THE EFFECT OF LEGO MANIPULATIVE USE ON STUDENT PERFORMANCE IN THE MATHEMATICAL SKILLS OF THE 2ND GRADE: PARENTS 'AND STUDENTS' VIEWS

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ABSTRACT

The purpose of this study was to investigate how the use of the action-based manipulatives affects students' problem-solving skills, fluency, understanding, and reasoning ability in mathematics classrooms. A case study was conducted as an out-of-school project with seven second grade students who were part of the study group. Data collection instruments included interview protocols, student observation forms, and student worksheets. Data were collected from the students and their parents. Linguistic and content validity were checked by experts in the field. Finally, the data were analyzed descriptively. The results showed that the performance of the students was above 85%. Solving questions with both software and physical materials made the learning process easy. Students socialized and shared opinions and solutions. Parents reported that the use of this teaching tool encouraged students' creativity in learning abstract concepts and provided opportunities for regular communication and cooperative group work in class. As a result, students learned alternative ways to solve problems, which improved their problem-solving skills and mathematical fluency. Constructing physical models using LEGO materials and MathBuilder software also facilitated their understanding of abstract concepts. The suggestions presented in this study are important and pave the way for the use of hands-on materials and 3D software for teaching abstract concepts in the classroom.

Keywords: *Problem solving, understanding, reasoning, fluency, manipulative objects, lego, modelling.*

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INTRODUCTION

Mathematics is the process of problem solving that an individual encounters by searching for a pattern or order and the ability to reason by incorporating events into a problem approach (Yenilmez & Avcu, 2009). Since it is a science that involves abstract concepts with a distinct language and system (Altun, 2002; Baykul, 2009). The biggest problem is the concretization and teaching of abstract concepts in mathematics education at an early age, because according to Piaget (1974), students are still in the concrete process.Manipulatives are used in mathematics classrooms to help students understand abstract concepts (Carbonneau, Marley & Selig, 2013). Especially in the early grades, teachers often use manipulatives such as pattern blocks, base ten blocks, or unifix cubes in the classroom (Perry & Howard 1997; Swan & Marshall, 2010). Manipulatives are concrete models that contain mathematical concepts, engage different senses, and can be touched and moved by students (Bouck & Flanagan, 2010; Hynes, 1986) or sensory objects that can be manipulated by individuals in a conscious and unconscious mathematical thinking (Carbonneau & Marley, 2012; Swan & Marshall, 2010). In examining the studies on the use of manipulatives in mathematics, it is believed that students can interact directly with the targeted knowledge using concrete objects (Carbonneau & Marley, 2012), increase academic achievement and provide for sustained learning, and contribute to the development of problem-solving skills (National Council of Teachers of Mathematics (NCTM), 2010; Yazlık, 2018).Virtual manipulatives, defined as interactive, web-based visual representations of a dynamic object that provide opportunities to construct mathematical information, can also be used (Bouck, Working, & Bone, 2018; Moyer, Bolyard, & Spikell, 2002). There is evidence that virtual manipulatives further reduce students' cognitive load compared to concrete manipulatives (Suh & Moyer, 2007). The use of interactive virtual environments boosts students' confidence by helping to build a solid mathematical foundation, especially at early ages (Rutherford et al., 2019), and enables students to learn abstract concepts more easily in courses such as geometry (Çetin, Aydın, & Yazar, 2019; Guerbuez, 2010; Sherman & Bisanz, 2009). When virtual manipulatives are used with a mobile application, it facilitates the inclusion of disabled students in mathematics classes (Bouck & Park, 2018; Bouck, Working, & Bone, 2018) and improves the early mathematical skills of preschool children (4-5 years) (Outhwaite et al. 2019).

The use of LEGO as a manipulative is widely used in interdisciplinary teaching of science, technology, engineering and mathematics (STEM) in various age groups (Kazez & Genç, 2016b). Lego bricks bring many mathematical concepts to life: basic cardinality and counting, addition and subtraction, multiplication and division, fractions, data and measurement, and statistics and probability. It helps students learn mathematical concepts through modelling. If a student can model a math problem and then understand and explain the model, the computational process will begin without struggling. Modeling helps students can visualize what is happening in a problem (Disseler, 2017). For example, teaching addition concept words such as addend, sum, result, solution, and altogether are content words. Mathematics teachers should use the action of the math so that students can attach words to their understanding of the process of adding numbers. Researchers have identified four distinct problems children need to solve: join, separate, part part,whole, and comparisons problems. These processes match the way the brain works when solving word problems. The use of direct modeling is beneficial to young learners because it provides a visual representation that leads to the understanding behind the action of the math (Cathcart et al., 2014). For example, as in Figure 1, when the teacher tells students to build a model consisting of eight studs while explaining the concept of addition, the possibilities that will enable the students to reach eight are as follows. When students see these possibilities visually, they realize that there are various ways to reach a result and that there are more than one possibility, they easily encode the addition process in their minds (Disseler, 2017).

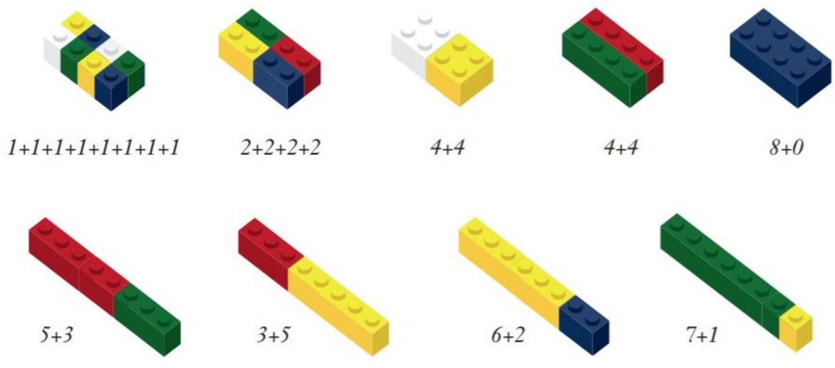

Figure 1. *Possible Models for Counting Eight (this figure was derived from the book titled " Teaching Addition Using LEGO® Bricks", Disseler , 2017, p.14)*

Besides the use of LEGO bricks and computer software together as robotic applications enables students to understand STEM concepts about each other on a task-based basis (Igel et al., 2012). In the use of LEGO in the teaching of concepts such as movement, strength and direction in students with mild and moderate disabilities, it is seen that students can learn abstract concepts and develop positive attitudes towards learning (Disseler & Mirand, 2017). Rejeki et al.(2017), in their study of low and high performing mathematics 7th-grade students using LEGOs for teaching fractions, observed that students at both levels increased their course success and learned concepts correctly. Besides, students' underperformance in mathematics has improved their ability to perform operations. When they solve problems related to daily life with LEGO, they discover that there are different ways to solve a problem and that different strategies can be developed (Wickstrom et al., 2019). In an authentic problem prepared by giving students a predetermined number of LEGO bricks, the researchers asked the students to calculate what they could only do with the materials at their disposal, and the students discovered that there were more than one solution to the problem. In doing so, they also worked in large and small groups and reasoned by establishing a cause-effect relationship (Özgün-Koca, Edwards, & Chelst, 2015).

LEGO MoretoMath is a manipulation of three components, a curriculum book based on Papert's constructivist approach, Australian mathematics gains, LEGO bricks of various numbers and sizes, and computer software enabling 3D modelling. The aim is to build a bridge between mathematical phenomena and mathematical competencies and help children develop and model solutions for real-world problems and create enduring learning using familiar LEGO parts and computer software (Lego MoretoMath Curriculum Pack, 2015). Thus, while students learn fractions, arithmetic, geometry, the four basic arithmetic operations, symmetry, patterns, graphical reading, and table interpretation in the first and second grades of elementary school, they also develop their problem-solving, comprehension, fluency, and reasoning skills in teamwork or individually (Kazez & Genç, 2016a; Kuekey, Gueneş, & Genç, 2019). Before the course, the students are tuned in to the activity with the visualization of the activity in the software. Then, they solve the activity worksheets with questions ranging from easy to difficult.

Since the questions in the worksheets are open-ended, they write their solutions on the worksheet with concrete and virtual manipulatives step by step. The visual of the worksheet is shown in Figure 2. In the example, the students are expected to use colorful concrete manipulatives, predetermined in numbers, as unity and decimal currency, and interpret the given table and calculate which product to keep. In Figure 3, the model used for teaching symmetry concepts prepared using concrete manipulative can be seen.

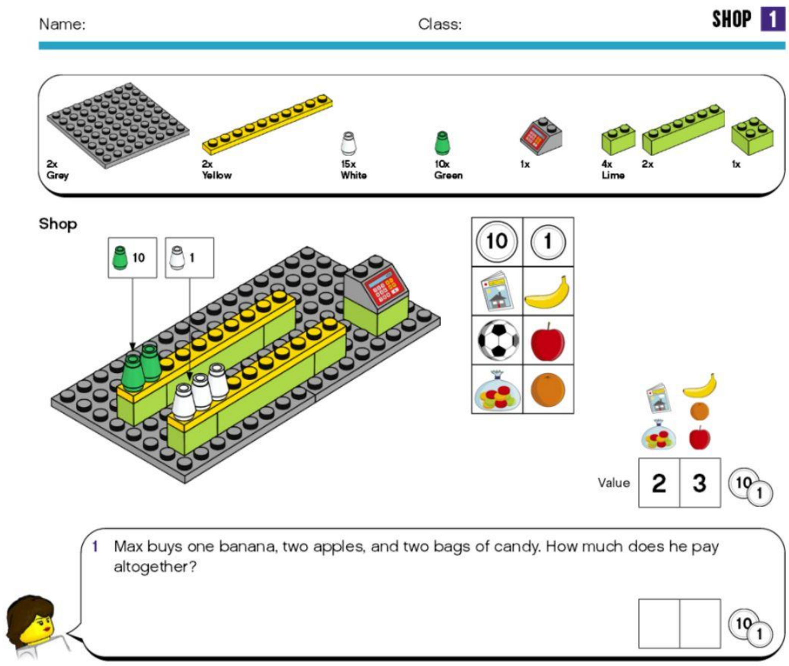

Figure 2. *Sample of Student Worksheet*

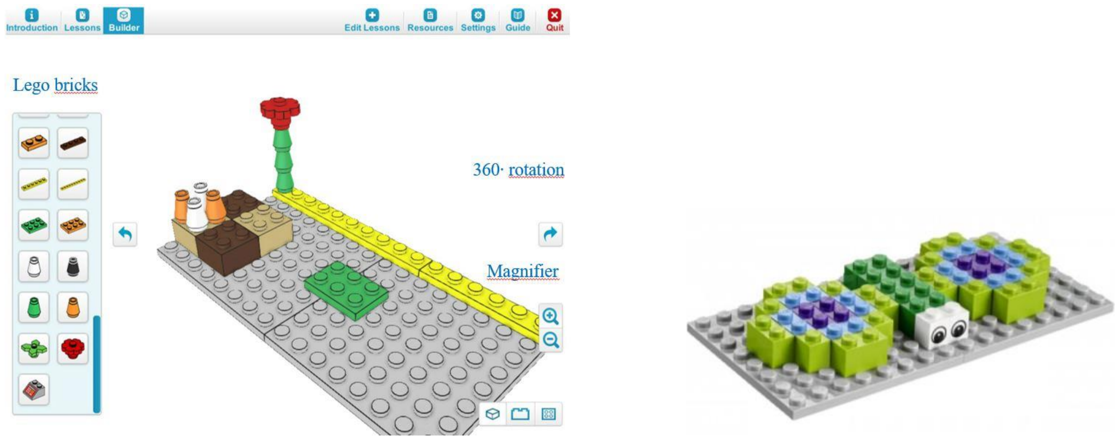

Figure 3. *Virtual Manipulative (MathBuilder Software) and Concrete Manipulative (LEGO Bricks)* Math Skills and Elementary School Students

According to the internationally accepted National Council of Teachers of Mathematics (NCTM) in mathematics, students should have the content and process standards they need to succeed in mathematics. In the context of mathematical content, content standards are determined as numbers and operations, algebra, geometry, measurement, data analysis and probability, and process standards were defined as problem-solving, reasoning and proof, communication, relations and expression (NCTM, 2013). The standards set for the content increase as the class level increases. In other words, each concept and subject that students learn will prepare the infrastructure for the following year. However, reasoning, problem-solving, communication and expression skills develop from year to year. Therefore, the connection between abstract thinking and mathematics should be established at early school ages (Koğ Uysal & Başer, 2011).

Problem-solving skills in the process standards is an action that includes the stages of understanding the problem, selecting the solution-related strategy, applying the strategy and evaluating the solution (Polya, 1957). The problem-solving process is not to solve questions but to solve the problem (Olkun & Toluk Uçar, 2012). With the ability of problem solving, the individual develops an increasingly complex capacity for logical thoughts and actions such as analysis, proof, evaluation, explanation, inference and generalization. While using mathematical concepts, phenomena and operations in problem-solving, individuals' mathematical reasoning skills come to the forefront (MEB, 2019; OECD, 2019).

The reasoning is the ability of students to develop an increasingly complex capacity for logical thinking and actions such as analysis, proof, evaluation, explanation, inference, justification, and generalization (CITATION is needed). Learners reason when they adapt what is known to the unknown, transfer learning from one context to another, prove that something is right or wrong, or compare relevant ideas and explain which choice and why (Australian Curriculum, 2019). In the Australian Curriculum using known ways to solve unknown situations in the second grade of primary school means the acquisition of skills to interpret or generate simple data.

Understanding skills; students can make a solid exchange or transformation of mathematical concepts, while they can relate to interrelated concepts and gradually adopt new concepts to new ideas. They can establish a connection between how and why mathematics. It includes understanding the relationship of numbers for the second year of primary school, sorting numbers, dividing and joining flexibly, identifying and defining the relationship between addition and subtraction (Australian Curriculum, 2019).

Students who develop fluency skills can choose flexible, accurate and efficient procedures by remembering the correct information and concepts while creating the problem's solution. They develop fluency skills when calculating answers effectively when they recognize the right ways to answer questions, choose appropriate methods and approaches, remember definitions, and know when to use expressions and equations to achieve solutions (PISA, 2021). The second year of primary school, this skill expresses the ability to count numbers quickly and fluently and use other objects as a measurement tool and length-measuring objects such as rulers. (Kazez, 2015).

Research Problem

The information boom in the twenty-first century has been equal to the total amount of information obtained in the history of the world until that period (Yılmaz, 2014). Today, it is sufficient for individuals to have processing skills and to be raised as individuals who can solve problems well, associate what they learn with daily life, reason, and explain mathematical knowledge they have learned (Doruk & Umay, 2010). However, according to Papert, since we still solve the multiplication and division operations with the same algorithm in Treviso Arithmetic, it seems possible that if a teacher from the 16th century was able to travel to the present day, it would be possible to teach in today's classes or schools. Because the programs in schools do not differ from those of 16th-century schools (Papert cited in Blikstein, 2013). In this case, we need innovation and new models in teaching and learning environments (Saralar, Ainsworth, & Wake, 2019). In addition, when the results of the PISA exam and Kassel project are examined, Ersoy and Erbaş (2005) reported that students in Turkey have misconceptions, equality and problems in mathematics teaching.

Similarly, Saralar and Ainsworth (2020) looked for students misconceptions in geometry and reported some errors in their study. To be successful in national exams and international exams where high-level skills such as PISA are measured, students need to use mathematical reasoning skills and mathematical concepts and operations to explain and predict events (MEB, 2019). Although the low success graph in the international arena shows an increase in points compared to 2015 when we evaluate all the years we participated in the exam, it is seen that the OECD average still does not reach the desired standards (TEDMEM, 2019). This situation indicates the necessity of different approaches in education (Akpınar & Aydın, 2007; Saralar, Ainsworth, & Wake, 2019). It is possible to visualize the concepts in mathematics with manipulatives, can help students to direct the mathematics they see as a difficult lesson in a positive direction and to embody the concrete concepts more easily and to understand the mathematical topics they will see in the following years with the helplessness they have developed towards mathematics (Koğ Uysal & Başer, 2011).

Purpose of The Research

The purpose of this study was to investigate how the use of the activity-based LEGO MoretoMath manipulative (concrete and virtual materials) affects students' problem solving, fluency, understanding and reasoning skills during math lessons in 2nd grade. It also aims to understand what kind of conveniences or difficulties the student is experiencing in real practice and understand parents 'opinions about the students' performance. The research questions determined in accordance with the general purpose of the research are as follows:

Research Questions

1. What are the students' performance levels regarding the questions in the activities of the mathematics lesson prepared with concrete and virtual manipulative use?

2. What are the students' views on concrete and virtual manipulatives used in activities?

3. What are the parents' views on using concrete materials and software in teaching mathematical skills with Legos?

RESEARCH METHOD

Research Model

In this study, a case study, which is a type of research that allows observation and not a theory, is used. In cases where there is more than one evidence or data source, which investigates a current phenomenon within its uncertain boundaries with the content to which it belongs (Merriam, 2013). Research questions were developed and participants were selected by purposeful sampling. Multiple data sources (interviews, student worksheets and observation forms for each activity)used and analyzed.

Participants

The study group consisted of seven second grade students who had volunteered to participate in the extracurricular course and their seven parents. Ethics committee approval was obtained. Random sampling was used in selecting the study group, which is one of the types of sampling selection. Five of the students attended public school and two attended private school. In terms of gender, 4 students were boys and 3 were girls 8 years old except for one 7 year old.

Data Collection Tools

In this study, to find answers to research questions, data were collected through observation, document analysis, and interview techniques, qualitative data collection tools. Observation forms and student worksheets are pre-determined in the MTM(MoreToMath)curriculum. However, interview forms for students and parents were prepared by the researchers. Field experts checked language and content validity.

To understand how each math skill varied in the first research question, the total scores students solved and modelled for each activity were compared at the end of the worksheet. The worksheet contained 3 or 4 open-ended questions. If the answer and solution to the question was correct, the teacher gave the student two points each. Students were given 1 point if the solution was correct but they had trouble finding the answer. If both the solution and answers were wrong, they received zero points from the teacher for each question. Although the activities focus on one important mathematical skill, they can also promote more than one skill (e.g., fluency). In this way, the score obtained for the activity was interpreted to mean that the student was successful in that skill. The difficulty level of the activities was predetermined in the MTM curriculum and increased gradually from the first to the last activity.In order to understand parents' and students' views of the process, video recordings, images and media recordings with observer notes were made and then analysed. Semi-structured interviews were also conducted. Interview forms were developed separately for parents and students. Interviews with students were conducted during the course and at the end of the course. The data sheets were analysed considering the modelling sheets, solution path and outcome steps used as document analysis, and outcome sheets formulated by the students themselves at the end of the activity.

The Implementation Process:

During the implementation process, while each lesson was completed by dividing the activity into three in the first three weeks, the remaining activities were solved by completing one each week. The order in which the activities should be solved was determined by the teacher considering the progress of the activities from easy to difficult, their compatibility with the school curriculum, and the students' readiness levels. Although the questions in the activities seem to focus on one skill, according to Table 1, they actually support the development of more than one skill due to the interrelated mathematical skills. For example, an activity that focuses on problem-solving skills can contribute to the development of fluency skill. However, the activity was classified according to the most prominent skill in the curriculum of MTM.

Table 1 shows which mathematical skills are associated with which activity. As shown in the table, running, shopping, shot put, and gardening activities focus on numbers and algebra in terms of content and statistics and measurement, while individual students use manipulative and modelling activities. Swimming pool, party cake, long jump, and baking day are activities for peers that focus on measurement and geometry, numbers, and algebra. In the implementation, the teacher first selected the activity from the curriculum (see Table 1). Then the picture of the activity was shown on the board with the projector. The teacher asked questions about what the students knew about the activity and the mathematical concepts. Then the students were given the worksheets for the activity. They first solved the problems and then built their solution models using concrete Lego pieces. Finally, they modeled their solution to the problem in MathBuilder software and shared their ideas with others.

Table 1. *Weekly The Implementation Process*

Weeks	Activity Name	Math Skill (Mainly Focus on)	Supportive Math Skill	Mathematics fact concepts	Math Content Strands
1,2,3	Gardenning (Lesson1,2&3) (Ind.)	Fluency (F)	PS, R and U	Measurement and Data	Measurement& Statistics
4	Running (Lesson 1&2) (Ind.)	Problem solving (PS)	R, F and U	Numbers and Operations in Base Ten	Number & Algebra
5	Running (Lesson 3) (In.) & Long Jump (Lesson 1) (Peer.)	Problem solving & Reasoning	R, F and U PS and F	Numbers and Operations in Base Ten & Operations and Algebraic Thinking	Number & Algebra
6	Long Jump (Lesson 2&3) (Peer.)	Reasoning (R)	PS and F	Operations and Algebraic Thinking	Number & Algebra
7	Swimming Pool (Peer.)	Understanding (U)	PS, F and R	Geometry and Spatial skills	Measurement and Geometry
8	Shopping (Ind.)	Problem solving	R and F	Numbers and Operations in Base Ten	Number & Algebra
9	Shot Put (Ind.)	Fluency	PS	Measurement and Data	Measurement& Statistics
10	Baking Day (Peer.)	Reasoning	PS and F	Operations and Algebraic Thinking	Number & Algebra
11	Party Cake (Peer.)	Understanding	PS, R and F	Geometry and Spatial skills	Measurement and Geometry

Note: Peer used for peer activities and **Ind.** used for individually solved activities.

Researcher's Role

The researcher participated in the course activities as a participant-observer during the application by performing data collection and observation processes together. In addition to the researcher, a prospective teacher studying Computer Education and Instructional Technologies and experienced in LEGO education has been present with the researcher throughout the process to assist the students in the questions that cannot be solved in the classroom and to share their observations with the researcher.

Data Analysis

This study describes the data with interpretations and summaries. To find answers to the research questions, descriptive analysis was used to analyze the data obtained from the observations, student worksheets, and interviews (Table 2). Before beginning the data analysis, the field notes, consisting of 21 pages kept by the researcher during his observations and eight observation sheets kept at the activities in all three courses, were examined in parallel with the research questions. The audio recordings from the parent and student interviews were transcribed.

Table 2. *Data Resources for Research Questions*

Research Questions	Data Analyze Resources
1. Student performance	Observation forms and Students Scores on Worksheets
2. Students' views about implementation	Semi-structured student interview questions
3. Parents' views about implementation	Semi-structured parental interview questions

Validity and Credibility

In qualitative studies, the principle of long-term interaction is used to increase credibility (Miles & Huberman, 1994) Therefore, it has been tried to be achieved by presenting the researcher in the classroom environment as a participant-observer and interacting with the students for one semester (11 weeks). In this research, triangulation, participant validation, expert review, audit technique and rich, intensive identification strategies proposed to improve validity and reliability indicated by Merriam (2013) were utilized. The triangulation strategy is used to increase the diversity of data. Multiple data collection methods were used to support each other. For this purpose, interviews, observation forms, video recordings, worksheets and results sheets were used. Unclear situations that emerged during the interviews were directed back to the participant and clarified and participant verification was performed. or the expert review, opinions were obtained from two experts working in the same field as the researcher. In addition, the opinions of experts in mathematics and primary school teachers were sought in the interpretation and analysis of the data. In addition, the researcher along with a mathematics expert evaluated the worksheets separately according to the scoring rubric provided. This was done to ensure the reliability of the scores assigned for student performance by examining the correlation between raters in rating student worksheets. Detailed records were kept in the transcript of the video recordings and during the observation sheets, each step was reported and the inspection technique was used. Finally, so that readers can make comparisons with their surroundings and understand the similarities and differences, the investigation was presented in a detailed description.

FINDINGS

Performance of Students in Manipulative Supported Activities

Students modelled the questions in the activities by using concrete and virtual manipulatives in the activity. Since the questions were open-ended, there was not only one correct answer, but multiple correct answers could be given. Thus, students' responses to the mathematical questions were not only questioned on their processing abilities, but also on how they could think about different possibilities. Generally, in the first activity, students struggled to understand how to solve the questions, and in the second activity, they were able to solve the questions without difficulty. However, as the question level becomes more difficult in the same activity and between activities, the error rate increases in the following activities (e.g., students solved F1 first and then F2) because they misread the questions. The worksheets were evaluated to determine the level of students' overall performance in an activity. Accordingly, each question in the three courses involved in the activity was scored based on two points. One score was given for his explanations and transactions and the other if he wrote down the result correctly. Even if the student struggled with the question, both the solution and explanations and the results were given zero points if the result was not correct. The performance of the students in the first and second activities according to the four skills is shown in Table 3.

Table 3. *Student Performances Based on Activities*

Students	PS1	PS2	R1	R2	U1	U2	F1	F2
S1	87,5	100	77,7	83,3	100	95	61,1	77,7
S2	100	100	88,8	100	100	95	94,4	83,3
S3	87,5	100	88,8	83,3	100	90	83,3	88,8
S4	95,8	100	66,6	94,4	94,4	95	83,3	88,8
S5	91,6	100	100	100	100	90	100	77,7
S6	95,8	94,4	94,4	83,3	77,7	100	88,8	94,4
S7	91,6	88,8	100	100	100	90	83,3	83,3

Note: Problem Solving (PS), Reasoning (R), Understanding (U) and Fluency (F). Number 1 and 2 represents which activity solved first.

When Table 3 is examined, it is seen that the activities that students solved most easily are shopping (PS2), focusing on problem-solving skills and swimming pool focusing on understanding (U1) skills. The most challenging activity was the shot put activity (F1), which focused on fluency. The students could not understand what many questions they wanted to ask in this activity because multiple consecutive operations were required and they had difficulty in interpreting the tables. When the table was examined, it was seen that the students' overall success in activities was high and the difference between the first and last scores of each skill type was generally positive. It was observed that in the activities that focused only on comprehension (S1, S2, S3, S5, and S7) and fluency (S2 and S5), the scores of the last solved activity decreased for some students due to the increasing difficulty of the questions and the students' lack of understanding and cultural differences of the concepts.

All of the students enjoyed the activities that had to do with daily life; they were able to visualize the questions as they solved them with manipulatives, and they even understood the concepts and procedures that they had not seen before in their schools and were able to follow the steps to be taken in the activity without difficulty. For example, even though the students had not gone through a division procedure in school, they could easily solve the operations they had not seen in their heads and see the answer concretely.*R (Researcher): Can you take one out of five, divisible? How many pieces?*

S2 (Student 2): There are 32 here, divided by 5.

R: Is there an increasing number, or is it exactly dividing?

S2: I can't do it in my head. (He tries to solve it using the S2 model and a stylus.) S2 finds that there are two increments after counting the units. Since 32 units cannot be cut from two units, they reach indivisible results without 5. "

When the students' individual performances were examined, it was seenthat each student recorded unique achievements and mistakes throughout the process. Student S1 was a high-grade student but didn't like to read the questions. This situation arouses the fear that the student may fail the exams that he/she will encounter in their future life. The student generally completed the activities with high scores and showed interest in the course by solving the purple brick questions in the worksheet. Purple brick questions were challenging and could be used for students who finished quickly and needed extension activities. Although he was a student who did not read the questions, he dealt with and modelled the questions one by one. Initially, 87.5% performance in running and shopping activities was solved in problem-solving skills and 100% performance in shopping activities. It was concluded that the student used 21 different types of questions and problem-solving approaches in both activities and solved by modelling the questions. In the fluency skill, it was seen that the 61.1% performance of the garden activity increased to 77.7% in shot put. While the shot put activity was the most challenging activity for students, there was progress in student performance. In understanding, he showed a 100% performance in the swimming pool, but a 95% performance in the party cake. The reason for this decline was that the student misread a question. Nevertheless, it has been observed that when the observations were used, comprehension skills developed depending on reading the questions. It can be said that there was an improvement in S1's reasoning skills since it increased its performance from 77.7% to 83.3%.

S2 student likes mathematics in his daily life and interested enough to deal with upper-class problems. Both activities were solved due to their problem-solving skills and they achieved a full score of 100%. Since the first score was also high, it may not be right to say that the problem-solving skills are developed, so it would be correct to say that he only achieved the activities. The student, who was also indicated by his parents, who developed fluency skills, showed a 94.4% performance in garden activity and an 83.3% success in shot put. Shot put is the most challenging activity, so its performance was lower than the first activity. However, this is due to activity difficulty. When the student worked on the model, he grouped the numbers more fluently than the first weeks and accelerated his solutions. The student, whose reasoning skills are thought to have developed, achieved a success of 100% from his first performance, 88.8%. It is believed that activities help the students benefit from visualising the concepts and inferences, as they frequently use the processes they have learned in their daily lives. For understanding, the 100% performance in the swimming pool was reduced to 95% in the party cake. Although he did not understand the question, his performance decreased in the last activity, but 95% was very high. Therefore, it is possible to say that the student understands the activities related to comprehension skills and grasps the questions in general terms.

S3, the most significant achievement of the student is that he breaks his asociality, a point that his parents are upset about. The teamwork and collaboration environment in the course boosted the success of the course and reassured the self-confidence. In addition, problem-solving ability increased from 87.5% to 100% and eloquence from 83.3% to 88.8%, indicating that these skills have developed. However, the decrease in reasoning ability from 88.8% to 83.3% could mean that they did not make the connexion between questions sufficiently and did not understand the instructions. Because these are the most common types of errors in these activities. On the other hand, the percentage of students who had 100% success in understanding dropped to 90% in the next activity. The reason is that he solves the question without understanding. Therefore, it is not possible to make a clear interpretation of the development of comprehension skills, although it can be said that high performance was achieved in both activities.

When S4 was a student who was very dependent on the teacher in the first weeks, he felt the need to ask every step of the process and reached the right solutions without any further support. He has developed this skill because he has completed his fluency activities and increased his performance between the two activities from 83.3% to 88.8%. On the other hand, in problem solving, the increase from 95.8% to 100% indicates that he has learned alternative ways for problem solutions and can formulate the strategies required by the questions. The 94% success in comprehension skills and the increase from 4% to 95% is sufficient to say that this skill also develops slightly. For reasoning skills, 66% showed the highest performance increase by 6 to 94.4%, and activities contributed the most to the development of this skill.

Although S5 is a student who already loves mathematics and is in a very good condition regarding the status of the course, he had several positive reflections about the activity. Although problem solving skills and reasoning skills are quite high, the performance on the shot put, which can be used as a final test of the activities aimed mainly at developing fluency, dropped to 77.7%. This situation occurs when the student does not fully understand the questions. However, this ability develops to solve the questions more quickly and easily group the numbers in the model, according to the observation of parents and teachers.S6 is another student who is compatible with the class and loves mathematics. One of the most evolving features, according to the guardian, is communication and fluency. When we look at the performance in fluency skills, it is possible to say that the performance has improved from 88.8% to 94.4%. In problem-solving and reasoning activities, although the performance in the last activities is lower than the first one, we can say that these skills are improved even if they are not as fluent as they complete the activities with high success percentages. Particularly, the success graph, which reaches from 77.7% to 100% in comprehension skills, concludes that the questions that it suffers most are overcoming the problems of misreading and not understanding the instructions and understanding the more comfortable questions.

Student S7 is a student who has prejudices against mathematics and whose parents have problems with this subject. His parents stated that he had problems with mathematics homework and in class when he was not interested in individual work. Although there is no difference between the first and the last situation in terms of performance in fluent reading, it can be said that the student is successful because he has a success of more than 84%. This is because he was a student who needed individual tutoring in the first weeks and completed the activities in the class at the slowest pace, but in the following weeks he participated in the class with less help and correct answers and was able to follow the pace of the class. Students who showed higher performance in problem solving and reasoning skills compared to the class also increased their growth in these skills. The most significant difference for the S7 students was the decrease in post-activity math biases, faster and more fluent completion of activities, and presenting abstract concepts through models.

Students' Views on Concrete and Virtual Manipulatives

The MathBuilder software used in class was used to visualize the questions on the worksheet (Figure 4) for students by creating the models given or requested with the questions in the activity and to embody the new models created by the teacher or students. It has been shown that visualization is a pedagogical and financial facilitator during the activities. In order not to waste time during the activities they found easy, students preferred either to model on the computer or to create their physical models using only LEGO pieces, and for difficult questions they used both types of modeling. This is because modeling the solutions of difficult questions with both concrete manipulatives and software enabled learners to learn and solve the problem more easily. Usually, they used the software only to embody their ideas and solve the question more easily through visualization when the learner does not have a specific strategy for the question and they do not understand the question. However, when this is not the case, it shows that they prefer LEGO bricks when the questions are simple and they want to solve the question quickly. This is because they think that it is faster to use LEGO bricks than to create models in the software. S4: "Instead of clicking in the software, I would rather build with Lego bricks, it's faster."

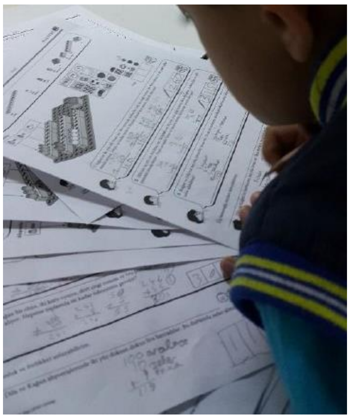

Figure 4. *Student Solves questions on Workshee*

Figure 5. *Student model on MathBuilder Software*

Software

Students felt the need to create models using software and LEGO bricks for questions that they did not fully understand or where they could not perform routine operations such as addition and subtraction (Figure 5). They solved the questions by examining the models they created using the top, side, or front views in 3D. In some cases, according to the researcher's observation notes, if the question is not very clear, they want to create a model with LEGO bricks first, if the question is clearer, they just need visual support, or if they are forced to create a model, they prefer to create a model in the software.

In addition to the interviews with the students, the researcher's opinions about what the students did with the software were sought from time to time. For example, students were asked what would have happened if we had only used the software. The students indicated that they did not find it amusing to use only LEGO bricks or only the software. In order to understand students' views on using sets of LEGO bricks in the classroom, students were asked questions. When S1 and S5 were asked whether one set of LEGO bricks was enough and whether it would be better if everyone had a separate set, the students indicated that they could work together and that one set was enough. S1: "One set is enough for us, my teacher would have been confused if there were two. "A similar question was asked again in a different time frame. Asked whether it would be better to give each student a set, S2 and S3 stated they found it boring to study separately. The students preferred to solve the questions in the activities by sharing their solutions in cooperation.

“R: Does S2 teach you anything during activity, S3? Sometimes when you can't solve the questions…

S3: Sometimes in free times, yes we are okay with that…”

The students were not disturbed to work together and had no problems sharing a set. The observations of the researcher confirm these findings. Activities related to teamwork strengthened the students' communication, enabled them to listen to others, and express their solutions to each other improved their expression skills.

Parents' Opinions on Manipulative Use

As a result of the interviews, it was seen that the parents of the students agreed that they and the students were satisfied with a mathematics lesson using LEGO bricks and computer software. From the parents' point of view, they all stated that their children were eager to come to the course and that they told about what they did during the day when they came home. Parents reported that using this educational tool enhanced students’ creativity while learning abstract concepts and provided opportunities for regular communication and cooperative group work in class. In addition, parents observed that their children socialized and accelerated while doing their homework and observed that they understood the division problems they learned during the second term of the school together with the course and understood the problems more easily.

Moreover, at the beginning of her parents "S2... There is nothing I cannot do in his nature, when we play games at home, he should definitely win". As a student who likes to win, he is always described as a student who wants to be first and foremost. However, according to the researcher's observations, the student could easily accept when he could not solve the question first in the activities. He was able to continue his relationship with his friend who solved the question first normally. In other words, it was observed that the behaviours described by the family did not occur during the activities. This can be referred to as ambition, this behaviour can be interpreted as decreasing and gradually decreasing. In addition, it was stated by the parents that the student always called his parents when doing homework. However, lately the parents observed that the student hardly needs any help and does all the work himself after some time. When the parents inquired whether S2 had made any progress after the course, his father said, "So he started doing math faster. For example, 40 questions in 10-15 minutes is very enjoyable so he comes and solves. He loves it more than anything else. For example, if you put his favourite toy, playing ball and riding bike, that place comes first. " It was noted that the student indicated that his speed increased when solving the two questions. He also shared that the student had a positive attitude about the course.On the other hand, S1's mother described her son as a student who did not like reading books and even solved questions without reading them. She said *“He doesn’t even bother to read questions at school exams…”* In this case, it can be said that the questions attracted the attention of S1 and found the lesson enjoyable. His mother also added that he was not an enthusiastic student to take responsibility. However, in the observation reports, S1 was observed to read the questions aloud and participate in the lesson during the activities solved in the classroom.According to his mother, if another plan was discussed in the family on the day of the course, S1 immediately intervened and stated that he had a course. Taking the responsibility of the student's course was another development that surprised and pleased his mother. It can be understood from the expression: “*In fact, for example, we are talking among ourselves, a program about tomorrow. He says no, I have a course tomorrow. Actually, he's not a responsible child, he doesn't follow the time and lesson about the school, but he's sensitive to the course…”* According to S1's mother, her son only wants to deal with difficult questions with a huge prize. She says “For example, the teacher sometimes writes award-winning questions on the board. When S1 comes home he says, *"Mom today I've solved the award-winning question"*. In light of this statement, S1 is known to be very active in the questions and in the classroom when necessary feedback and motivation are provided. However, it can be stated that the motivation needed by the student during the lessons is given because his participation in the activities is high.S6's parent stated that the student already loved mathematics and enjoyed solving with LEGO bricks. When the student goes shopping with her mother, the money account is stated by her parents. As the student's shopping activity she solved in the classroom, she calculated her mind from her budget and surprised her mother. This was stated in the interview with the researcher:

“S6Mom: She usually loved mathematics, but she is now faster to find the answers.

R: Well, then it was super. So, if S6 encounters a problem in everyday life, how does it solve something about mathematics? Like an example?

S6Mom: Exactly, I mean, if we go to the market together, I follow the prices or throw the clothes to the market. If I buy 20 pounds, my dear, we give them 50 pounds; how much money do they give us back? I say. Immediately, she says, mother, they will give us 30 pounds, quickly she answers. "

S7's mother explained that after the change of class teacher at school, S7's mathematics declined. She stated that the student usually spent a lot of time doing maths homework at home. Therefore, in one of the activities, her parent in the classroom had the chance to monitor student performance one-on-one and examined how S7 solves the questions. The result certainly surprised her, because the S7 quickly solved the activity questions independently and found the right answers with very few errors.

The parents were interviewed by S5's father and asked if there was any improvement when the learner affirmed that he was attending the course. According to his parents, S5, who is normally social, and he can often use mathematics in daily life. It is understood that the course provides an environment in which it can use its communication skills and keep it away from the technological tools in the house. Also after course, he can solve problems which has multiple steps. S4's mother says similar opinions with S5's father. According to her:*"S4 was able to focus more easily after coming to the course. The student began to understand the questions more easily and solve more accurately. "*The parents of S3 were interviewed simultaneously with their parents to obtain more detailed information about the student's general development and personality traits. According to his mother, the student came to the course fondly. S3, who also loves mathematics at school, can solve the difficulties in doing homework at home by consulting his family. His family stated that he enjoyed mathematics after the practice and showed responsibility for the continuity of the course. They said *"If we're out, he asks to us you're going to take me to a course, don't you think? His speed increased when he solve and* think *the solution to the problems."*

Parents who have never heard of the event have been told that it is an activity that their children excitedly tell them about when they get home, and that they solve questions by modeling with computer software and LEGO bricks. Apart from this, they seem to believe that it is an activity that accelerates and strengthens their mathematical skills while developing friendships and socializing them. The parents who help the students with their homework were involved one on one in this process. They believe that visualization is important in education. It is evident that the course gives the students a sense of responsibility and that they have no other agenda on the day of the course, they enjoy coming to the course and they believe it is beneficial to the students.

DISCUSSION AND CONCLUSION

Results of the Evaluation of Students' General Performance

It was found that students could understand the questions more easily when they embodied abstract concepts with concrete manipulatives (LEGO bricks). It was found that modeling enabled students to find the correct answer by reducing the time to solution. Therefore, it is concluded that visualization is important and computer program support is also necessary. After students visualized, it was found that their interpretation skills improved more. This situation is similar to Bulut's (2009) study which concluded that students who receive computer algebra support can analyze, visualize, and interpret problems more easily than students who do not. In the study, it was found that students who did not use computer programs answered fewer questions correctly and avoided interpreting their solutions and questions than the experimental group (Bulut, 2009). It has been found that students' use of mathematics programs and software enhances content learning in mathematics and geometry (Ertem, 1999; Keskin, 2016). In this study, it was found that modeling geometric shapes makes students' abstract knowledge more understandable. Visualization in mathematics using manipulatives increases attention and motivation, makes concepts meaningful by concretizing and organizing students' knowledge, and promotes the association of concrete and abstract expressions of concepts (Işık & Konyalıoğlu, 2005; Swan & Marshall, 2010).

It was understood through the student interviews that the students preferred the LEGO bricks as building toys more than the computer software. Although the students liked the software during the activities, it was understood that their priority was to build models with concrete LEGO bricks. When the students did not solve the question with the material, they solved the questions incorrectly. This is in parallel with Yurt and Sünbül's (2012) studies on the effect of using the virtual environment and concrete objects on spatial thinking and mental translation skills. The research concluded that students are more successful in the virtual environment, in a computer environment, instead of using concrete materials because of their mental translation skills during the abstract process period. This may conclude that students in concrete operations are more successful in spatial skills by using concrete materials. In the same way, it can be concluded that the students in the abstract operations period are more successful by doing modelling activities with virtual environments and computer software.

It is seen that concrete and virtual manipulative use allows and develops students' creativity. This is similar to Kandemir's (2006) finding that allowing students to use their creativity in an educational environment will lead to a positive attitude towards mathematics. Students enjoyed and enjoyed the modelling activities. Besides, it is known that the student's positive attitude towards mathematics increases mathematics literacy and prevents them from experiencing learned helplessness against the lesson (Koğ Uysal & Başer, 2011). The research results are in parallel with the finding that their performances are higher when they learn them fondly (Akyüz & Pala, 2010). Although many of the students already liked mathematics, they liked their work more and they understood what they did not understand more easily after the intervention. For example, some students saw the issue of division simultaneously as the school and others saw this subject first in course, before school. The students who divide large numbers into smaller numbers by using concrete manipulatives stated that they remembered what they did during the course while performing the division process at school. In this case, it is concluded that students transfer what they have learned to school life. Although the students want to use this system in school, they think the activity can be difficult because they think their classes are crowded.

Consequences for Parents

When the opinion of parents was sought, it was concluded that the lessons motivated their children. This playful environment attracted even the students who did not read books and answered the questions in school. It allowed them to solve the questions by reading, modeling, and having fun. It provided an opportunity for the children to socialize and improve their communication skills. Poon (2018) found a similar result that using LEGO as a manipulative tool with preschool children in the classroom improved the children's communication skills, creativity, teamwork skills, hand-eye coordination, and motor skills according to the teachers. According to Boucher and Amery (2009), play allows the child to learn, develop, gain self-confidence, process experiences gained through discovery, increase creativity, and socialize while having fun. Levin and Rosenquest (2001) also argue that games help children interact with people and explore the world. Looking at all these definitions, it is found that play arouses strong emotions by entertaining, socializing, and enabling people to understand and learn about their environment. Although mathematical activities were carried out during the study, a playful mood generally prevailed and students enjoyed learning. It was concluded that playful environments allow for entertaining learning and that this situation is important from the parents' point of view for their children.According to the parents, this activity adds to the students' ability to perform their daily mathematics operations more quickly. It is seen that their perceptions are more open and they can use these activities in daily life, for example, in shopping or grocery stores. It is also a result of the parents' view that their children take responsibility for their own learning and solve their homework with less help. When we look at the students' skills progress through the parents' eyes, it is seen that the parents who think that the activity improves their fluency skills are S1, S2, S3 and S4 families. While parents of all students argue that there is progress in problem-solving skills, it can be said that activities aimed at this skill enable students to understand incomprehensible concepts and read the questions more accurately, since the parents of S1 and S7 only emphasize comprehension skills. Looking at the parents' view of reasoning skills, it can be seen that students like S1, S2, S5 and S6 are normally contributing to high mathematics achievement. After the activity, these students developed these skills by using more mathematical operations in their daily lives and made them aware of their parents.

Suggestions

To understand more clearly how student performances develop in problem solving, fluency,

In order to improve reasoning and comprehension skills, it is necessary to develop appropriate measurement tools for these skills. This is because it is difficult to obtain sufficiently objective information from observations and interviews alone.

Since such activities contribute to students' mathematical skills and are found to be enjoyable /motivating by students, it is recommended that courses be offered to improve the knowledge and skills of teachers in training in this direction. In addition, there may be in-service training courses for teachers in training for their professional development.

In order for students to develop their skills in mathematical content and processes at an early age, their parents can also conduct activities at home, relate mathematics to daily life, stimulate concrete examples and encourage their children to acquire new knowledge or repeat what they have learned at school. because students are interested in such courses and these courses contribute to mathematical skills and accelerate, contribute to communication skills and the ability to take responsibility. Therefore, parents can plan such activities for these skills.

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Appendix

Appendix 1: Student Interview Form

1) Would you love math before this course?

• What types of questions can you solve in mathematics mostly?

• Do you have difficulties in mathematics? (For example, creating patterns, collecting large numbers, division process)

2) What do you think about math after this course?

3) Have you ever used modelling to solve questions at school? Did you visualize/ think about it in class?

4) Have you learned anything you didn't know before in the activities we did here?

• Which activity do you like the most? Why?

• What was the most difficult of you? Why?

5) Have you ever used such a training program before?

• Is it better to do something on the computer or on the tablet?

• Is it more difficult to make the software without a mouse?

6) Is it just good to model with software or with LEGO bricks? Or do you need two?

Appendix 2: Interview Form for Parents

1- Have you ever heard of LEGO MoretoMath?

2- Has your child used LEGO or robotic systems before?

3- Does your child like maths? Did he/she like it before this course?

4- Do you do homework together at home? How do you solve math assignments?

* If you solve the questions together, how do you explain the unclear points?

5- How is your child's attitude towards mathematics after this practice?

6- Has there been any change in the way your child thinks or makes calculations during the time we do the practice?

7- How does he/she solve a problem in daily life?

8- Does he/she make money account in shopping or elsewhere and takes a similar responsibility?

9- How does he/she interact with friends? Can he/she easily be part of a group?

10- Do you have any other opinions you want to add?