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HOW DO PRESERVICE MATHEMATICS TEACHERS USE MANIPULATIVES TO TEACH MATHEMATICS?

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Abstract: The aim of the research was to examine and evaluate how preservice mathematics teachers' use of manipulatives to teach mathematics. In the current research, one of the qualitative research methods, case study was used. The research was conducted with 21 preservice mathematics teachers. Ten instructional sessions with manipulatives were carried out during a five-week period by researcher. After the instructional sessions preservice teachers made lesson plans and they designed a learning environment that teaches mathematics with manipulatives. The findings of the research indicated that most of the preservice teachers could not use manipulatives effectively and appropriately for the purposes. In addition, some preservice teachers had difficulty in making connections between mathematical concepts, daily life and manipulatives.

Key words: Manipulatives, preservice mathematics teachers, mathematics education

1. Introduction

Teachers are one of the main factors of the learning and teaching process as they have a crucial function and a determining and guiding role for gaining the behaviors predicted by the educational process (Atav, Kunduz, & Seçken, 2014). Therefore, the teacher training program constitutes a large part of the efforts to increase the quality of education. The importance of teacher training programs is also stressed for their important role in terms of preparing preservice teachers for their future classroom (Simon, 2013) so teacher competencies and teacher training is one of the issues that teacher educators frequently research on. General Competencies of the teacher profession refer to the knowledge, skills, attitudes and values that a teacher should have. Teacher competencies include competencies in the field, professional knowledge and general culture (Çelik, Yorulmaz & Çokçalışkan, 2019). It can be thought that teachers with these competencies will provide a qualified education. In this context, teachers and preservice teachers should be equipped and developed with the general and special field competencies that teachers should have in preservice and inservice training programs (Sarpkaya- Aktaş, 2017). In this framework, preservice teachers are provided with sufficient proficiency in subjects such as classroom management, measurement and evaluation, using strategy, method, technology and instructional materials (Shulman, 1986).

The competencies that teachers should have are considered as pedagogical content knowledge, mathematical content knowledge and curriculum knowledge (Ministry of National Education [MoNE], 2006; Shulman, 1986). In order to help to students learn, teachers must have sufficient knowledge of the subjects they will teach. This knowledge forms the content knowledge. Content knowledge is not sufficient for effective teaching (Ball & McDiarmid, 1990). Therefore, another competency, pedagogical content knowledge is essential. Pedagogical content knowledge as one of the components of teachers' knowledge is the type of knowledge that includes the most useful representations, simulations, examples and explanations that enable the understanding of frequently taught concepts specific to the field (Shulman, 1986). According to Shulman's (1995, s.130) model, teachers who have strong pedagogical content knowledge are more successful in designing effective teaching and learning environments, in understanding of what makes the learning of mathematics topics easy or difficult and in representing and formulating the subject that make it comprehensible to others.

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One of the skills that should be acquired by preservice mathematics teachers is using manipulatives since the effective use of manipulatives in mathematics lessons depends on teachers (Sowell, 1989; Kelly, 2006). In order to facilitate learning by using manipulatives, teachers need to create effective learning environments and know when and how to use manipulatives on teaching mathematical concepts (Marshall & Swan, 2008; Moore, 2012). Manipulatives can only help the children's learning when they are used correctly in class (Boggan, Harper & Whitmire, 2010). Teachers should allow their students to have free time to play with the manipulatives (Boggan, Harper & Whitmire, 2010) and to explore them. On the other hand, teachers also need to know how to manage the learning environment when they use manipulatives (Marshall & Swan, 2008).

Despite the importance of using manipulatives in mathematics lessons, teachers had difficulties in using manipulatives, establishing connections between manipulatives and mathematics symbols (Kamina-Iyer, 2009). Moyer (2001, p.194) stated that, "it is difficult for teachers to transfer students' representations of their mathematical thinking and represent connections among mathematical ideas". In order to teach mathematics effectively, teachers should have a deep understanding about mathematics, they should know how to use manipulatives to support the development of a specific mathematical concept (Marshall & Swan, 2008).

Teacher educators should guide preservice teachers in the proper use of manipulatives in their teaching practices (Willis & Browning, 2013). Yetkin-Özdemir (2008) revealed that although preservice elementary teachers had knowledge and skills about manipulatives, they had difficulties to guide students to make connections between mathematical concepts and manipulatives. One of the reasons of difficulties is that even though the preservice teachers learned how to use manipulatives in teaching, there was not enough time to become a competent user of the manipulatives (Pişkin-Tunç, Çakıroğlu, & Bulut, 2020).

Preservice teachers should develop knowledge and skills to use manipulatives for mathematical subjects appropriately (Yetkin-Özdemir, 2008). For that reason, it is important for preservice teachers to gain skills of using manipulatives. In this context, the aim of the research is to examine and evaluate the skills of preservice mathematics teachers about using manipulatives to teach mathematics. Findings of this research can give clues about how preservice teachers will teach mathematics with manipulatives in their future classroom. Exploring preservice mathematics teachers' use of manipulatives in mathematics teaching will also give some important ideas to teacher educators about how to design learning environments to improve preservice teachers' knowledge of using manipulatives.

1.1. Conceptual Framework

Bruner's theory promoted the use of manipulatives in education. Besides Bruner's theory Piaget's theory also pointed the use of manipulatives (O'Meara, Johnson, & Leavy, 2020). In literature concrete mathematical tools are named as manipulative (Kamina-Iyer, 2009; Moyer, 2001), material (Furner & Worrell, 2017), concrete models (Sowell, 1989) and manipulative materials (Swan & Marshall, 2010). In this research "manipulatives" are used to define concrete mathematical tools. Moyer (2001) defined manipulatives as objects that are designed to represent abstract mathematical context concretely. Bellonio (2012) defined manipulatives as "objects that can be touched and moved by students to introduce or reinforce a mathematical concept". Manipulatives consist of objects used in daily life such as money, matches or measuring tools, or objects such as base ten blocks, algebra tiles (Yetkin-Özdemir, 2008) and can be in many forms, like fraction set, geometry strip, graph paper, empty cartons, etc. On the other hand, manipulatives can be in concrete, pictorial, and abstract or symbolic form (Sowell, 1989). Concrete manipulatives are objects that students can use and carry such as geo-boards, bean sticks; visual manipulatives are tools such as pictures, diagrams and graphics or videos, and abstract (symbolic) manipulatives are materials such as books, worksheets and pens that students use while working.

Base ten blocks, geo-board, geometry strip, tangrams, fraction sets, fraction cards, counters, pattern blocks, algebra tiles, unit cubes, geometric objects, symmetry mirror, volumes set, multi-squares set, multi-cubes set are used as manipulatives in mathematics lessons (Ministry of National Education, [MoNE], 2017). By using the geo-board, polygonal models, congruent and similar shapes can be constructed by students. It is also possible to construct polygon models with geometry stripes. Base ten blocks can be used to teach operations with natural numbers and decimals. The symmetry mirror allows

students to take the reflection symmetry of geometric shapes. The volume set can be used to teach the volumes of geometric objects. One of the mathematics manipulatives, counters are tools that can be used to model integers and operations with integers. Many new shapes can be created using tangrams which develop students' spatial skills. Another manipulative pattern blocks are tools to make patterns and tessellations. Fraction cards and fraction sets are manipulatives that can be used teaching fractions and operations with fractions. Algebra tiles are tools that can be used to express algebraic expressions. A set of multi-squares are useful materials to teach area and perimeter. On the other hand, unit cubes and multi-cubes can be used to teach geometric objects and develop spatial visualization skills.

These manipulatives especially concretize abstract mathematical concepts (Moyer, 2001) and establish connections between daily life experiences, mathematical concepts and symbols (Swan & Marshall, 2010; Uttal, Scudder & DeLoache, 1997). Szendrei (1996) stated that manipulatives help students develop a deep understanding of mathematical concepts and critical aspects of mathematics. As a matter of fact, some researches indicated that manipulatives make mathematical concepts easier to understand (Allen, 2007; Izsak, 2004; Kennedy & Tipps, 1994; Moyer, 2001; Suh & Moyer- Packenham, 2007) and increase achievement (Aburime, 2007; Boggan, Harper & Whitmire, 2010; Manches, O'Malley & Benford, 2010; Martelly, 1998; Martin & Shwartz 2005; Sowell, 1989; Swan & Marshall, 2010). Ünlü (2018) revealed that preservice teachers stressed the contributions of manipulatives such as increasing permanent learning, reification of abstract concepts, facilitation of learning and understanding, provision of visualization, conceptual learning, visualization in the mind/spatial thinking, effective teaching and reinforcement of subjects. On the other hand some researches indicated that using manipulatives does not have an effect on performance (Thompson, 1994) since the effectiveness of manipulatives depends on the teacher's skills and their instruction that is implemented (Pişkin-Tunç, Çakıroğlu & Bulut, 2020).

As a result of reviewing the literature, it has been determined that some preservice teachers have difficulty in making connections between mathematical concepts and manipulatives (Kamina-Iyer, 2009; Yetkin-Özdemir, 2008). Despite this, the number of studies examining in detail what the preservice teachers experienced while using the manipulatives and what difficulties they encountered is quite limited. Gökkurt-Özdemir, Uygun, Gün ve Koçak (2020) found that, although many preservice teachers wanted to use the manipulatives for the purpose of teaching the subject, they could not go beyond using for the purpose of practicing. Yazlık (2018) emphasized that teachers should make plans for the lessons in which they will use manipulatives and carefully prepare instructions for using manipulatives. In line with these researches, considering the role of teachers in the teaching process, it is important to investigate the skills of preservice teachers about using manipulatives. Moyer (2001) stated that teachers use manipulatives to enrich activities or as a game at the end of the mathematics lessons and students only used the manipulatives by following the teachers' directives.

2. Methodology

2. 1. Research Design

This research aimed to examine and evaluate the skills of preservice mathematics teachers' about using manipulatives in mathematics lessons. For this reason, one of the qualitative research methods, case study were used. In the case study, environments, individuals or processes are evaluated as a whole in real context (Patton, 2015). It allows an in-depth investigation of a particular group (Yıldırım & Şimşek, 2008). The case study was realized on a group of preservice elementary mathematics teachers. They were selected to examine their skills about using manipulatives. In this study, this method was preferred because the skills of using manipulatives of the preservice teachers in the natural environment were examined and more than one data collection tool (documents related to the lesson plans, field notes taken by the researcher during the observation process) were used.

2.2. Participants

The current research was conducted with 21 preservice mathematics teachers who were enrolled in a mathematics teacher education program at a state university. Preservice teachers who were taken a Material Design in Mathematics Education course were purposefully chosen for this research. In this course, instructional technologies and manipulatives which were used in teaching mathematics were

taught and at the end of the course preservice mathematics teachers designed a concrete material about mathematics subjects.

2.3. Data Collection

During the implementations, theoretical information was given about designing and using manipulatives. Manipulatives that were used in mathematics teaching were introduced by the researcher. Examples were given and courses were designed to learn and discuss how to use manipulatives in mathematics classes. Detailed data collection process was presented in Table 1.

Table 1. *Data collection process and activities*

Week	Activities	Process
1	Giving general information about manipulatives	Introducing manipulatives, showing examples of manipulatives, introducing mathematics acquisitions in middle school mathematics curriculum
2-6	Conducting activities related to manipulatives	i. Introduction of manipulatives related to mathematics learning and teaching ii. Allowing preservice teachers to have free time to explore the manipulatives iii. Conducting activities related to manipulatives. As manipulatives: Geo-board, geometry strip, base ten blocks, tangrams, fraction cards, fraction bars sets, unit cubes, algebra tiles, symmetry mirror, multi-square set, multi-cubes set and volume set were used
7	Preparation of lesson plans	Providing preservice teachers mathematics acquisitions in middle school mathematics curriculum, choosing one of them and making lesson plans
8-13	Presentation of lesson plans	Designing a learning environment that teaches mathematics with manipulatives and applying the lesson plans integrated acquisitions.
14	Evaluation	

According to Table 1, in 2-6 th weeks, activities related to manipulatives were conducted. It took 10 sessions and every session was 50 minutes duration. In 7th week, preservice teachers prepared their lesson plans and in 8-13th weeks, they presented their lesson plans. After the presentations in the 14th week, preservice teachers and researcher evaluated their process. Manipulatives used in instructions and corresponding concepts were presented in Table 2.

Table 2. *Manipulatives used in instruction and corresponding concepts*

Sessions	Manipulatives	Concepts	Duration (minutes)
Session 1	Base-ten blocks	Natural numbers, Decimals	50
Session 2	Fraction cards, Fraction bars	Fractions	50
Session 3	Hundres table, Transparent counters, Square dot paper, Based-ten blocks	Natural numbers, Integers	50
Session 4	Algebra tiles, Paper	Algebraic expressions, Equations	50
Session 5	Geometry strips, Square paper, Square geoboard, Circular geoboard	Two dimensional shapes	50
Session 6	Squares set, Square dot paper, Paper	Perimeters and areas of geometric shapes	50
Session 7	Symmetry mirror	Symmetry	50
Session 8	Pattern blocks, Tangram	Patterns, fractions	50
Session 9	Unit cubes, Cubes set, Isometric dot paper	Three- dimensional shapes	50
Session 10	Solid figures, Volume set	Three- dimensional shapes, volumes of geometric shapes	50

As seen in Table 2, the first session consisted of manipulatives such as base-ten blocks that can be used for teaching natural numbers and decimals. Activities with these manipulatives were carried out for modelling natural numbers and decimals, comparing and ordering decimals, and operations with natural numbers and decimals. In the second session the activities about equivalent fractions, comparing and ordering fractions, and operations with fractions were explored by using fraction cards and fraction bars. In the third session, activities with hundred tables and counters were made. In the fourth session, algebra tiles were used to model algebraic expressions and operations with these expressions. In the fifth session, the participants were asked to construct polygons and to explore the relationships between triangle's edges by using geometry strips and geo-boards. In the sixth session, they were asked to construct different shapes by using squares sets and then estimate and calculate the areas and perimeters of these shapes. In the seventh session, activities with a symmetry mirror were carried out for the subjects of symmetry. In the eighth session pattern blocks and tangrams were used for teaching concepts of transformation geometry. In the ninth session such as unit cubes, cubes set, isometric dot paper that can be used for teaching three-dimensional shapes and spatial visualisation were introduced. Preservice teachers were expected to draw two-dimensional views (top, front, and sides) of the three-dimensional shapes. In the tenth session preservice teachers were supposed to construct a cube, a rectangular prism and a square prism with unit cubes and then to explore the volumes of these three-dimensional shapes.

After the instruction, every preservice teacher made a lesson plan and designed a learning environment that teaches mathematics with manipulatives within 20-30 minutes in class. Teaching practices were video-recorded and after the lessons, the recordings were analysed by the researcher. While collecting the data of the study, unstructured observation was also used. Case studies utilize multiple sources of evidence. One of these source types is direct observations that focus on human activities, the physical environment, and real-world events (Yıldırım & Şimşek, 2013). As a result of the observations, answers to the following questions were sought.

1. Did the preservice teacher know how to use manipulatives?
2. Did the preservice teacher introduce the manipulatives ?
3. Did the preservice teacher allow the student to use manipulatives?
4. Did the preservice teacher give correct instructions and directives while using the manipulatives?
5. Did the preservice teacher give feedback to the student about the use of manipulatives?
6. Did the preservice teacher make connections between manipulatives and the mathematical concept?
7. Did the preservice teacher concretize the mathematical concept using manipulatives?
8. Did the preservice teacher make connections between manipulatives and daily life?
9. Did the preservice teacher able transform manipulatives to mathematical symbols?
10. Did the preservice teacher manage class while using the manipulatives?

3.4. Data Analysis

The current research was carried out within a 14-week period with the participation of the preservice mathematics teachers. Manipulatives used by preservice teachers and the mathematics subjects they used in mathematics teaching are given in Table 3.

Table 3. *Manipulatives used in preservice teachers' instruction and corresponding concepts*

Preservice teacher crt. no.	Manipulatives materials	Topic
S_1	**Geo-board**	Congruency and Similarity
S_2		Area
S_3	**Geometry strip**	Angle-edge relations
S_4		Angle-edge relations
S_5	**Based ten blocks**	Operations with national numbers
S_6		Operations with decimal numbers
S_7	**Symmetry mirror**	Absolute value
S_8		Symmetry

S_9	**Volumes set**	Measuring volume
S_{10}	**Pattern blocks**	Patterns
S_{11}	**Tangrams**	Translations
S_{12}	**Counting stamps**	Addition and subtraction with integers
S_{13}	**Fraction cards**	Equivalent fractions
S_{14}		Multiplication with fractions
S_{15}	**Fraction sets**	Sorting fractions
S_{16}	**Algebra tiles**	Algebraic expressions and identity
S_{17}		Algebraic expressions
S_{18}	**Multi-squares set**	Perimeter-Area
S_{19}		Area
S_{20}	**Dotted-isometric-square paper**	Area relation of trapezoid
S_{21}		Congruency and Similarity

During the implementation, skills of preservice mathematics teachers' about using manipulatives were evaluated by the researcher. Data from preservice teachers were obtained through document analysis, observation and video records. In order to establish validity and reliability, video-records were analyzed and categorized by different mathematics education researchers independently. Then these sets of categories were compared with each other and their final form was given. The themes and sub-themes and their frequencies (f) were presented. In this study, direct quotations about the observations, and lesson plan of the preservice teachers were included for the reliability of the research. After the coding process, for making required corrections, the issues on which there were "agreements" and "disagreements" were discussed. In order to calculate the reliability of the research, the reliability formula Reliability = Agreement/ (Agreement + Disagreement) was used (Miles & Huberman, 1994). In the current research, the reliability was calculated to be 91%.

3. Findings

In this section, according to the documents, video-records and observations, the findings related to the skills of preservice mathematics teachers about using manipulatives are presented in Table 4.

Table 4. *Skills of preservice mathematics teachers' about using manipulatives*

Thema	Code	Preservice Teachers	f
Plans	Adequate knowledge of using manipulatives in lessons plans	$S_2, S_4, S_5, S_6, S_7, S_8, S_{10}, S_{12}, S_{14}, S_{15}, S_{16}, S_{18}, S_{21}$	13
	Making plans with manipulatives	$S_4, S_5, S_6, S_7, S_8, S_{12}, S_{14}, S_{15}, S_{16}, S_{18}, S_{21}$	11
Learning-Teaching Process	Introducing manipulatives to the students	$S_2, S_4, S_5, S_7, S_8, S_{12}, S_{13}, S_{14}, S_{16}, S_{17}$	10
	Allowing students to use manipulatives	$S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{20}, S_{21}$	20
	Giving correct directives, clear explanations and instructions	$S_4, S_5, S_6, S_7, S_8, S_{10}, S_{12}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}$	12
	Concretizing abstract mathematical concepts	$S_1, S_3, S_4, S_5, S_8, S_9, S_{10}, S_{12}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}$	14
	Making connections between daily life experiences and manipulatives	S_6, S_{21}	2
	Making connections between mathematical concepts and manipulatives	$S_4, S_6, S_7, S_{10}, S_{12}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}$	11
	Transforming manipulatives to mathematical symbols	$S_4, S_5, S_6, S_7, S_9, S_{10}, S_{12}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{21}$	13
	Giving feedback to the student about using of manipulatives	$S_4, S_5, S_6, S_8, S_{10}, S_{12}, S_{14}, S_{15}, S_{21}$	9
Classroom Management	Effective communication	$S_2, S_4, S_6, S_7, S_8, S_{10}, S_{12}, S_{14}, S_{15}, S_{16}, S_{18}, S_{19}, S_{21}$	13
	Time Management	$S_2, S_4, S_5, S_6, S_7, S_8, S_{10}, S_{12}, S_{13}, S_{15}, S_{16}, S_{18}, S_{19}, S_{21}$	14

	Distributing and retrieving manipulatives	S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_{10}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17}, S_{18}, S_{19}, S_{20}, S_{21}	19

Initially, lesson plans of the preservice teachers' were examined. Some of the preservice teachers had adequate knowledge of using manipulatives in lesson plans (f=13). It has been observed during their teaching process that some of the preservice teachers have knowledge about where and how the manipulatives will be used. Despite this lesson plans were generally superficial, the preparation, teaching and evaluation stages of the course were not detailed enough in their lesson plans. For example, the lesson plan of preservice teacher S_1, is not adequate to teach mathematics with manipulatives.

"Preparation: First of all, the subject and acquisition of the lesson are explained. Then the geo-boards were given to the students and the students are told to construct equal and similar polygons using the geo-board.

Process: First, they are told to construct 2 different triangles on the geo-board to see if they can be constructed or not. Secondly, they are asked to construct 2 identical triangles and to compare these triangles. It is expected to do the same steps with the rectangle and the square. After that properties of rectangles and squares are discussed. Then ask students to construct the same shape on the circular geo-board. At the end, it is concluded that it is constructed congruent geometric shapes.

Conclusion: Students understand the concept of congruence and similarity of geometric shapes."

According to the plan, preservice teacher S_1 only gave directives to the students but it is not possible to teach congruence and similarity concepts in such a way. During his implementation, he allowed students to use manipulatives but he could not give correct directives and clear explanations. As a result, preservice teacher could not use geoboard for the purpose of concept learning and go beyond using them for the purpose of practicing.

Another preservice teacher S_{14}'s plan, "*Preparation: First, fraction cards are introduced and an example is shown about the use of fraction cards. After that fraction cards are given to the students and they are asked to multiply fractions with these fraction cards. As an example, two fractions are written on the board and a student is chosen from the class and asked to multiply these two fractions. The student models the multiplication by placing these two fraction cards painted in different colours on top of each other, one vertically and the other horizontally. When the fraction cards are put on top of each other, the total number of squares formed constitutes the denominator of the fraction, and the total number of squares with colour change forms the numerator of the fraction. It is also represented concepts such as equivalent fractions using fraction cards.*

Result: An abstract subject such as multiplication with fractions becomes concrete by modelling them with fraction cards.
Evaluation: Multiply $\frac{2}{5}$ by $\frac{3}{4}$ *using fraction cards. Choose different fractions and make comparisons between two fractions by using fraction cards.*

During his presentation, he allowed students to use manipulatives but he did not give correct directives and clear explanations. It is not possible to make connections between mathematical concepts and manipulatives in such a way since the result was found by applying the given instructions rather than teaching the multiplication with fractions conceptually. As a result, he taught multiplication with fractions traditionally.

According to the observation results, some preservice teachers (f=10) started lesson by introducing the manipulatives to the students in the learning-teaching processes. For example, preservice teacher S_{16} stated to give information about manipulatives in the lesson plan such as *"First of all, the manipulatives are introduced to the class. Then, algebra tiles are given to the students…."* In the lesson, S_{16} started the lesson after introducing manipulatives; on the contrary, half of the preservice teachers started teaching the concepts directly without introducing manipulatives in any way (f=11). This situation may cause misuse of manipulatives as students do not have knowledge about where and how to use manipulatives.

According to the findings obtained as a result of video recordings and observations, all of the preservice teachers allowed the students to use the manipulatives individually or in the form of group work in the learning-teaching processes. They gave all of the manipulatives to the students before the lessons. Thus,

it would be possible for students to gain experiences about manipulatives and explore mathematical concepts by using manipulatives.

While some preservice teachers gave clear, understandable and correct instructions in their teaching process (f=12), some of them could not give correct instructions to the students (f=9). *For example, S_3 asked to construct 3- 4-5 triangles firstly and 3- 4-10 triangles with the geometry strip to see if it is possible to construct this triangle or not. Then triangles were compared. The reason why it can be constructed or not was discussed and explained in class. After that angle-edge relations were discussed.* Another preservice teacher S_{21} gave instructions such as *"Similar or non-similar polygon models are drawn on the worksheet. From these polygons which polygons are similar? Why are they similar? Name similar polygons. Determine congruent angles and proportional edges. Find the similarity ratios of similar polygons?"* This instruction was not understood very well in the lesson and the preservice teachers did not know exactly what to do.

As a result of the research, the findings obtained from the videos and lesson plans showed that most of the preservice teachers concretized abstract mathematical concepts (f=14). For example, preservice teacher S_{13} taught equivalent fractions with fraction cards. *"Represent* $\frac{1}{2}, \frac{2}{4}, \frac{3}{6}$ $\frac{1}{2}$, $\frac{2}{4}$, $\frac{3}{6}$ *by using fraction cards. Now, put these fraction cards on top of each other. What did you see?" What can you say about these fractions? Are they equivalent?"* In this example preservice teacher represented fraction with fraction cards and concretized the concept of fraction. On the other hand, some preservice teachers did not concretize abstract mathematical concepts (f=7).

Another important finding obtained from the research is that only two preservice teachers made connections between daily life experiences and manipulatives. It was determined that other preservice teachers could not make connections between daily life experiences and manipulatives, neither in their lesson plans nor in the learning-teaching processes. For example, S_6 gave this example and made connections between daily life and decimal numbers and base ten blocks. "*Melek was born with a weight of 3.44 kilograms and Şeyma was born with a weight of 3.35 kilograms. Accordingly, let's find out how many kilograms more Melek was born than Şeyma. The problem is written on the board. They are asked to represent the given numbers with base ten blocks. It is discussed which operation the problem requires and students asked to represent the operation.* Preservice teacher S_6 thought that*.....Decimal numbers, which can also be encountered in daily life, are handled visual, thereby ensuring its retention in mind."*

Half of the participants (f=11) made connections between mathematical concepts and manipulatives. According to the preservice teacher S_{18}' s teaching process *"Work sheet was given to the students and it was expected to fill the table that consisted of an area and largest perimeter of multi squares. The set of multi-squares were examined. First, area of manipulative was calculated and the table was filled on the work sheet. For the possible largest perimeter of multi-square was examined and noted on table. Second, the area of another multi-square was calculated and the largest perimeter was found. For the possible largest perimeter of manipulative is examined and so on… Finally, the pattern between the area and the largest possible perimeter was found. It was concluded that multi-square set with the same area may have different perimeters.*", preservice teacher S_{18} made connections between concepts of area, perimeter and multi-square set.

Some preservice teachers transformed manipulatives to mathematical symbols (f = 13). Preservice teacher S_7 taught absolute value by using a symmetry mirror. According to the plan, S_7 designed learning environment: "*Ask students to draw number lines on squared paper. It is requested to put the symmetry mirror at the zero point on the number line. Ask students to say the pairs of numbers that overlap on the symmetry mirror. Discuss and compare distances of these pairs of numbers from zero. It is noticed that the distances of the number pairs from zero are equal. The definition of distance to zero is absolute value and it is represented by "| |". |2|=2 [distance of 2 from zero (absolute value of 2)]; |-2 |=2 [Distance of (-2) from zero (absolute value of -2)], thus |2|=|-2|=2. The result is that the absolute value comes out as positive, whether the number inside is positive or negative. |a|>|b| if a>b is true or false, it is explained by giving examples."* As a result of observation, S_7 transformed manipulatives to mathematical symbols.

In the teaching process, only 9 preservice teachers gave feedback about the use of manipulatives. During the lesson, they walked around the classroom, checked the students' representations with manipulatives and guided the students. They also corrected students' mistakes who used manipulatives wrongly.

Another important factor is classroom management. Every preservice teacher managed the classroom during the distributing and retrieving manipulatives. According to the finding, S_6 stressed that *"I think that classroom management will become difficult when teaching with manipulatives. Because some students may see manipulatives as a game. This can make teaching mathematics difficult."* Another preservice teacher S_7:*"I think we need to guide students correctly about using manipulatives while teaching mathematics in the classroom. Otherwise, classroom management can become difficult."* Most of the preservice teachers (f=13) were good at communication. They used gestures, mimics and the tone of voice properly and communicated with preservice teachers by getting them to participate in the lesson. 14 preservice teachers could manage time effectively. Another 7 preservice teachers coul not finish activities on time.

4. Conclusion

According to the findings, it has been determined that some of the preservice teachers have a general command of using manipulatives. In light of the results of the study, it was observed that they chose suitable manipulatives for mathematics subjects and mathematics acquisitions. However, most of the preservice teachers could not use manipulatives effectively and appropriately for the purposes. Although many preservice teachers wanted to use the manipulatives for the purpose of teaching the subject, they could not go beyond using them for the purpose of practicing. These findings are correspond to findings of related literature (Gökkurt-Özdemir et al., Moyer, 2001). Whereas teachers should create effective learning environments and know when and how to use manipulatives on teaching mathematical concepts (Marshall & Swan, 2008; Moore, 2012). For that reason, it is crucial for preservice teachers to learn to use manipulatives correctly in the correct place in teacher education. Therefore, it is recommended to increase the number of courses in which manipulatives are used in teacher education program. It is also recommended to teacher educators to guide preservice teachers in the proper use of manipulatives in their teaching practices (Willis & Browning, 2013).

Another important issue is making lesson plans by using manipulatives. Approximately half of the preservice teachers could plan their lessons appropriately. Teachers should make plans for the lessons in which they will use manipulatives and prepare instructions for using manipulatives carefully (Yazlık, 2018). If preservice teachers have enough knowledge about making lesson plans with manipulatives, they will plan their future lessons effectively when they become teachers. Thus, it helps them to develop knowledge and skills to select and use appropriate manipulatives (Yetkin-Özdemir, 2008).

According to the findings obtained from this research, most of the preservice mathematics teachers started the teaching process without introducing the manipulatives sufficiently. In order to understand how to use the manipulatives, students need to learn the manipulatives. Otherwise, it will be difficult for them to use manipulatives effectively.

The preservice teachers allowed to use manipulatives during the lessons. For this reason, they gave all of the manipulatives to the students before starting the lessons. In this context, they gave enough time to use manipulatives during the lessons. They used manipulatives individually or in the form of group work in the learning-teaching processes. This situation enabled preservice teachers to interact with manipulatives. Boggan, Harper and Whitmire (2010) stated that teachers should allow their students to have free time to play with the manipulatives. However preservice teachers are not given enough time to become a competent user of the manipulatives in teacher education programmes (Pişkin-Tunç, Çakıroğlu & Bulut, 2020). On the contrary, it is expected from preservice teachers to give enough time to their students to explore and use manipulatives. For this reason, giving manipulatives to students to make practice is good evidence for preservice teachers to become competent users of manipulatives.

While some preservice teachers gave correct directives, clear and understandable explanations in their lessons, others did not. Students should learn mathematical concepts conceptually. Moyer (2001) stated that students used the manipulatives following the teachers' directives. So they learn mathematics

traditionally. However, if preservice teachers could not give correct directives, clear and understandable explanations in their lessons, students could not understand what to do with manipulatives.

As a result of the research, some preservice teachers concretized abstract mathematical concepts. Mathematics involves many abstract concepts. Manipulatives are important tools that concretize abstract mathematical concepts (Moyer, 2001) and they make mathematical concepts easier to understand (Allen, 2007; Izsak, 2004; Kennedy & Tipps, 1994; Suh & Moyer, 2007). If preservice teachers and teachers concretize abstract concepts with manipulatives, students will learn mathematics more quickly.

When the lesson plans and teaching process of preservice teachers' were examined, it was determined that the preservice teachers mostly experienced difficulty in making connections between daily life experiences and manipulatives. Many researches also indicated that preservice teachers have difficulty in making connections between daily life and manipulatives. A few related studies show that making connections in mathematics teaching is far below the predicted level and quality (Gainsburg, 2008). For this reason, it is important to relate mathematical concepts with daily life for understanding mathematics. In addition, associating with real life motivates students and increases students' interest in mathematics (Stylianides & Stylianides, 2008). In spite of that, teachers generally choose real-life contexts to motivate their students, engage them, and show that mathematics is more understandable when it is related to real life (Gainsburg, 2008).

Half of the participants made connections between mathematical concepts and manipulatives. Despite this, it has been determined that some preservice teachers have difficulty about making connections between mathematical concepts and manipulatives (Kamina-Iyer, 2009; Yetkin-Özdemir, 2008). Manipulatives provide students with an additional perspective about mathematical concepts (Johnson, O'Meara, & Leavy, 2020). However, manipulatives are not automatically meaningful to students they need to be connected to the situations being represented (Kilpatrick, Swafford & Findell, 2001). Yetkin-Özdemir (2008) revealed that although preservice teachers had knowledge and skills about manipulatives, they had difficulty in guiding students to establish connections between mathematical concepts and manipulatives. Therefore, it may be useful to increase the number of examples that preservice teachers can relate mathematics concepts to manipulatives in teacher education courses.

The findings of the research revealed that only 9 preservice teachers gave feedback to the student about using manipulatives. Feedback is an information that is given about the student´s performance or understanding (Hattie & Timperlay, 2007). If teachers give feedback about using manipulatives, students will be aware of their misuse and misunderstanding and they will have a chance for correcting their mistakes.

More than half of the participants transformed manipulatives to mathematical symbols. Despite this, it has been determined that some preservice teachers have difficulty in transforming manipulatives to mathematical symbols. Some researchers also indicated that preservice teachers have difficulty in establishing connections between mathematical concepts and symbols (Swan & Marshall, 2010; Uttal, Scudder & DeLoache, 1997).

Another important factor is classroom management. Teachers should know to manage the learning environment when they use manipulatives (Marshall & Swan, 2008). They managed the classroom during the distributing and retrieving manipulatives. Most of the preservice teachers were able to communicate with their classmates and could manage time effectively. On the other hand, teachers also need to know how to manage the learning environment (collection and distribution of materials). These research findings are parallel to findings researches. Pişkin (2010) emphasized that the preservice teachers think that the greatest difficulty while teaching mathematical concepts by using manipulatives is classroom management. Ünlü (2018) found that some pre-service teachers think that manipulatives should not be used in elementary classrooms as they make the classroom management difficult.

In order for manipulatives to be recognized and used by the preservice teachers, it is recommended that the lecturers give the preservice teachers plenty of opportunities to gain experience with the manipulatives. One of the important sources of gaining experiences is direct experiences, so preservice teachers to live direct experiences of using manipulatives. By creating classroom environments in which preservice teachers feel psychologically and physically comfortable, they can make practice about teaching mathematics.

As a conclusion, incorporating such practices into teacher training programs is believed to make contributions to the attempts made to train more qualified teachers. These practices can help preservice teachers develop skills in terms of using manipulatives effectively, classroom management and time management. Therefore, such implementations can be conducted in the courses of Teaching Practicum and Teaching Methods courses. Moreover, such researchs can be conducted for teachers. In this way, teachers can also see their mistakes and shortcomings in the use of manipulatives.

References

Allen, C. (2007). An action based research study on how using manipulatives will increase students' achievement in mathematics. Online Submission. Retrieved from *http://files.eric.ed.gov/fulltext/ED499956.pdf.*

Atav, E., Kunduz, N., & Seçken, N. (2014). Biyoloji eğitiminde mikro öğretim uygulamalarına dair öğretmen adaylarının görüşleri [Pre-Service teachers' views about micro teaching practices in biology education.] *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi* (H. U. Journal of Education), *29*(4), 01-15.

Ball, D. (1992). Magical hopes: Manipulatives and the reform of math education. *American Educator: The Professional Journal of the American Federation of Teachers, 16*(2), 14-18.

Ball, D. L., & McDiarmid, G. W. (1990). The subject matter preparation of teachers. In R. Houston (Ed.), *Handbook of research on teacher education* (pp. 437–449). Macmillan.

Bayram, S. (2004). The Effect of Instruction with Concrete Models on Eighth Grade Students' Geometry Achievement and Attitudes Toward Geometry, Master's Thesis, Middle East Technical University, Ankara, Turkey. [Master's thesis, Gazi University]. Turkish Higher Education Council thesis repository (#290710). https://tez.yok.gov.tr/UlusalTezMerkezi/

Bellinio, J. L. (2012). Multi-Sensory Manipulatives in Mathematics: Linking the Abstract to the Concrete. Yale-New Haven Teachers Institute. In http://www.yale.edu/ynhti/curriculum/units/2001/6/01.06.12.x.html (15.02.2016).

Boggan, M., Harper, S. & Whitmire, A. (2010). Using manipulatives to teach elementary mathematics. *Journal of Instructional Pedagogies, (3),* 1-6.

Cass, M., Cates, D., Smith, M., & Jackson, C. (2003). Effects of manipulative instruction on solving area and perimeter problems by students with learning disabilities. *Learning Disabilities Research & Practice, 18*(2), 112-12.

Çelik, Ö., Yorulmaz, A., & Çokçalışkan, H. (2019). Öğretmen genel yeterlikleri açısından sınıf öğretmenleri ve öğretmen adaylarının kendilerini değerlendirmeleri. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi, 20,* 203-215.

Dienes, Z. (1967). A Theory of mathematics-learning. In F. J. Crosswhite, et al. (Eds.). (1973). *Teaching mathematic: Psychology foundations*. Worthington, Ohio, Charles A. Jones Pub. Co. Dienes.

Fuson, K. C., & Briars, D. J. (1990). Using a base-ten blocks learning/teaching approach for first- and second-grade place-value and multidigit addition and subtraction. *Journal for Research in Mathematics Education, 21*(3), 180-206.

Gainsburg, J. (2008). Real world connections in secondary mathematics teaching. *Journal of Mathematics Teacher Education, 11(*3), 199-219.

Gökkurt-Özdemir, B., Uygun, T., Gün, Ö., & Koçak, M. (2020). Matematik öğretmeni adaylarının somut materyalleri kullanma becerilerinin incelenmesi. *Akdeniz Eğitim Araştırmaları Dergisi, 14*(34), 153-175.

Gökmen, A., Budak, A., & Ertekin, E. (2015). İlköğretim öğretmenlerinin matematik öğretiminde somut materyal kullanmaya yönelik inançları ve sonuç beklentileri. *Kastamonu Eğitim Dergisi, 24*(3), 859-874.

Hattie, J., & Timperlay, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Izsak, A. (2004). Students' coordination of knowledge when learning to model physical situations. *Cognition and Instruction, 22*(1), 81-128.

Johnson, P., O'Meara, N., & Leavy, A. (2021). Factors supporting and inhibiting teachers' use of manipulatives around the primary to post-primary education transition. *International Journal of Mathematical Education In Science and Technology, 52*(7), 1006-1028.

Kelly, A. C. (2006). Using manipulatives in mathematical problem solving: A performance- based analysis. *The Montana Mathematics Enthusiast, 3* (2), 184– 193

Kennedy, L. M., & Tipps, S. (1994). *Guiding children's learning of mathematics.* Belmont, Ca: Wadsworth Pub. Co.

Marshall, L., & Swan, P. (2008). Exploring the use of mathematics manipulative materials: is it what we think it is?. *Proceedings of the EDU-COM 2008 Sustainability in Higher Education: Directions for Change.* 338-350.

Martelly, D., I. (1998). Effects of using manipulative materials to teach remedial algebra to community college students on achievement and attitudes towards mathematics. Unpublished doctoral dissertation, Florida International University, Miami.

Martin, T., & Schwartz, D. L. (2005). Physically distributed learning: Adapting and reinterpreting physical environments in the development of fraction concepts. *Cognitive Science, 29*(4), 587-625.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded source book*. California, CA: Sage.

Milli Eğitim Bakanlığı. (2006). *İlköğretim (6-8) Matematik öğretim programı* [Elementary mathematics 6-8 curriculum]. MEB.

Milli Eğitim Bakanlığı. (2017). *İlkokul ve ortaokul matematik dersi (1, 2, 3, 4, 5, 6,7 ve 8. sınıflar) öğretim programı* [Elementary and middle school (1, 2, 3, 4, 5, 6, 7, 8 th class mathematics curriculum]. MEB. http://mufredat.meb.gov.tr/Dosyalar/201813017165445-MATEMAT%C4%B0K%20%C3%96%C4%9ERET%C4%B0M%20PROGRAMI%202018v.pdf

Ministry of National Education. (2013). Ortaokul matematik dersi (5, 6, 7 ve 8. sınıflar) öğretim programı [Middle school mathematics course (5th, 6th, 7th and 8th grade) curriculum]. Ankara, Turkey: Author. Retrieved from http://ttkb.Milli Eğitim Bakanlığı.. gov.tr/program2.aspx?islem=2&kno=215.

Moyer, P.S. (2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics, 47,* 175-197.

O'Meara, N., Johnson, P., & Leavy, A. (2020). A comparative study investigating the use of manipulatives at the transition from primary to post-primary education. *International Journal of Mathematical Education in Science and Technology, 51*(6), 835-857.

Patton, M. Q. (2002). Qualitative research and evaluation methods (3rd ed.). Thousand Oaks, CA: Sage.

Pişkin, M. (2010). *Investigation of pre-service elementary mathematics teachers' self-efficacy beliefs about using concrete models in teaching mathematics.* Master's Thesis, Middle East Technical University, Ankara, Turkey.

Pişkin-Tunç, M., Çakıroğlu, E., & Bulut, S. (2019). Exploring self-efficacy beliefs within the context of teaching mathematics with concrete models. *Elementary Education Online, 19*(1), 100-117.

Sarpkaya- Aktaş, G. (2017). Teacher competencies according to peer evaluations in micro-teaching applications. *International Journal of Social Sciences and Education Research*, *3*(5 S), 1657-1669.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L.S. (1995). Those who understand: knowledge growth in teaching. In B. Moon & A.S. Mayes (Eds) *Teaching and learning in the secondary school* (London: Routledge).

Simon, S. E. (2013). Chaos of textures or 'tapisserie'? A model for creative teacher education curriculum design. *Australian Journal of Teacher Education, 38*(11), 87-102.

Sowell, E. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20,* 498-505.

Stylianides, A. J., & Stylianides, G. J. (2008). Studying the implementation of tasks in classroom settings: High-level mathematics tasks embedded in "real-life" contexts. *Teaching and Teacher Education, 24,* 859-875.

Suh, J., & Moyer-Packenham, P. (2007). Developing students' representational fluency using virtual and physical algebra balances. *Journal of Computers in Mathematics and Science Teaching, 26*(2), 155-173.

Suydam, M., & Higgins. J. (1977). *Activity-based learning in elementary school mathematics.* Reston, Virginia: NCTM.

Swan, P., & Marshall, L. (2010). Revisiting Mathematics Manipulative Materials. *Australian Primary Mathematics Classroom, 15*(2), 13-19.

Thompson, P. (1994). Concrete materials and teaching for mathematical understanding. *Arithmetic Teacher, 41*(9), 556-558.

Tschannen-Moran, M., Woolfolk-Hoy, A., & Hoy, W. (1998). Teacher efficacy: Its meaning and measure. *Review of Education Research, 68*(2), 202–248.

Uttal, D. H., Scudder, K. V., & DeLoache, J. S. (1997). Manipulatives as symbols: A new perspective on the use of concrete objects to teach mathematics. *Journal of Applied Developmental Psychology, 18,* 37-54.

Ünlü, M. (2018). Effect of micro-teaching practices with concrete models on pre-service mathematics teachers' self-efficacy beliefs about using concrete models. *Universal Journal of Educational Research*, *6*(1), 68-82.

Yazlık, D. Ö. (2018). Öğretmenlerin matematik öğretiminde somut öğretim materyali kullanımına yönelik görüşleri. *OPUS International Journal of Society Researches*, *8*(15), 775-805.

Yetkin- Özdemir, E. (2008). Sınıf öğretmeni adaylarının matematik öğretiminde materyal kullanımına ilişkin bilişsel süreçleri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 35*, 362-373.

Yıldırım, A. & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* (8th Edition). Ankara: Seçkin Yayıncılık.

Willis, J., & Browning, S. (2013, March). Introduction to Mathematics Manipulatives: Preservice Teachers Create Digital Stories Illustrating Types and Application of Manipulatives. In *Society for Information Technology & Teacher Education International Conference* (pp. 1795-1815). Association for the Advancement of Computing in Education (AACE).

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