \frac{125}{100} = \%125$$

1,25'i bir de onluk taban bloklarıyla modellemeleri istenir. Yüzde sembolü ile göstermemiz istendiğinden payda da 100 olması gerektiği hatırlatılır yani; 1/100'e denk gelen onluk bloklardan elimizde kaç tane var ona bakmamız gerektiği vurgulanır. Binlik bloğun içinde 100 tane, yüzlük bloğun içinde ise 2 x 10=20 tane onluk blok var. 5 tane de baştan onluk blok vardı, aşağıdaki gibi toplam 125 tane onluk blok olduğunu bulmaları istenir.

$$100\times\frac{1}{100} + 20\times\frac{1}{100} + 5\times\frac{1}{100} = 125\times\frac{1}{100} = \frac{125}{100}$$

Bu şekilde, ondalık kesir paydasında yüz olan bir kesir cinsinden yazılır ve buradan da yüzde sembolüyle yazılır.

Ders III

Konu: Cebir Öğretiminde Kullanılabilecek Somut Modeller

Kullanılan Somut Modeller: Cebir karoları, kâğıt, şeffaf sayma pulları, bardak.

Etkinlik 1: Cebirsel İfadeleri Modelleme

Öğretmen adaylarından aşağıdaki cebirsel ifadeleri cebir karolarını kullanarak modellemeleri istenir. Üçüncü cebirsel ifadede değişkenin x'ten farklı olduğu vurgulanarak karoların x'ten başka bir harfte alabildiği hatırlatılır.

a) $2x-1$ **b)** $2x^2 – x + 4$ **c)** $-b^2 + 3b – 1$

Etkinlik 2: Cebirsel İfadelerle Toplama İşlemi

Öğretmen adaylarının $(2x^2– 2x + 4) + (x–5)$ işlemini cebir karolarıyla yapmaları istenir. Cebirsel ifadelerle toplama işlemini modellemek için her bir ifadeyi karolarla modelleyip oluşan karoların alanlarını toplamamız gerektiği hatırlatılır ve sıfır çifti oluşturan karelerin değerinin sıfır olduğuna dikkat etmeleri gerektiği vurgulanır.

Etkinlik 3: Cebirsel İfadelerle Çıkarma İşlemi

Öncelikle, cebirsel ifadelerle çıkarma işlemini modellemek için atma metodunun kullanılabileceği söylenir. Atma metodunun; çıkan ifadeyi temsil eden karoların, eksilen ifadeyi temsil eden karolardan atılması olduğu hatırlatılır ve öğretmen adaylarının $(x^2 – 3x + 5) – (x^2 – 2x)$ çıkarma işlemi atma metoduyla çözmeleri istenir. Daha sonra, öğretmen adaylarına "Atma metodu atılacak karo olduğunda çalışıyor; ama ya eksilen ifadede atılacak karo olmasaydı?" sorusu yöneltilir ve $(x^2 - 2x + 3) – (x^2 + 3x - 1)$ işlemini sıfır çiftlerini kullanarak çözmeleri istenir. Bu işlemde, öğretmen adaylarının eksilen ifadenin modelinde atacak +3x ve -1 karolarının olmadığını fark etmeleri sağlanır ve sıfır çiftlerini kullanarak istediğimiz kadar karo ekleyebileceğimiz, daha sonra da istediğimiz karoları atabileceğimiz söylenir.

Etkinlik 4: Cebirsel İfadelerle Çarpma İşlemi

Öğretmen adaylarına, cebirsel ifadelerle çarpma işleminin modellenmesinin alan kavramı üzerine kurulduğu ve istenilen çarpımın sonucunun kenarları çarpılan ifadelerin modellenmesiyle oluşan dikdörtgensel bölgenin alanı olduğu söylenir. Daha sonra, aşağıdaki işlemleri cebir karolarıyla yapmaları istenir.

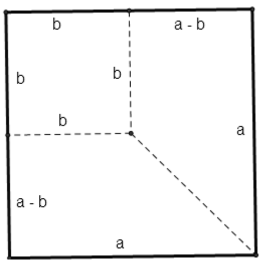
a) x.(x+2) = ? **b)** (x + 1) (2x + 1) = ? **c)** (x + 2) (x + 3) = ?

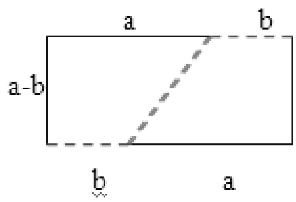
Etkinlik 5: Cebirsel İfadeleri Çarpanlarına Ayırma

Cebir karoları kullanılarak cebirsel ifadeleri çarpanlarına ayırmak için, önce ifadeye karşılık gelen parçaların seçildiği, daha sonra bu parçaları kullanarak bir dikdörtgensel bölgenin oluşturulduğu ve bu dikdörtgensel bölgenin kenarlarının çarpım biçiminde yazılışının ifadenin çarpanlara ayrılmış şekli olduğu vurgulanır. Sonrasında, öğretmen adaylarından $2x^2 + 5x + 2$ ifadesini cebir karolarını kullanarak çarpanlarına ayırmaları istenir.

Etkinlik 6: $a^2 – b^2$ = (a-b). (a+b) Özdeşliğini Modelle Açıklama

Öğretmen adaylarının bir kenar uzunluğu a olan bir karenin bir köşesinden kenar uzunluğu b olan bir başka kare çizerek kesmeleri istenir. Kalan parçaları aşağıdaki gibi birleştirilip bir dikdörtgen oluşturmaları söylenir.



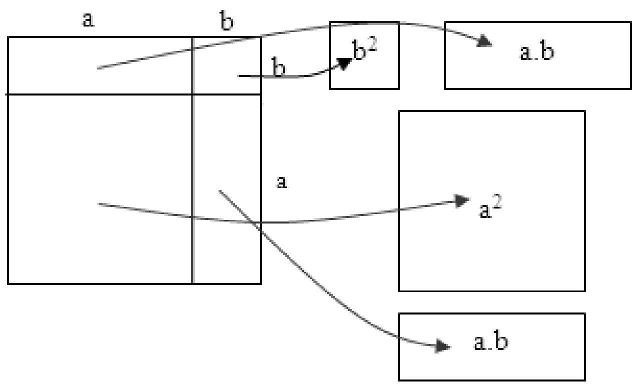


Bu dikdörtgenin alanının, (a-b). (a+b) olduğuna ve alanı a^2 olan büyük kareden, alanı b^2 olan küçük karenin çıkarılmasından sonra elde edildiğine dikkat çekilerek aşağıdaki özdeşlik buldurulur. Ayrıca a>b olarak seçildiği vurgulanır.

$a^2 – b^2$ = (a-b). (a+b)

Etkinlik 7: $(a+b)^2 = a^2 +2ab+ b^2$ Özdeşliğini Modelle Açıklama

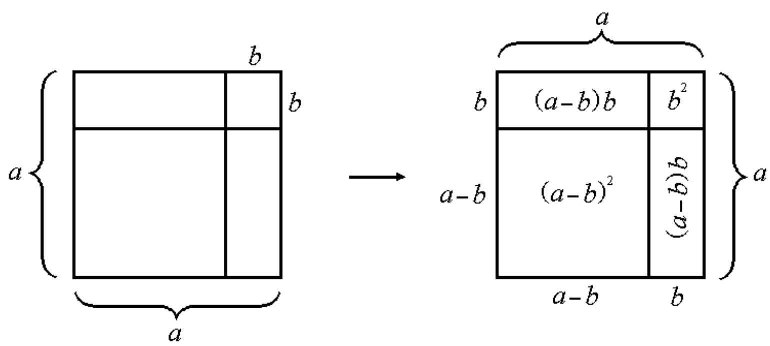
Öğretmen adaylarından kare biçimindeki bir kâğıdı aşağıdaki gibi parçalara ayırarak baştaki karenin alanını, bu parçalarının alanları cinsinden ifade etmeleri istenir. Daha sonra, parçaların alanlarının toplamı baştaki karenin alanına eşitlenerek aşağıdaki özdeşlik buldurulur.



Karenin alanı: $(a+b)^2 = a^2 + 2ab + b^2$

Etkinlik 8: $(a-b)^2 = a^2 - 2ab + b^2$ Özdeşliğini Modelle Açıklama

Öğretmen adaylarından bir kenar uzunluğu a olan bir kareyi aşağıdaki gibi parçalara ayırmaları istenir.



Daha sonra aşağıdaki gibi parçaların alanlarının toplamı baştaki karenin alanına eşitlenerek özdeşlik buldurulur.

$$(a-b)^2 + b(a-b) + b(a-b) + b^2 = a^2$$
$$(a-b)^2 + ab - b^2 + ba - b^2 + b^2 = a^2$$
$$(a-b)^2 = a^2 - 2ab + b^2$$

Etkinlik 9: Birinci Dereceden Bir Bilinmeyenli Denklem Çözümü

Öğretmen adaylarından aşağıdaki birinci dereceden bir bilinmeyenli denklemeleri sayma pulları ve bardakları kullanarak çözmeleri istenir. Burada bilinmeyen ifadeler yerine bardakların bilinen ifadeler yerine şeffaf sayma pullarının kullanılacağı vurgulanılır. Ayrıca, amacın bardağı yani bilinmeyeni eşitliğin dengesini bozmadan yalnız bırakıp kaç sayma puluna denk geldiğini bulmak olduğu hatırlatılır.

a) $x+4 = 5$ **b)** $2x+1 = 7$

Ders IV

Konu: Doğal Sayılar, Tam Sayılar ve Kareköklü Sayıların Öğretiminde Kullanılabilecek Somut Modeller

Kullanılan Somut Modeller: Yüzlük tablo, şeffaf sayma pulları, noktalı kâğıt, onluk taban blokları.

Etkinlik 1: Bölünebilme

Öğretmen adaylarından yüzlük tabloda 2 ve 2'nin katlarını daire içine almaları ve bu sayıları listelemeleri istenir. Listedeki sayıların birler basamağındaki rakamlara dikkat çekilerek buradaki örüntüyü ifade etmeleri ve bu örüntüden yararlanarak 2'ye bölünebilme kuralını yazmaları istenir. Aynı şekilde, diğer sayılar içinde yüzlük tablo kullanılarak örüntülerin fark ettirilebileceği ve bölünebilme kurallarının öğrencilerin kendilerine buldurulabileceği vurgulanır.

Etkinlik 2: Asal Sayılar

Öğretmen adaylarından yüzlük tabloda 2'yi yuvarlak içine almaları ve 2'nin bütün katlarını boyamaları istenir. Daha sonra, 3'ü yuvarlak içine alıp onun da bütün katlarını boyamaları istenir. 4, 2'nin katı olduğu için aynı işleme 5 ve 7 ile devam etmeleri söylenir. İşlem, benzer şekilde tamamlatılır. Öğretmen adaylarına "Bu sayıların ortak özelliği nedir?" sorusu yöneltilir ve 100'den küçük bütün asal sayıların 1 hariç boyanmayan ve yuvarlak içinde olan sayılar olduğu vurgulanır. Buna aynı zamanda Eratosten kalburu da dendiği hatırlatılır.

Etkinlik 3: Doğal Sayıların Ortak Katları ve EKOK

Öğretmen adaylarından yüzlük tabloda 4'ün katlarını sarıya 5'in katlarını maviye boyamaları istenir. Hem sarı hem maviye boyamak zorunda kaldığımız sayıların 4 ve 5'in ortak katları olduğu fark ettirilir. Bu katların en küçüğüne de bu sayıların EKOK'u dendiği vurgulanır.

Etkinlik 4: Tam Sayılarla Toplama İşlemi

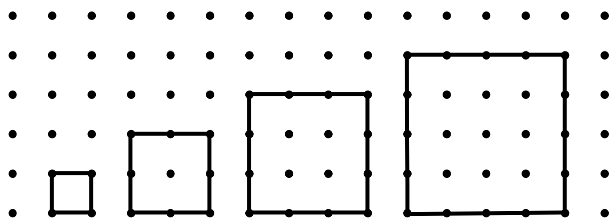
Öğretmen adaylarından (-5) + (+3) işlemini sayma pullarıyla modelleyerek çözmeleri istenir. Farklı renklerde olan pozitif ve negatif sayma pullarının sıfır çifti oluşturduğu vurgulanır.

Etkinlik 5: Tam Sayılarla Çıkarma İşlemi

Öğretmen adaylarından (-5) – (+2) işlemini şeffaf sayma pullarını kullanarak yapmaları istenir. Bunun için, 5 tane negatif sayma pulundan 2 tane pozitif sayma pulunu çıkarmaları gerekir ama 2 tane pozitif pul olmadığı için (-5) sayısının değerini bozmayacak şekilde 2 pozitif ve 2 negatif pul eklendiği hatırlatılır. Oluşan modelden (+2)'yi temsil eden 2 tane pozitif pulu çıkarınca kalan pulların sonucu verdiği vurgulanır.

Etkinlik 6: Tam Kare Sayılar

Öğretmen adaylarından noktalı kâğıt üzerinde aşağıdaki gibi kare modelleri oluşturmaları istenir. Bu karelerin alanlarını veren 1, 4, 9, 16… gibi sayılar tam kare doğal sayılar olduğu vurgulanır. Ayrıca bu etkinlikte, karelerin alan ve kenar uzunluklarından yararlanarak sayıların karesi ve karekökleri arasındaki ilişkiyi gösterebilecekleri vurgulanır.



Daha sonra, 121 ve 132 sayılarını onluk taban bloklarını kullanarak modellemeleri istenir. Öğretmen adaylarına "Hangi sayı modeli karesel bölge oluşturur ve oluşan karesel bölgenin bir kenar uzunluğu nedir?" sorusu yöneltilir. Bu şekilde, onluk taban bloklarını kullanarak tam kare sayılar keşfettirilebileceği vurgulanır.

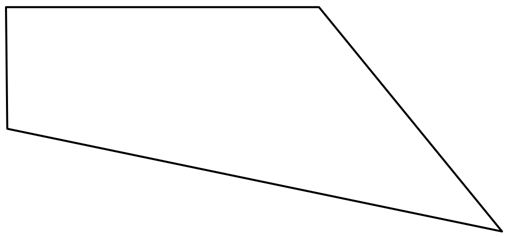
Ders V

Konu: İki Boyutlu ve Üç Boyutlu Cisimlerin Öğretiminde Kullanılabilecek Somut Modeller

Kullanılan Somut Modeller: Simetri aynası, geometri şeritleri, birim küpler, kareli kâğıt, izometrik kâğıt.

Etkinlik 1: Çokgenlerin Simetri Eksenleri

Öğretmen adaylarının, simetri aynasını kullanarak aşağıda verilen şekilden kare, kare olmayan bir dikdörtgen, dik üçgen, ikizkenar üçgen ve paralelkenar oluşturmaları istenir.



Öğretmen adayları kare, paralelkenar, ikizkenar üçgen ve dik üçgen oluşturulabilirken kare olmayan bir dikdörtgen oluşturamadıklarını fark ederler. Daha sonra, öğretmen adaylarının bunun nedenleri üstünde tartışmaları istenir. Ayrıca, bu etkinliğin, çokgenlerin simetri eksenleri ve özelliklerinin pekiştirilmesi için kullanılabileceği vurgulanır.

Etkinlik 2: Üçgen Eşitsizliği

Öğretmen adaylarından geometri şeritlerini kullanarak aşağıdaki sorulara cevap aramaları istenir.

a) 1 uzun, 1 orta ve 1 kısa şeridi kullanarak üçgen oluşturabilir miyiz?

b) 2 orta, 1 kısa şeridi kullanarak üçgen oluşturabilir miyiz?

c) 2 kısa, 1 orta boy şeridi kullanarak üçgen oluşturabilir miyiz?

d) 2 uzun, 1 orta boy şeridi kullanarak üçgen oluşturabilir miyiz?

e) 2 orta, 1 uzun şeridi kullanarak üçgen oluşturabilir miyiz?

f) 2 kısa, 1 uzun şeridi kullanarak üçgen oluşturabilir miyiz?

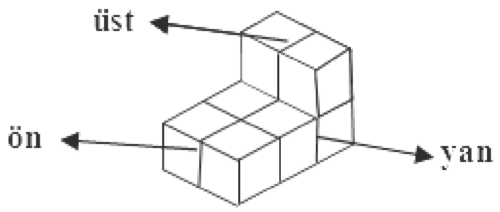
Daha sonra, üçgen oluşturan ve oluşturmayan şeritlerin uzunluğuna bakarak bir üçgenin iki kenar uzunluğunun toplamı üçüncü kenardan küçük ve farkı üçüncü kenardan büyük olamaz kuralının bu şekilde öğretilebileceği vurgulanır.

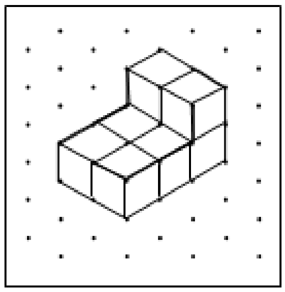
Etkinlik 3: Paralelkenar ve Dörtgenin İlişkisi

Öğretmen adaylarından geometri şeritlerini kullanarak bir dikdörtgen ve bir kare modeli oluşturmaları istenir. Daha sonra aynı modelleri kullanarak paralelkenar oluşturmaları istenir ve "İlk modellerle ikinci modeller arasındaki fark nedir?" sorusu yöneltilir. Bu sayede, öğretmen adaylarının sadece açıların değiştiğini karşılıklı kenarların hala paralel olduğunu fark etmeleri sağlanır. Buradan da paralelkenarın kenarları paralel olan dörtgen olduğundan, kare ve dikdörtgenin de birer paralelkenar olduğu hatırlatılır. Ayrıca, üçgen, yamuk, beşgen, altıgen gibi farklı çokgenlerin özelliklerinin hareket edebilen bu şeritler sayesinde daha iyi anlatılabileceği vurgulanır.

Etkinlik 4: Üç Boyutlu Cisimlerin İki Boyutlu Görünümleri

Öğretmen adaylarından aşağıdaki yapıyı birim küplerle oluşturup; öncelikle önden, yandan ve üstten görünümlerini kareli kâğıda çizmeleri istenir.





Daha sonra, oluşturdukları bu modeli izometrik kâğıda yukarıdaki gibi çizmeleri istenir. Buna benzer birkaç etkinlik daha yaptırılarak üç boyutlu cisimleri birim küplerle oluşturmakta ve izometrik kâğıda çizmekte deneyim kazanmaları sağlanır.

Ders VI

Konu: Geometrik Cisimlerin Çevre, Alan ve Hacimlerinin Öğretiminde Kullanılabilecek Somut Modeller

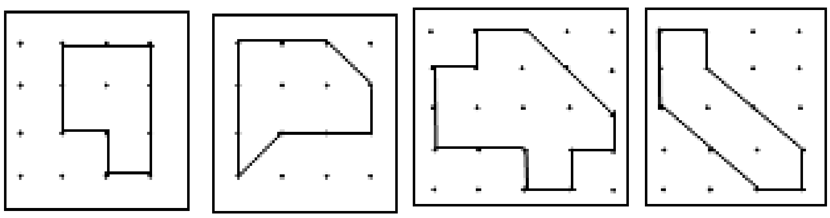
Kullanılan Somut Modeller: Çok kareliler takımı, çok küplüler takımı, tangram, noktalı kâğıt, karesel geometri tahtası, çembersel geometri tahtası, lastik, hacimler takımı, kâğıt.

Etkinlik 1: Geometrik Cisimlerin Alan ve Çevrelerini Bulma

Öğretmen adaylarından beş kareliler takımının uygun olan parçalarını kullanarak kare ve dikdörtgenler oluşturmaları ve oluşturdukları şekillerin alanlarını ve çevrelerini bulmaları istenir. Daha sonra, tangram parçalarını kullanarak kedi, ördek gibi figürler oluşturmaları ve oluşturdukları figürlerin alanlarını ve çevrelerini bulmaları istenir. Oluşturdukları figürlerin alanlarının, her figür için aynı parçalar kullanıldığı için, eşit olduğuna dikkat çekilir.

Etkinlik 2: Alanı Strateji Kullanarak Tahmin Etme

Öğretmen adaylarından aşağıdaki çokgenleri geometri tahtasında göstermeleri istenir.



Daha sonra, bu çokgenlerin alanlarının kaç birim olduğunu strateji kullanarak tahmin etmeleri beklenir. Tahminlerinin doğruluğunu aşağıda verilen Pick Teoremiyle kontrol etmeleri istenir.

T= sınırdaki çivi sayısı,

i= içerde kalan çivi sayısı olmak üzere Alan=(T/2+i)-1.

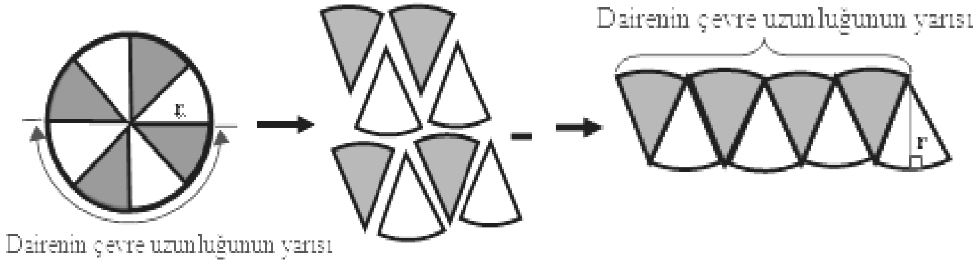
Ayrıca, öğretmen adaylarına çembersel geometri tahtası tanıtılıp bu somut modelin çemberde çap, yarıçap, çevre açı, merkez açı gibi birçok özelliğin anlatılmasında kullanılabileceği vurgulanır.

Etkinlik 3: Dikdörtgenler Prizması, Kare Prizma ve Küpün Hacim Bağıntısı
Öğretmen adaylarından birim küpleri kullanarak dikdörtgenler prizmasını, kare prizmayı ve küpü oluşturmaları istenir. Daha sonra, oluşturulan cisimlerin boyutları ile birim küp sayısı ilişkilendirilerek hacim bağıntılarını bulmaları istenir.

Etkinlik 4: Dik Piramidin Hacim Bağıntısı
Öğretmen adaylarının, hacimler takımından eş tabana ve eş yüksekliğe sahip dikdörtgenler prizması ve dikdörtgen piramit modellerini seçmeleri istenir. Dikdörtgen piramit modelini su ile tamamen doldurduktan sonra, dikdörtgenler prizması modelinin içine boşaltarak bu işleme dikdörtgenler prizması modeli tamamen dolana kadar devam etmeleri söylenir. Daha sonra, "Dikdörtgenler prizmasının hacmi, dikdörtgen piramidin hacminin kaç katıdır?" sorusu yöneltilir ve cevap üç olduğu için dik piramidin hacim bağıntısı dikdörtgenler prizmasının hacim bağıntısının üçe bölümünden bulunur.

Etkinlik 5: Dik Dairesel Koninin Hacim Bağıntısı
Öğretmen adaylarının, hacimler takımından eş tabana ve eş yüksekliğe sahip dik silindir ve dik dairesel koni modellerini seçmeleri istenir. Dik dairesel koni modelini su ile tamamen doldurduktan sonra, dik silindir modelinin içine boşaltarak bu işleme dik silindir modeli tamamen dolana kadar devam etmeleri söylenir. Daha sonra, "Dik silindir hacmi, dik dairesel koninin hacminin kaç katıdır?" sorusu yöneltilir ve cevap üç olduğu için dik dairesel koninin hacim bağıntısı dik silindirin hacim bağıntısının üçe bölümünden bulunur.

Etkinlik 6: Dairenin Alan Bağıntısı
Öğretmen adaylarından aşağıda verilen daireyi işaretli yerlerinden keserek elde ettikleri daire dilimleriyle paralelkenarsal bölgeye benzer bir şekil oluşturmaları istenir. Bu şeklin yüksekliği ve uzunluğuyla çemberin uzunluğu ve yarıçapını ilişkilendirerek dairenin alanını aşağıdaki gibi bulmaları istenir. Ayrıca, daire dilimleri küçüldükçe şeklin dikdörtgensel bölgeye benzediği vurgulanır.

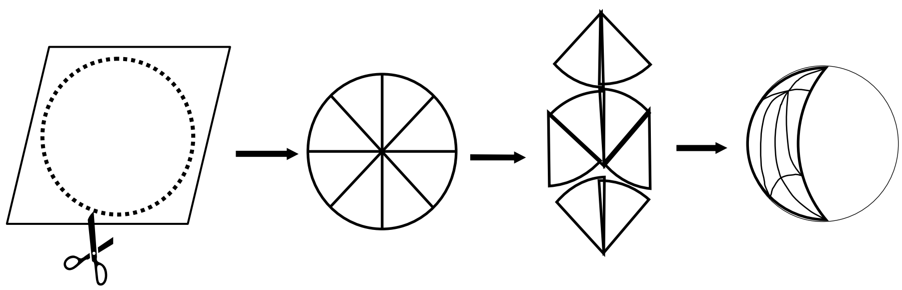


Dairenin alanı = dairenin çevre uzunluğunun yarısı x yarıçap uzunluğu

Dairenin alanı = $\pi r \times r = \pi r^2$

Etkinlik 7: Kürenin Yüzey Alanı Bağıntısı

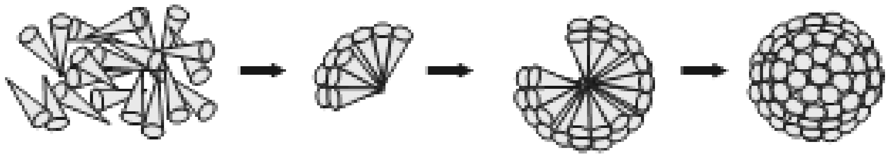
Öğretmen adaylarından aşağıdaki şekildeki gibi bir kâğıttan daire şeklinde bir parça kesmeleri, bu parçayı daire dilimlerine ayırmaları ve aynı yarıçapa sahip bir kürenin çevresini bu parçalarla kaplamaları istenir. Öğretmen adaylarına, “Küreyi kaplamak için kaç tane aynı yarıçaplı daireye ihtiyaç vardır?” sorusu sorulur.



Cevap dört olduğu için kürenin yüzey alanı = $(\pi.r^2) \times 4 = 4\,\pi.\,r^2$ olarak bulunur.

Etkinlik 8: Kürenin Hacim Bağıntısı

Öğretmen adayları, kâğıttan aynı büyüklükte külâhlar yaparlar. Bu külâhları sivri uçlarından birleştirerek bir küre oluştururlar. Böylece aşağıdaki gibi “n” tane koninin tabanı ile bir küre oluşturmuş olurlar.



Öğretmen adaylarına şu soru yöneltilir; "Eş konilerin taban alanına T denirse n tane koninin taban alanı kürenin yüzey alanına eşit olur, koninin yüksekliği de kürenin yarıçapına eşittir, buna göre kürenin hacmini bulunuz?" Öğretmen adaylarının kürenin hacmini aşağıdaki gibi bulmaları beklenir.

$$\text{Kürenin hacmi} = \underbrace{\frac{Tr}{3} + \frac{Tr}{3} + \frac{Tr}{3} \ldots\ldots + \frac{Tr}{3}}_{\text{n tane}} = n.(T.\frac{r}{3}) = (n.T)\frac{r}{3} = 4\pi r^2.\frac{r}{3} = \frac{4}{3}\pi r^3$$

APPENDIX C

Turkish Version of the Survey

Adınız Soyadınız:………………… Yaşınız:.......... Cinsiyetiniz:………..

Genel Açıklama: Aşağıdaki iki soruyu her bir somut model için yanıtlayınız.

Somut Modeller	Somut model hakkında bilginiz var mı?		Somut modeli matematik öğretiminde/öğrenimin -de kullandınız mı?	
	Evet	Hayır	Evet	Hayır
Onluk Taban Blokları	( )	( )	( )	( )
Birim Küpler	( )	( )	( )	( )
Örüntü Blokları	( )	( )	( )	( )
Onluk Kart	( )	( )	( )	( )
Simetri Aynası	( )	( )	( )	( )
Tangram	( )	( )	( )	( )
Karesel Geometri Tahtası	( )	( )	( )	( )
Çembersel Geometri Tahtası	( )	( )	( )	( )
Kesir Çubukları	( )	( )	( )	( )
Şeffaf Kesir Kartları	( )	( )	( )	( )
Geometri Şeritleri	( )	( )	( )	( )
Çok Kareliler Takımı	( )	( )	( )	( )
Çok Küplüler Takımı	( )	( )	( )	( )
Cebir Karoları	( )	( )	( )	( )
Hacimler Takımı	( )	( )	( )	( )
Şeffaf Sayma Pulları	( )	( )	( )	( )
Yüzlük Tablo	( )	( )	( )	( )
Yüzlük Kart	( )	( )	( )	( )
Noktalı Kâğıt	( )	( )	( )	( )
İzometrik Kâğıt	( )	( )	( )	( )
Üçgensel Kâğıt	( )	( )	( )	( )
Çizgisiz kâğıt/karton /elişi kâğıdı	( )	( )	( )	( )
Günlük hayattan nesneler/araç gereçler	( )	( )	( )	( )

Genel Açıklama: Aşağıda somut modellerin kullanımına yönelik farklı fikirleri belirten cümleler ile her cümlenin karşısında "Tamamen Katılıyorum", "Katılıyorum", "Kararsızım", "Katılmıyorum" ve "Hiç Katılmıyorum" olmak üzere beş seçenek verilmiştir. Her bir cümleyi dikkatli okuyarak boş bırakmadan bu cümlelere ne ölçüde katılıp katılmadığınızı seçeneklerden birini işaretleyerek belirtiniz.

		Tamamen Katılıyorum	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç Katılmıyorum**
1.	Somut modellerle ders işlerken sınıfı kontrol edemeyeceğimi düşünüyorum.					
2.	Somut model kullanarak işlediğim dersler amacına ulaşmazsa nedenini kendimde ararım.					
3.	Matematik öğretiminde somut model kullanımı ile ilgili bilgiye yeterince sahip değilim.					
4.	Dersi somut modellerle işlemek için gerekli becerilere sahip olacağımı düşünüyorum.					
5.	Somut modeller hakkında öğrencilerin sorularını cevaplayabileceğimi düşünüyorum.					
6.	Somut modelleri ders içinde etkili biçimde kullanabileceğimi düşünüyorum.					
7.	Somut model kullanımı öğrencilerin kafasını karıştıracaktır.					
8.	Matematik öğretiminde model kullanımı öğrencilerin başarısına büyük ölçüde yardımcı olur.					
9.	Bir öğrenci matematik dersinde daha başarılı ise bunun nedeni büyük olasılıkla o dersin somut modellerle işlenmesidir.					
10.	Öğrencilerin matematik bilgilerindeki yetersizliklerinin üstesinden somut model kullanımı ile gelinebilir.					

11.	Derste somut modellerin nasıl kullanılacağını öğrencilere anlatmakta zorluk çekeceğim.					
12.	Derslerin zengin somut model ile desteklenmesi öğrencinin başarısını doğrudan etkiler.					
13.	Matematikte somut model kullanmak zaman kaybıdır.					
14.	Dersi somut model kullanarak işlemede yeterli olacağımı düşünüyorum.					
15.	Kendimin de model geliştirebileceğimi düşünüyorum.					
16.	Somut modellerle dersimi işlerken tedirgin olacağımı düşünüyorum.					

APPENDIX D

Descriptive Statistics of Pretest Questions

Pretest Questions	N	Minimum	Maximum	Mean	Std. Deviation
1	31	1	5	3.29	1.006
2	31	1	4	2.55	.675
3	31	1	4	2.06	.929
4	31	2	5	3.74	.815
5	31	2	4	3.06	.727
6	31	2	4	3.13	.763
7	31	2	5	3.65	.798
8	31	2	5	4.10	.651
9	31	1	4	3.16	.735
10	31	3	4	3.81	.402
11	31	1	4	3.10	.831
12	31	2	5	3.94	.512
13	31	2	5	4.00	.632
14	31	1	4	2.97	.948
15	31	1	4	3.03	.757
16	31	2	5	3.23	.920

Descriptive Statistics of Posttest Questions

Posttest Questions	N	Minimum	Maximum	Mean	Std. Deviation
1	31	2	5	3.65	1.006
2	31	2	4	2.48	.675
3	31	3	5	4.26	.929
4	31	1	5	4.13	.815
5	31	4	5	4.16	.727
6	31	3	5	4.06	.763
7	31	2	5	4.10	.798
8	31	3	5	4.42	.651
9	31	2	5	3.65	.735
10	31	3	5	4.13	.402
11	31	2	5	3.97	.831
12	31	3	5	4.13	.512
13	31	3	5	4.23	.632
14	31	2	5	3.90	.948
15	31	1	5	3.55	.757
16	31	2	5	4.00	.920