IMPACT OF 5E LEARNING CYCLE ON SIXTH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT ON AND ATTITUDES TOWARD MATHEMATICS

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ABSTRACT

IMPACT OF 5E LEARNING CYCLE ON SIXTH GRADE STUDENTS' MATHEMATICS ACHIEVEMENT ON AND ATTITUDES TOWARD MATHEMATICS

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The purpose of the study was to investigate the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics. The study was carried out in a public school in one of the towns of the Central Anatolia Region with 28 sixth-grade elementary school students. One group pretest-posttest design was used. Mathematics Achievement Test and Mathematics Attitude Scale were administered to collect the necessary data. The instruction will be applied by the researcher five hours per week in a 15-week. The data were analyzed by using one-way repeated measures analysis of variance and a paired-samples t-test.

According to the results of the study it was found that there was a statistically significant change in mathematics achievement of sixth grade students who participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up). There was only no statistically significant mean difference between post-intervention and follow-up mathematics achievement. Furthermore, there was a statistically significant decrease in mean scores of attitudes toward mathematics from prior intervention to after intervention.

Keywords: 5E learning cycle, mathematics achievement, attitude, manipulatives

ÖZ

5E ÖĞRENME DÖNGÜSÜNÜN 6. SINIF ÖĞRENCİLERİNİN MATEMATİK BAŞARISINA VE MATEMATİĞE YÖNELİK OLAN TUTUMLARINA ETKİSİ

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Çalışmanın amacı, 5E öğrenme döngüsünün 6. sınıf öğrencilerinin matematik başarısına ve matematiğe yönelik olan tutumlarına etkisini araştırmaktır**.** Çalışma İç Anadolu Bölgesi'nde bulunan bir ilçedeki devlet okulunda 28 altıncı sınıf öğrencisiyle yapılmıştır. Bir gruplu öntest – sontest araştırma deseni kullanılmıştır. Matematik başarı testi ve matematik dersine yönelik tutum ölçeği gerekli verileri toplamak için uygulanmıştır. Uygulama araştırmacı tarafından haftada beş saat olmak üzere 15 hafta yapılmıştır. Veriler tek yönlü tekrarlı varyans analiz ve bağımlı t-test kullanılarak analiz edilmiştir.

Çalışmanın sonuçlarına göre, 3 zamanlı periyotta (uygulamadan önce, uygulamadan hemen sonra, belirli bir zaman sonra) 5E öğrenme döngüsüne dayalı ders işlenişine katılan 6. Sınıf öğrencilerinin matematik başarısında istatistiksel olarak anlamlı bir değişim bulunmuştur. Sadece uygulamadan hemen sonrası ve belirli bir zaman sonrası matematik başarıları arasında istatistiksel olarak anlamlı bir ortalama farkı yoktur. Ayrıca ilk uygulamadan son uygulamaya kadar geçen süreçte matematiğe yönelik tutum puanlarının ortalamasında istatistiksel olarak anlamlı bir azalma vardır.

Anahtar Kelimeler: 5E öğrenme döngüsü, matematik başarısı, tutum, öğrenme materyalleri

To My Mother

Ayşe BALCI

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LIST OF ABBREVIATIONS

SCIS: Science Curriculum Improvement Study

BSCS: Biological Sciences Curriculum Study

MAT: Mathematics Achievement Test

MAS: Mathematics Attitude Scale

MoNE: Turkish Ministry of National Education

NCTM: National Council of Teachers of Mathematics

ANOVA: Analysis of Variance

M: Mean

SD: Standard Deviation

df: Degrees of Freedom

p: Probability

CHAPTER 1

INTRODUCTION

Students are generally expected to learn mathematics meaningfully and have a positive attitude toward mathematics in order to acquire the various mathematical skills needed to handle the problems they encounter in real life. Gaining these skills and making them life-long requires a modern education but not an education that includes memorizing. Since 2003 the Turkish Republic of Ministry of National Education (MoNE) spent intensive efforts for development of mathematics curriculum in order improve the educational system in Turkey. These efforts resulted in the development of the new reformed elementary school mathematics curriculum which has been applied in all primary schools all over the country since 2005-2006 education years. This curriculum is based on the principle that “every child can learn mathematics” (MoNE, 2008). Besides conceptual learning, significance has been allocated to procedure skills. Moreover, emphasis was given to the affective domain of the children as it promotes students’ positive attitudes toward mathematics. Finally, the curriculum focuses on discovery learning and cooperative working and the 5E learning cycle (MoNE, 2008).

In the mathematics education literature some instructional methods have been utilized in teaching/learning mathematics. In the present study, 5E learning cycle is utilized despite its being a method generally utilized in science learning as it is, based on the activities which are experimental. In other words, it is basically a constructivist learning theory. This model was built on the results of National Science Education Standards (Newby, 2004). 5E learning cycle is something that improves students’ enthusiasm of investigation, meets their expectations and encourages them focus on active research. Moreover, it is a model that utilizes skills and activities. It also provides students with opportunities to learn the already known deeply and meaningfully. With the help of Biological Science Curriculum Study (BSCS) a reliable formula has been defined to view constructivism. The process is defined as five "E"s. These 5 Es represent the verbs engage, explore, explain, elaborate and evaluate (Bybee, 2001). In the engagement stage, firstly the instructional task is identified and introduced to the students. In this stage, connections are made between past and present learning experiences. They concentrate on this task by asking questions, describing a problem, demonstrating a surprising event and making act-outs. In the exploration stage, the students have the opportunity to engage with the materials and phenomena. By this way, they have the chance to construct experiences with the phenomenon. By working cooperatively, students construct a sense of common experience which helps them in sharing and communicating. The facilitator is the teacher who provides materials and guides the students' concentration. If the students are curious and inquire, these characteristics run the instruction of exploration. In the stage of 'explain', the students begin to have abstract experiences. A logical format of motivation is composed by language. Communication is provided by peers, facilitators, or the learner himself. By working cooperatively, learners support each other's considerations as they work together. Language itself is a tool of communication labels. These labels provide the learner with a variety of explorations. Explanations of the facilitator can provide names corresponding to historical and standard language with student findings and events. However, the labels should be introduced after the child has had a direct experience because this experiential base offers the student an attachment place for the label. Using the same language increases the sharing and communication between facilitator and students. The facilitator can discover levels of misconception and conception. The learner's development, progress and growth are provided by some communication tools such as tape recordings, videos, writings or drawings. In the stage of 'elaborate', the students enlarge their conceptions, make connections between related concepts and use what they have learned in the real world. These connections initiate further inquiry and new conceptions. The last stage which is evaluation is the process allowing the teacher to see if the students have attained conceptions and knowledge. Nonetheless, evaluation and assessment could take place at all points of the process (Bybee, 2001).

When compared to other approaches of instruction, the Science Curriculum Improvement Study (SCIS) learning cycle has many advantages according to a number of studies made (Bybee, et al., 2006). Since its start in the 1960s, there have been many studies focusing on the assessment of the learning cycle's effectiveness (Lawson, 2001). That lab activities precede teacher-led lectures of the concepts to be taught is a key feature of the learning-cycle. Since the start in 1960s, the learning cycle has been the focus of many studies which were conducted to discover its effectiveness (Ates, 2005). In different areas of education, the SCIS learning cycle has been implemented and reported to be a big success (Bybee, et al., 2006). There is not many research-based instructional models such as the learning cycle which lets students think more critically than most of all the hands-on activities or discovery activities alone (Settlage, 2000).

No matter how many the number of phases there are in a learning cycle, each has its center in the same inductive instructional sequence. Shortly, active engagement of students in investigating the natural phenomena begins the learning cycle. Throughout this exploration, the teacher acts as facilitator by, providing the materials and directions which guide the physical process of the experiment. When the exploration finishes, the teacher promotes a period of discussion in which students share their observations with classmates. In this time, the teacher makes connections between student experiences and the target science concept which includes the identification of scientific vocabulary. By the time the concept has been taught, students are included in additional activities in which they apply their recently conformed ideas to new situations. All in all, it is not easy to be a skilled learning cycle teacher, which requires both time and effort. Nevertheless, when the teacher got skilled, it is very rewarding for both the students and the teacher. Once you become a real learning cycle teacher, you can never go back again (Lawson. 2001). Despite the reported benefits of learning cycles, not many studies have been conducted on the 5E learning cycle (Wilder & Shuttleworth, 2004). However, most students have anxiety of mathematics. Students who used traditional approach were reported to have higher levels of anxiety than those who used the alternative approach (Newstead, 1998)

The purpose of the present study was to investigate the impact of the 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics. The activities were prepared and applied to enable students to understand the lesson easily, have fun and determine their own abilities. Before the treatment a mathematics achievement test and mathematics attitude scale were administered. After the application of pre-tests, the instruction based on 5E learning cycle was applied within 15 weeks. After the treatment the measuring instruments were given to the participants once more. Moreover, a mathematics achievement test was applied to students 6 weeks later as a retention test.

1.1. Main and Sub-Problems of the Study and Associated Hypotheses

In this section main and sub problems and hypotheses are stated.

The main problem was stated as "What is the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics?"

It consisted of two sub-problems. They were given below:

1. Does 5E learning cycle have an impact on sixth grade students' mathematics achievement?
2. Does 5E learning cycle have an impact on sixth grade students' attitudes toward mathematics?

In order to investigate the main problem following two hypotheses were stated in the null form and tested at a significance level of 0.05.

H_o 1: There is no statistically significant change in mathematics achievement of sixth grade students who participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up).

H_o 2: There is no statistically significant mean difference between prior and post attitudes toward mathematics scores of sixth grade students who participated in the instruction based on 5E learning cycle.

1.2. Definitions of Terms

The important terms used in the study were explained below:

5E Learning cycle: 5E learning cycle is one of the constructivist approach models, developed by the BSCS group. It consists of five phases; engagement, exploration, explanation, elaboration and evaluation (Bybee, et al., 2006).

Engagement: The learners' prior knowledge is accessed by the teacher or a curriculum and the teachers assist them to be engaged in the lessons through the use of short activities which make them curious about learning and assess the pre-knowledge. A connection was made between past and present knowledge (Bybee, et al., 2006).

Exploration: Students are provided with a common base of activities by exploration experiences. Learners are let to use pre-knowledge to compose new ideas, explore questions and possibilities and design an investigation (Bybee, et al., 2006).

Explanation: The students' concentration is directed through experiences, by the explanation phase the students are provided with opportunities to show their conceptual understanding, process skills or behaviours. The critical part of this phase is that there can occur a deeper understanding by the teachers' explanations (Bybee, et al., 2006).

Elaboration: Students' conceptual understanding and skills are challenged by teachers. The students are provided with deeper and broader understanding by new experiences. Students implement their understanding by additional activities (Bybee, et al., 2006).

Evaluation: Students are encouraged to assess their understanding and abilities by the evaluation phase and the teachers are provided to assess student progress (Bybee, et al., 2006).

Mathematics achievement: It refers to students scores obtained from mathematics achievement test.

Attitude: It refers to “a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept or another person” (Aiken, 1970, p.551).

Attitudes toward mathematics: It refers to score obtained from Mathematics Attitude Scale.

Manipulatives: It refers to the “objects that students can grasp with their hands” (Clements, 1999, p. 46).

1.3. Significance of the Study

Although only a few studies have investigated the effect of the 5E learning cycle on mathematics achievement and attitudes toward mathematics (e.g. Baser, 2008; Hiccan, 2008; Ozdal, Unlu, Catak & Sari, 2006), there were many studies on both the 5E learning cycle and science achievement and attitudes toward different science fields (e.g. Balci, 2005; Cakiroglu, 2006; Cardak, Dikmenli & Saritas, 2008; Demircioglu, Ozmen & Demircioglu, 2004; Ozsevgec, 2006; Saygin, Atılboz & Salman, 2006; Yildirim, Er Nas, Senel & Ayas, 2007). However, not many studies on the 5E learning cycle and mathematics were conducted in Turkey. In fact, most of these studies on science and 5E learning cycle were conducted abroad (e.g. Lord, 1999; Whilder & Shuttleworth, 2004). Because Turkey’s new elementary school mathematics curriculum recommends the application of 5E learning cycle with 5 stages engagement, exploration, explanation, elaboration, evaluation , and development of positive attitudes toward mathematics (MoNE, 2008), it is necessary to conduct research studies on the instruction based on 5E learning cycle in mathematics courses by taking into consideration students' attitudes toward and achievement in mathematics. Hence, this study will contribute the mathematics education literature by investigating the impact of 5E learning cycle on students' mathematics achievement and attitudes toward mathematics.

The present study included 5E learning cycle oriented activities in the subjects of probability, prime numbers, natural numbers, statistics, integers, time, factors, multiples, divisibility and fractions. With the help of this research, mathematics teachers will be enlightened on the effects of 5E learning cycle on students' achievement in mathematics and attitudes toward mathematics. They also can learn the positive and negative experiences during instruction. In light of the reported results, teachers may be able to improve their instruction. In other words, they can develop their own instruction based on 5E learning cycle by removing the obstacles occurring during the instruction accomplished in this study. Shortly, this study can be feedback for them. In addition to the teacher, this study can be shown as an example of the 5E learning cycle to teachers in pre-service teacher education and in-service training programs. Finally, the present study can serve as a basis for future research studies on 5E learning cycle in mathematics.

CHAPTER 2

REVIEW OF THE LITERATURE

The literature related to the present study was reviewed in this chapter. On the basis of the content and the main objectives of the study, the literature consisted of three sections: 5E learning cycle, manipulatives and attitudes toward mathematics.

2.1. 5E Learning Cycle Model

In this section, firstly theoretical background for 5E learning cycle was explained. Secondly, the research studies on the utilization this cycle in mathematics and science were given.

2.1.1. Theoretical Background for 5E Learning Cycle

An instructional model for constructivism was developed by the investigator Roger Bybee in BSCS. This instructional model was called the "Five E". Shortly, we could summarize this learning approach connected with science like this; learning something new or attempting to something familiar in greater depth. While we were trying to learn something new, we used both our prior experience and the first-hand knowledge gained from new explorations. Stage by stage, the knowledge was gained. Sometimes, the pieces were connected for better understanding. When the pieces did not fit together, the old knowledge had to be broken and renewed. Our conceptual understanding was made bigger and larger by the help of discussions and creative efforts. It was proved that our theories were true as the problems were solved. If we gained clarity in understanding a concept, it gave us the ability to implement this understanding to new situations and new mysteries. It was a permanent and very individual process. It was seen that the effects of our developmental level, our personal story and style in learning experiences. Facilitating the constructivist learning process was up to the teacher. Opportunities were offered for the structure of learning environment and for the events that promote and give rise to the building of understanding. With the help of the BSCS group a reliable formula had been defined to view constructivism. The process was defined as five “E”s. They were engage, explore, explain, elaborate and evaluate (Bybee, 2001). There were five phases in the BSCS model: engagement, exploration, explanation, elaboration, and evaluation. When formulating the BSCS 5E Instructional Model, the SCIS learning cycle was deliberately carried out. The three elements of the BSCS model that were exploration, explanation and elaboration were adapted from SCIS and basically equivalent to the models of exploration, invention (term introduction) and discovery (concept application) (Bybee, et al., 2006). 5E learning cycle requires learning new things, or trying to consider familiar things in a deep way. It was not a procedure which was linear. In learning new things, the students used both their pre-knowledge and newly acquired knowledge from new explorations. The science lesson required several months and weeks to be over. The 5E learning cycle was structured through the tasks of inquiry which was recognized in the National Science Education Standards (Newby, 2004). Each phase was explained below (Bybee, et al., 2006).

The engagement is the first phase in which students are involved in the learning task. Students become mentally focusing on an object, problem, situation, or event. In this task, the activities make connections to past experiences and exposed students’ misconceptions; they should serve to mitigate cognitive disequilibrium. The students are engaged to problematic situations by some ways, such as asking a question, defining a problem, showing a discrepant event and making them focus on the instructional phase. What the role of the teacher is to pose the situation and recognize the instructional task. And also, rules and procedures for establishing the task are set by the teacher. As a result, after successful engagement, students are puzzled by and actively motivated in the learning activity, referring to both mental and physical activity (Bybee, et al., 2006).

The second phase is called as "exploration". When the students are involved in the activities, the students have psychological need for time to explore the ideas. The reason for the design of exploration activities is that the students in the class have common concrete experiences upon which they go on formulating concepts, processes and skills. Disequilibrium resulted from engagement and the process of equilibration begins with exploration. This phase should be concrete. Although educational software can be used in the phase it should be carefully designed to help the initial process of formulating adequate and scientifically correct concepts. The purpose of exploration activities is to establish experiences that both students and teachers can use later to discuss concepts, processes or skills. Throughout the activity, the students have time in which they can find out objects, events or situations. Being mentally or physically involved in the activity makes students establish relationships, observe patterns, identify variables and question events. The teacher is like a facilitator or coach in the exploration phase. The teacher gives the students time and opportunity to investigate objects, events or situations during the activity, these situations are based on each student's own opinions about the phenomena. The teacher begins to coach or guide students as they are reconstructing their explanations. Moreover, using tangible materials and concrete experiences is necessary (Bybee, et al., 2006).

The third phase is called as "explanation". In this phase the act or process in which concepts, processes, or skills becomes plain, comprehensible and clearly defines the word "explanation". Explanation process let both the teachers and the students know a common use of terms relative to the learning task. In this phase, students' attention to specific aspects of the involvement and exploration experiences is directed by the teacher. Firstly, the students' ideas are asked to give their explanations by the teacher. Exploratory experiences are ordered by explanations. The initial part of this phase is based on the students' explanations. The explanations are clearly connected to experiences in the engagement and exploration phases of the instructional model. Presenting concepts, processes or skills briefly, simply, clearly and directly and moving to the next phase are the keys to this phase. A variety of techniques and strategies to extract and develop student explanations are used by teachers. Verbal explanations are commonly used by educators; but there are also numerous other strategies; such as videos, films and educational software. In this phase, the process of mental ordering continues and terms for explanations are provided. Finally, exploratory experiences and experiences that have engaged them by using common terms can be explained by the students. Since learning takes time, students will not instantly express and implement the explanations (Bybee, et al., 2006).

The fourth phase is “elaboration” in which when the students have an explanation and terms for their learning tasks, involving the students in further experiences that extend, or elaborate, the concepts, processes or skills is important. This phase simplify the transfer of concepts into the new situations. But misconceptions can already be in some situations; or they may only understand a concept in terms of the exploratory experience. Further time and experiences, contributing to learning are provided by elaboration activities. The use of interactions within student within student groups as part of the elaboration process is notable. Opportunities for students to express their understanding of the subject and receiving feedback from others who are very close to their own level of understanding are provided by group discussions and cooperative learning situations. Involving students in new situations and problems that required the transfer of identical or similar explanations is also an opportunity in this phase. The first aim is the generalization of concepts, processes and skills (Bybee, et al., 2006).

The last phase of 5E learning cycle is evaluation. It is a vital for students to use the skills they have acquired and evaluate their understanding. Moreover, feedback should be received on the adequacy of their explanations by the students. At the beginning and throughout the 5E sequence, informal evaluation can occur. A formal evaluation after the elaboration phase is completed by the teacher. Educational outcomes should be assessed as a practical educational matter. In this phase, teachers manage assessments to discover each student's level of understanding (Bybee, et al., 2006). Even though, "evaluation" is presented as the final stage of 5E learning cycle, it is possible for it to occur at each stage of the instructional unit. It did not need to be formal. It can be an instant question from the teacher or a unit test and assessment on specific information (Orgill & Thomas, 2007). Evaluation and assessment can happen at all phases of the permanent instructional process. Here are some of the means that help in this diagnostic process: rubrics (qualified and prioritized outcome expectations) determined hand-in-hand with the lesson design, teacher observation structured by checklists, student interviews, portfolios with specific aims, projects and problem-based learning products and fixed assessments. In communications between students, teachers, parents and administrators, concrete evidence of the learning proceed is very valuable seeing the evaluation process as permanent caused the constructivist philosophy to be a kind of cyclical structure. The learning cycle is open to change. In this cycle, questions lead to answers. Moreover, more questions and instruction is driven by both predetermined lesson design and the inquiry process (Bybee, 2001).

2.1.2. Research Studies on 5E Learning Cycle and Achievement

While there were too many studies about 5E learning cycle in the world, in our country these studies were limited. 5E model was generally carried out in science lessons but seldom in mathematics classes.

In Turkey we met three research studies on both 5E learning cycle and mathematics. They were conducted with Ozdal, Unlu, Catak and Sari (2006), Baser (2008) and Hiccan (2008). They were explained below:

Ozdal, Unlu, Catak and Sari (2006) undertook the mathematics' design project in 2003-2004s for the Malaysia Ministry in their studies in the name of RtB Educational Solutions. In the project, a teaching courseware which could be used by mathematics teachers was prepared as being suitable for 5E learning cycle. This courseware was prepared for grade 7 about the teaching of Pi. In the work, the teaching of Pi was applied by introducing the sequences of 5E. After this application, it was seen that the students understood Pi and applied it to new situations.

Another study on both 5E learning cycle and mathematics was carried out by Hiccan (2008). In her study she examined the influence of 5E learning cycle on 7th grade students' achievements in linear equation with one variable. She found that the in 5E learning cycle group there was statistically significant difference pre and post achievement. In addition, while retention test scores were greater than pre-test scores, it was less than post-test scores. Moreover, it was revealed that 5E learning cycle had a statistically significant effect on conceptual and procedural knowledge.

In her study, Baser (2008) aimed to compare the application of teaching activities of 5E model based on constructivist approach with traditional teaching methods for teaching of cylinder, empty circle and filled circle topics in primary education seventh grade mathematics lesson. Analysis results showed that the students who studied with the activities of 5E learning cycle learnt better than the students who studied with traditional teaching methods.

In the present study includes some of the research studies on 5E learning cycle and science discipline because of the few studies on 5E learning cycle and mathematics. They were explained below.

Study performed by Campbell (2000) investigated the fifth grade students' understanding of force and motion concepts through the use of the 5E learning cycle. Students participated in investigations about force and motion concepts weekly for a period of 14 weeks. Findings showed that students' knowledge about force and motion concepts increased although their knowledge as demonstrated on paper was insufficient. It seemed that the students were of the same opinion that learning science through text book was not the best way for them.

The aim of the study conducted by Ozsevgec, Cepni and Bayri (2007) was to discover the effectiveness of the 5E model on 5th grade students' constant conceptual changes. The researcher developed the 5E learning activities based on the 'Force and Motion' unit's objectives. It was noticed that although there were not differences between the initial conceptual level of the experiment and control group students before 5E learning cycle, after the application, treatment group students were better at having conceptual changes than the students in the control group. However, the difference was remarkable between the pre-test and post-test scores, on the other hand, we did not see much important changes between the post-test and retention test scores in the students of treatment group. As a conclusion, 5E model was more effective in changing students' attitudes than traditional instruction.

Ozsevgec (2006) investigated the effect of 5E learning cycle on 5th grade students' achievement and attitudes toward science and technology course. It was found that there was a statistically significant mean difference in the favour of 5E learning cycle group.

In another study performed by Lee (2003), in his lesson of plant nutrition which was prepared according to learning cycle during 10 years, provided from 5E learning cycle to make the lesson more real by using real plants as well as pictures and figures. In this way, students were in an interaction with each other with small groups and in the level of all classrooms. Eventually, the students were provided to acquire knowledge about the plants in daily life and also to understand the concepts better.

Study performed by Whilder and Shuttleworth (2004) investigated in the effectiveness of 5E learning cycle in "Cell Inquiry". The participants of the study consisted of high school students in the lesson of Biology-1. In the start of study, students were provided to rethink what they learned and knew and were made to be motivated. In the phase of exploration, the students were faced with everyday-life situations but in the phase of explaining, the teacher led students to explain their own results scientifically. In the sequence of extension, the students were given more problems and different problems, and in the sequence of evaluation, they wanted to see if the students developed a true understanding on the concepts.

Saygin, Atilboz and Salman's (2006) studies were carried out by 47 students in 9^{th} classes. In the classes in which constructivist teaching approach was applied, Rodger Bybee's 5E model was used. The tests were applied to students as pre-test and post-test. It was reported that, the students who studied with constructivist teaching approach were more successful than the ones who studied with traditional method in learning the cell subject.

Balci (2005) was studied photosynthesis and respiration in plants with 8th grade students. In the first experimental group, the classes were assigned according to the 5E learning cycle and in the second one, the classes were assigned according to the conceptual change text based instruction. As for the control group, the traditional teaching method was applied. Two-tier multiple choice diagnostic test was applied to all test groups as pre-test and post-test. The results show that the students of experimental group were more successful. Moreover, the methods applied in the experimental groups were impressive in eliminating the students' misconceptions.

In other study effectiveness of 5E learning cycle on 8th grade students' achievement on photosynthesis and respiration in plants was investigated by Cakiroglu (2006). Students' knowledge on photosynthesis and respiration in plants was determined by a test developed by Haslam and Treagust. This test was applied to 67 eight-grade students in two classes of the same elementary school as pre-test and post-test while the experimental group students (n=33) learned the lesson by 5E learning cycle instruction, control group students (n=34) learned the lesson by traditional instruction. The significant difference was found between the experimental and control groups in favor of 5E learning cycle instruction.

Another research conducted by Lord (1999) compared 5E learning cycle instruction with the traditional instruction in environmental science course by choosing two control and two experimental groups which consisted of college undergraduates. Each group was given environmental science class by the instructor for 90 minutes 2 times a week. Data was collected by using polls, determining student ideas with 3 multiple-chosen exams composed from 50 questions. As a result, it was seen that experimental group's approximate test scores were higher than the control group. In the questions about remembering the knowledge, both groups got nearly the same scores. But in the questions about interpreting, analyzing and thinking critically, the control group students showed lower performances.

Cardak, Dikmenli and Saritas (2008) aimed to investigate that the effect of the 5E learning cycle on sixth grade students' achievement during the circulatory system unit. While the experimental group and the control group were the same at first, after implementation, there was an important difference in favour of the experimental group.

The study performed by Demircioglu, Ozmen and Demircioglu (2004)was based on the 5E, which was instructional model for the constructivist view of learning, about the topic "Factors Affecting the Solubility Equilibrium" in lycee-2 chemistry curriculum. It was noticed that experimental group students were more successful than the other group. Because in the experimental group, the activities used were based on 5E learning method. Moreover, the students' opinions were taken into consideration.

Yildirim, Er Nas, Senel and Ayas (2007) expressed the aim of their study to. discover 7th grade students' misunderstandings about dissolution and melting and solution them via activities designed based on the 5E learning cycle. At the beginning of the study, a concept test was implemented as a pre-test. According to the results of the test, an activity was developed based on the 5E learning cycle. The teacher implemented the activity regularly in the period of the lesson. After two weeks passing, pre-test was implemented as post-test. Finally, three students played role in the semi-structure interviews that was conducted. At last, it was pointed out that the activity designed according to the teaching model affected students in a positive way in remediation of students' misunderstandings about dissolution and melting.

Orgill and Thomas (2007) suggested that analogies could be useful tools in each phase of the 5E learning cycle and pointed out that science classes would provide from performing the lesson with the challenging concepts that were related to everyday experiences. They gave examples about what the students and teachers could do while using analogies in each phase.

2.2. Manipulatives

In this section the theoretical background and the findings of research studies for the manipulatives in teaching/learning mathematics were explained.

2.2.1. Theoretical Background for Manipulatives

This approach of using manipulatives in mathematics had a long history. In the 19th century Pestalozzi supported their use, and manipulatives were comprised in the activity curriculum of the 1930s. In the mid-1960s there was also emphasis on using concrete objects and pictorial representations in the instruction of mathematics (Sowell, 1989). Both Pestalozzi, in the 19th century, and Montessori, in the early 20th century, supported the active participation of children in the learning procedure. In all decade since 1940, the National Council of Teachers of Mathematics (NCTM) had supported the use of manipulatives at every grade levels. Indeed, every recent issue of the “Arithmetic Teacher” had emphasized the importance of manipulatives (Hartshorn & Boren, 1990).

The small students learn better and with more meaning, in the learning environment in which the knowledge was given with the concrete models. So, using concrete models in mathematics teaching was so important. In teaching, the conditions that the knowledge was represented in different ways must be used (symbols, concrete means, photos, oral and written expressions etc.) (MoNE, 2008). According to Barman and Allard (1993) abstract thinking begins when a person begins to make the transition from concrete operational to formal operational thinking. This was a gradual process and this person making the transition could do abstract reasoning in some areas, but in all. According to Piaget, mental maturity was not affected only by age. He said that if a person lacked appropriate physical experiences and verbal interaction as a child, this person may not use formal reasoning to deal with specific concepts even as an adult. Understanding specific abstract concepts requires a person thinking by using concrete teaching methods encouraging appropriate discussion with peers and the instructor.

All students from prekindergarten through grade 12 in instructional programs were provided to;

- Produce and use representations to make organization, record and consider about mathematics.
- Make selections, implement and translate among representations to had solutions.
- Use representations to create copy, comment about physical, social and mathematical phenomena (NCTM, 2000).

According to Heddens (2005) manipulative materials were concrete models involving mathematics concepts, appealing to various senses to be touched and moved around by the students. The manipulative materials must be related with the students' real world. Each student should manipulate the materials independently. It was not enough for demonstrations to be just by one student or the teacher. They must be chosen if they were proper for the concept being developed and for the improving level of students.

Suydam and Higgins (1977) carried out a meta-analysis of studies consisting of manipulatives and provided some recommendations on proper use of manipulatives:

- Manipulatives should be a constant characteristic in a whole mathematics program supported by the program's aims.

- Manipulatives should be connected with other media consisting of pictures, diagrams, textbooks, films and similar materials.
- Manipulative materials should be used in proper ways to mathematics content, and the content should be changed to increase the use of manipulatives.
- Manipulatives should be used with both exploratory and inductive approaches.
- In the mathematical studies, the simplest materials should be used.
- In organizing content, manipulatives should be used to help children.
- Manipulatives should be used with programs which give rise to become symbolically.

Mathematics manipulative was the representation of any object or material from the real world so children should see the realities to understand the mathematics concept. Manipulatives in teaching mathematics take a very big importance in understanding. But there was also a potential of being harmful if they were used poorly. In this way, students will be made to believe that there were two existing worlds; manipulative and symbolic. Now that all mathematics was related with the real world, then the real situation must be transformed into the mathematic symbols for calculating (Heddens, 2005). He reported that appropriate mathematics materials were durable, simplistic (easily manipulated), attractive (to create interest), and manageable. As a conclusion, using manipulatives in mathematics effectively helps to understand the concepts better.

Recently, the general view was that the concrete materials should be used in the mathematics teaching in the primary school for an impressive teaching (Thompson, 1994). The students' activities in class play a vital role in formalizing the teachers' beliefs of self-proficiency and self-sensation that helps them to be motivated and be interested (Antencio, 2004). Activities play a role in students' building conceptions that were meaningful about mathematics (Clements, 1999). Students' learning was improved by the active role of students in the lesson according to experiential education. However, it was hard to apply this idea to mathematics because of being “abstract”. Using manipulatives was the practical route for getting experience to have about mathematical understanding. It was widely accepted the importance of manipulatives by the teachers in primary grades. Furthermore, there was a new interest in the use of manipulatives across all grades accordin g to the recent studies of mathematical learning (Hartshorn & Boren, 1990).

Kober (1991) suggests that despite the perceptions of some teachers, manipulatives were still effective instructional means for both middle school students, elementary students and for children with various achievement levels.

The representations rising students’ thinking were provided by teachers who play a vital role in establishing mathematical environments (Moyer, 2001). Burns (1996b) points out that not only the students struggling but also the others could benefit from manipulatives’ uses.

According to Klein (2005) in higher grades, educational goals which were important could be sabotaged by manipulatives. When a physical object was appropriate in a demonstration, there may be situations but paper and pencil were by far the most useful and important manipulatives. They were the materials that students will use to calculate for the rest of their lives. By its very nature, mathematics was abstract and it takes its power from this abstraction. However, many state standards documents suggest and even need the use of an important array of manipulatives for instruction or assessment in counterproductive ways.

According to Hartshorn and Boren (1990) the most important factor in affecting the use of manipulatives seems to be the availability. As, if manipulatives were not available, they could not be used by the teachers at all. However, most of the materials, such as buttons and spools, were easy to be found by the teachers. On the other hand, some others such as bean sticks and attribute blocks were easy rather to make.

According to Heddens (2005) students will provide from using manipulatives in learning mathematics in a various ways:

- Making connections between real world and mathematical symbols.
- Working cooperatively in problem solving.
- Making discussions about mathematical ideas and concepts.
- Expressing their feeling and ideas in words.
- Presenting in front of the audience.
- Noticing that there were differences in the ways of problem solving.
- Realizing that there was not one way in making symbols.
- And in noticing that they could solve the problems on their own and not only by following the directions, given by the teacher.

Spear-Swerling (2006) claims that some pitfalls could occur in using manipulatives, particularly if they did not meet the students' requirements. Manipulatives could confuse the teachers and students provided that they were presented in a random, confusedly behavior that lacks suitable guidance and teaching from the teacher. Moreover, they could result in much time which was spent off-task or on task activities that were not directly related to the certain students' requirements. For example, while the students lacking understanding the basic concept of multiplication could well benefit from grouping objects to represent simple equations, such as 3 × 6, children, having a good conceptual understanding of multiplication but lack of knowledge with the computational algorithm (the written series of steps) for solving multi-digit multiplication problems (e.g., 22 × 48), will not probably benefit from continued use of manipulatives with multiplication. Furthermore, it was not beneficial for some students who could do in a superior way with visual or pictorial representations (Spear-Swerling, 2006).

According to Klein (2005) manipulatives were physical objects meant to serve as teaching aids. In introducing new concepts for elementary students, this helps; but there was always a risk if it was too much and the risk will be that students will depend on manipulatives too much rather than the mathematics. Somehow, the purpose of elementary school mathematics was to get students to manipulate numbers, but not objects in order to solve problems.

Spear-Swerling (2006) stated that in classification or patterning assignments, attribute blocks and geometric solids in various colors and shapes could be used, in solving equations of simple addition and subtraction, plastic counters help us, in representing and performing operations on multi-digit numbers base-ten blocks were beneficial, and in representing different fractional concepts and relationships fraction pieces were advantageous.

According to Burns (1996b) there were seven 'musts' for using manipulatives. One of them was teaching students about the basis for using manipulatives in addition to setting some first ground rules. There were six other rules comprising permitting the students the chance to discover the manipulative as a concrete object they could explain, demonstrating charts or graphs about manipulative material showing students the importance of manipulatives, and allowing students to take manipulative material home to do activities after having some knowledge with using them. The final 'must' was that teachers must set up a system for storing materials and familiarize students with it. The materials become more reachable with a clear system and labeling and designating a particular place was very functional.

Clements (1999) states that "good manipulatives were those that aid students in building, strengthening, and connecting various representations of mathematical ideas" (p. 49). It was reported that students' mathematical learning was allowed by manipulatives (Burns, 1996b; Sowell, 1989).

According to Kober (1991) manipulatives were the materials appealing to several senses, such as touching, handling and moving. Materials, ranging from commercial products to everyday objects (from unifix cubes, cuisenaire rods, base-ten blocks to nickels and dimes). There had been various studies about the positive effects of them on student achievement. Students learning with manipulatives were good at crossing the bridge to the mathematics' abstract world and implementing their knowledge to real-life conditions. Manipulatives support active learning and help to build motivation and prevent from boredom by the help of their visual, auditory and tactile qualities. They provide students to be familiar with the new concepts. For example students learn place value by the help of bean sticks and by an apple which was cut in four ways, students were provided to grasp fractions.

2.2.2. Research Studies on Utilization of Instructional Materials related to Mathematics Instruction

In the literature there are many studies on utilizing manipulatives and concrete materials in teaching and learning mathematics (e.g. Fennema, 1972; Mayo, 1995; and Parham, 1983).

Fennema (1972) examined a study investigating the effects of manipulatives on 95 students of second grade who were haphazardly allotted to one of eight groups for a three week period of teaching during a unit on multiplication facts. A concrete (Cuisenaire rods) or symbolic treatment (drawings using pencil and paper) was given to all student. The results showed that neither group was in a greater degree at learning both ways, but when it comes to implementing their learning to a higher level including the students, the students who were taught using the symbolic approach were better. As a conclusion, to discover in which situations concrete models contributes more to the learning of mathematical ideas, more empirical data must be collected.

Parham (1983) had a study with sixty-four research with the elementary school children. There was a great difference between the students who used manipulatives and who did not. It could be said that the students using manipulatives had a success with an 85^{th} percentile and the students who do not with a 50^{th} percentile. Furthermore, it was concluded that when the level rises up, the effectiveness lessens.

Mayo (1995) carried out a quasi-experimental study to compare the achievement of primary grade students who used a manipulative-based approach (Math Their Way) with the ones using a traditional instructional approach. Moreover, the study was about the interrelationship of method, race, gender, socioeconomic status, and categorical grouping. The study was carried out with 590 first grade students who used the Math Their Way program and with 327 first grade students who utilized a traditional approach in the term of 1991-1992 school years. By investigating data on all students who had available test results as third graders, 454 students, longitudinal information was acquired As no significant difference was found between the first grade students educated by Math Their Way and the traditional approach, we were surprised. In Mayo's (1995) view, as the schools using Math Their Way frequently serve students from a higher socioeconomic status compared to schools using a traditional approach, these findings were important. The expectations were that high performances would be on the side of these students from the higher socioeconomic status. There were differences between gender, race and socioeconomic status in mathematics achievement, without regard to instruction method. The study was resulted by outlining recommendations for policy, practice and further research. The authors pointed out that manipulatives were best for all students who need further study.

Brecht (2000) carried out a quasi-experimental study that researched the effects of cooperative learning, manipulatives, and a combination of cooperative learning and manipulatives on the achievement of fourth grade students and their conceptual knowledge, computation knowledge, and skills of problem solving in multiplication. Furthermore, the effects of the three methods of instruction on student gender were investigated in the study. The students were divided into three groups: a cooperative learning group, manipulatives group, and a combined cooperative learning and manipulative group. A pre and post tests were applied to the students at the beginning and at the end of two units of multiplication. The concept of multiplying by 1-digit numbers composed unit one, and unit two focused on multiplying using 2-digit numbers. According to the results of the study, the students in the cooperative learning group were the most improved ones on problem solving while multiplying by 2-digit numbers. The greatest gains in computation with 1-digit numbers were showed by the combination of cooperative learning and manipulatives group. The results showed that there were main effects of teaching method in several different areas. As a conclusion, the students using both cooperative learning and manipulatives showed the greatest improvement when multiplying by 1-digit numbers while the students using cooperative learning showed the greatest improving when multiplying by 2-digit numbers. Moreover, students in the cooperative learning group showed a big improvement over the manipulative group in problem solving with 2-digit numbers. There was a difference between male and female students. Because male students performed significantly higher than female students on computation items using 2-digit numbers (Brecht, 2000).

Moyer (2001) carried out a yearlong study that researched 10 middle school teachers' uses of manipulatives for teaching mathematics using interviews and observations to examine how and why teachers used the manipulatives chosen. The teachers participating in the study attended a workshop of mathematics professional development for two weeks and got a manipulative kit that consists of base-10 blocks, color tiles, snap cubes, geometric solids, geoboards, dice, pattern blocks, hundreds boards, fractions bars and tangrams and additional measuring devices. According to the teachers' statements and behaviours, using manipulatives was little more than a diversion, that teachers perceived their use of manipulatives for mathematics instruction as playing, exploring or as a reward for appropriate classroom behaviour. Moreover, the teachers could not exactly represent the mathematics concepts themselves. In addition to this, the teachers' ideas were that the manipulatives were not essential for teaching and learning mathematics despite being funny.

This qualified study discovered the effectiveness of using manipulatives besides textbook to have achievement in the concepts of algebra with 4^{th} grade students. This study consisted of 85 fourth-grade students from four different classes at O'Malley Elementary School, for five years. 53 regular education students and 32 gifted students; special education students were not mentioned. The students were applied a test at the end of the unit lasted 3 weeks. Independent tests were implemented to 3 hypotheses. The results show that manipulatives make the achievement improved in algebra concepts with all regular and gifted/talented education fourth-grade students (Daniel, 2007).

Garcia (2004), with the aim of investigating the effects of two instructional strategies, conducted a survey: manipulative-based instruction and visual cues in mathematics with a subpopulation of young Hispanics students who were English language learners. The study was carried out for five weeks and 64 students from third and fourth grade participated in the study. The study investigated the students' performance with problem solving items from the Texas Assessment of Academic Skills achievement test from the 1999-2002 school years. The students were assessed beforehand using a combination of 10 of the 13 objectives of the test. Subdivision was made for the students, there were 3 groups: manipulative-based instruction, visual (drawings) cue instruction, and those who received no additional mathematical instruction. The students were applied a different assessment/probe for a total of 6 probes each week. Students' pre and post test improvements were measured using a mixed ANOVA (repeated measures, with a grouping factor). According to results, we could say that, neither of the experimental groups (manipulative-based instruction and visual cue instruction) showed an important improvement between the pre and post test assessment in the students of third and fourth grade.

Bayram (2004) suggested that there was an effect of concrete models on eighth grade students' geometry achievement and attitudes toward geometry. The study was carried out with 106 students in a private school of Ankara. The subjects of the study received instruction with concrete models, and by the traditional method. She found that there was a significant difference between students received instruction with concrete models and those received instruction with traditional method in terms of geometry achievement.

2.3. Attitude

In this section, first of all the definition of attitude and importance of attitude in teaching/learning subject will be explained. Then the findings of research studies on attitudes toward mathematics and topics in mathematics were stated. Lastly, the research studies on 5E learning cycle and attitudes toward science were explained.

2.3.1. Theoretical Background for Attitude

There are different definitions of attitude in the literature. Some of them were given below:

Aiken (1970) stated that an attitude was commonly thought as being partly cognitive, partly affective or emotional. Hence it appeared that information about attitude or at least about its emotional part could be gotten by measuring autonomic responses to selected stimuli. But such measurements were too complicated for assessments of attitudes which were mass; they had been applied in research, tough. Aiken's definition was accepted in the present study. The other definition was stated by Ruffell, Mason and Allen (1998) who claimed that the word attitude referred to the aspects of position which expresses emotion. Then, it was implemented metaphorically to the mental (an attitude of mind) from which the indicators of metaphor were removed. Here, there was confusion, because modern academic psychology distinguishes between cognitive, affective and enactive aspects of psyche. Sometimes the mental was separated from all aspects of the psyche. According to Hannula (2002) the everyday notion of attitude was defined as somebody's fundamental likes or dislikes of a familiar target. There were three conclusions to be drawn there. That the framework of emotions, associations, expectations, and values which were proposed was useful in defining attitudes and changes in detail was the most important one. Secondly, the attitudes tend to change dramatically in a very short time. As a third conclusion, the negative attitudes toward mathematics may be succeeding in defending a positive self-concept. Zan and Martino (2007) suggested that the word attitude was used in both practice and research together with the adjectives “positive”/”negative” actually. They argued that the dichotomy between positive and negative attitude was noticed in all parts of mathematics education research, both clearly and unclearly. For instance, studies about the classically relationship between attitude and achievement in fact research the relation between positive attitude and success. Similarly, the studies which aim to change attitude end up in building the objective of transforming a “negative” attitude into a “positive” one. The most of the questionnaires used to assess attitude was related with the emotions (“I like mathematics”) with the beliefs (“Mathematics was useful”) with behaviours (“I always do my homework in mathematics”). These “positive” results refer to various meanings of the word. Mostly, this meaning changes depending on whether “positive” refers to emotions, beliefs or behaviour:

- When referring to an emotion, “positive” normally means as “pleasurable”. Therefore, anxiety was considered as “negative” while pleasure was evaluated as “positive”.
- When referred to beliefs, “positive” means “shared by the experts” in this sense.
- When it refers to behaviour, “positive” means “successful”. In school, a successful behaviour brings high achievement with itself; this gave rise to the problem of how to evaluate achievement (Middleton & Spanias, 1999 as cited in Zan & Martino, 2007).

Brassell, Petry and Brooks (1980) suggested that in the formation of mathematics attitudes, the students’ attitudes towards teacher take some importance. Teachers need to know that this was a critical period of attitude formation (the junior high school level) when the students notice clearly the teachers’ attitudes toward mathematics which will be the determinants of students’ attitudes toward mathematics, too.

Aiken (1970) suggested that the teachers’ attitude and effectiveness in a specific subject take importance in determining the students’ attitudes and performance in that subject. The investigations of the classroom behaviour and techniques applied by teachers had the most influence on students' attitudes toward mathematics.

In the elementary school mathematics curriculum, having students' positive attitudes toward the mathematics is very important. The meaningful understanding can develop positive attitudes (MoNE, 2008; NCTM, 2000).

In the Turkish elementary school mathematics curriculum, while developing the students' mathematical concept and abilities, affective domain must be into consideration (MoNE, 2008). Some of the objectives were can be stated as:

Students should be able to enjoy Mathematics, appreciate the power and beauty of mathematics, be self-confident in mathematics, be aware the importance of mathematics in real life and believe that mathematics have a positive effect on mental development of students

In general, there must be positive attitudes toward mathematics for the following reasons:

- A positive attitude was such an important result itself.
- Attitude was usually positively or a little related to achievement.
- Positive attitude in mathematics help to increase the tendency of evaluating mathematics courses in both high school and college or positively one's tendency to consider careers in mathematics or mathematics-related fields. (Haladyna, Shaughnessy & Shaughnessy, 1983).

Most of the researchers support the vital relationship between attitude and achievement (Aiken, 1976; Haladyna, Shaughnessy, & Shaughnessy, 1983; Ma, 1997; Ma & Kishor, 1997). If students had positive beliefs about math, they perform well. If they perform well, they like math and feel good about themselves. On the contrary, if they had negative beliefs, it reinforces their low expectations and sense of failure (Kober, 1991).

2.3.2. Research Studies on Attitudes toward Mathematics and Science

In this section the research studies were explained by taking into consideration the following issues. They were studies on the effect of 5E learning cycle on attitudes toward mathematics, on the investigation of attitude toward mathematics and topics in mathematics course, and on the effect of 5E learning cycle on attitudes toward science in Turkey.

2.3.2.1. Research Studies on Attitudes toward mathematics

We met two research studies on the effect of 5E learning cycle on attitudes toward mathematics in Turkey. Hiccan (2008) applied 5E learning cycle in teaching linear equations with one variable. She found that this instruction increased 7th grade students' interests, motivations and participations. Another research performed by Baser (2008) compared the application of teaching activities of 5E model with traditional teaching methods. She found that 7^{th} grade students were eager to learn by 5E learning cycle methods.

In Turkey in spite of the lack of study there were many research studies on attitudes toward mathematics by taking account different variables. Some of them were explained below:

Tag (2000) developed a model which showed the reciprocal relationship between attitudes toward mathematics and achievement in mathematics. She found the reciprocal relationship between 9th grade students' attitudes toward mathematics and achievement in mathematics.

The study performed by Bayram (2004) suggested that there was an effect of concrete models on 8^{th} grade students' geometry achievement and attitudes toward geometry. She found that there was no statistically significant mean difference between students received instruction with concrete models and those received instruction with traditional method in terms of attitudes toward geometry.

Another study conducted by Akman (2005) expressed the aim of his study to examine the effect of analogy-enhanced instruction on students' achievement in function and attitudes toward mathematics. Research results showed that there was no significant mean difference between students received instruction with analogy-enhanced models and those received instruction with traditional method in terms of attitudes toward mathematics. However, there was a significant mean difference between gained scores of students received instruction with analogy-enhanced method and those received instruction with traditional method in terms of attitudes toward mathematics.

In the study carried out by Demir (2005) the effects of instruction with problem posing on tenth grade students' probability achievement and attitudes toward probability was investigated. The study was carried out with 10^{th} grade students in a town of a city in Central Anatolia. The results of the study showed that there was a statistically significant mean difference between problem posing group and traditional method group in terms of attitudes toward probability and mathematics in the favor of problem posing instruction group.

The study performed by Idikut (2007) investigated the effects of the usage of the mathematics history as a supportive technique on student's academic success, behavior toward the class and level of the permanence of the education taken. The participants were seventh-grade elementary school students. The study results showed that there was no statistically significant mean difference between the instruction based on mathematics history supported lessons and the instruction based on teacher guide booklet with respect to attitudes toward mathematics.

Bayrak (2008) expressed the aim of his study as to determine effects of visual treatment on students' opinion in terms of thinking process and students' opinion in terms of feelings in the spatial ability activities; to investigate the effects of visual treatment on students' spatial ability, spatial visualization and spatial orientation. The study was carried out with 21 sixth grade elementary school students. Two measurements were Spatial Ability Test, and Spatial Problem Attitude Scale. The results showed the change in students' spatial ability, orientation and visualization scores across three time periods (pre treatment, post treatment and retention). All scores were different from one another.

Another research conducted by Gursul (2008) was to determine effect of the online and face to face problem based learning approaches on freshmen's academic achievement, their attitudes toward mathematics and their views towards these learning approaches. According to changing the attitudes of the students towards mathematics, the increase in the online problem-based learning group was not statistically significant in terms of the results of the pre and post tests. On the other hand, when the increases in these two groups were considered, the increase in the online problem-based learning was higher than the one in the other group. Nevertheless, this difference was not statistically significant.

The aim of the experiment performed by Isık (2008) was to investigate how well the geometry achievement was explained by field dependency/independency cognitive styles, spatial orientation, spatial visualization and attitudes toward geometry. The participants of her study consisted of 9^{th} grade students in a city of Central Anatolia. The multiple regression analysis showed that students' cognitive styles were the most significant variable which explained the change in their geometry achievements. The other predictive variables also contributed statistically to explain the geometry achievements of the students. Four predictive variables of the study were entered the regression models, and revealed the % 47 of the variance in geometry achievement.

Another study was carried out by Yurekli (2008). In her study whether pre-service elementary school teachers' attitudes toward mathematics differ with respect to gender, age, type of high school graduated the education level of parents, the university attended and to examine the relationship between their self-efficacy perception and attitudes toward mathematics was investigated. Research results exhibited that the pre-service elementary school teachers' had highly developed highly positive attitudes toward mathematics. The result of the study showed that age, high school graduated and education level of mother and father were not related to attitudes. The outcomes revealed positive correlation between their self-efficacy perceptions and attitudes.

2.3.2.2. Research Studies on Effect of 5E Learning Cycle on Attitudes toward Science

There are many studies on 5E learning cycle and attitudes toward science. Some of them were explained below:

Lord (1999) compared 5E learning cycle instruction with the traditional instruction in environmental science. The participants were college undergraduates. It was found that that while the control group students found the lessons boring, the experimental group students found them interesting and had a lot of fun.

A study was conducted by Whilder and Shuttleworth (2004) investigated the effectiveness of 5E learning cycle in their study of "Cell Inquiry". It was reported that the high school students were motivated and by the 5E learning cycle.

In the study carried out by Kaynar (2007) the effectiveness of 5E learning cycle on sixth grade students' understanding of cell concepts, their attitudes toward science and their scientific epistemological beliefs was investigated. The study was carried out with 160 sixth-grade elementary school students. While a statistically significant treatment difference with respect to collective dependent variables; understanding of cell concept and epistemological beliefs was found there was no significant difference on attitudes toward science. The outcomes of the study exhibited that students in the experimental group who were engaged in learning cycle instruction demonstrated significantly better performance over the control group students who were engaged in traditional instruction in students' understanding of cell concepts and epistemological beliefs.

Another study was carried out by Ersahan (2007). In his study 5E instruction method supported by video movies and role play instruction method were compared in order to find the most effective method for teaching Science-Technology-Society-Environment skills in the Matter and Change Strand for 6th grade students. According to the results of the study it was found that there was no significant difference in the level of attitude to Science and Technology between students who instructed by 5E instruction method and role play instruction method.

Additionally, Ozsevgec (2006) investigated the effect of 5E on 5th grade students' achievement and attitudes toward science and technology course. It was found that there was no statistically significant change in attitude.

Keskin (2008) expressed the aim of his study was to compare the effectiveness of 5E learning cycle class to traditionally designed physics class on simple harmonic motion: simple pendulum concepts and attitudes toward physics on high school students. The study was carried out with eleventh-grade high school students. Research results showed that there was an increase in the scores of attitudes toward physics. However, it was found that there was no statistically significant difference in gained scores of the attitude.

The aim of the experiment performed by Pabuccu (2008) was to examine the effects of 5E learning cycle on eleventh-grade high school students' attitudes toward chemistry. The instruction developed the similar attitudes toward science as a school subject.

Study performed by Ceylan (2008) investigated the effectiveness of 5E learning cycle on 10th grade students' understanding of state of matter and solubility concepts and attitudes toward chemistry as a school subject. In the experimental group, students were taught with respect to the sequence of 5E learning cycle model through the use of activities such as demonstrations, video animations, laboratory activities, and discussions. In the control group, traditionally designed chemistry instruction was implemented through teacher explanations and use of textbook. The results showed that 5E learning cycle improved students' attitudes as a school subject.

2.4. Summary

The significance of learning mathematics through instruction based on 5E learning cycle model, usage of manipulatives and correlation between attitude and achievement were discussed. The previous study and review of literature shows that it was significant for teachers to make lessons more tangible to have the most impact on students' attitudes, and efficiency in mathematics. On the basis of the studies, it was concluded that using manipulatives had an important impact on the success of mathematics concepts. Lessons using manipulative had a higher chance of creating larger mathematical success than do non-manipulative lessons. In the literature, researchers emphasized the effects of attitude on students understanding of mathematics and science concepts and provided about the efficiency of attitudes on students' academic achievement. Although 5E learning cycle had become the topic of many investigations abroad, in Turkey it was not encountered so much. Nearly all the investigations consist of science. Much of the investigations was made in the year of 2000 and thereafter. 5E learning cycle was recommended in the new elementary school mathematics curriculum in 2004. It was possible to increase the examples of the study and besides this it had been reached as a conclusion that with the light of these studies, this constructivist 5E learning cycle helps the students with their attitudes toward the subjects, seeing their conceptual differences, and evaluating their misconceptions, improving their conceptual learning, and scientific process skills, and with improving their exploration and mental thinking skills and lastly with increasing the permanence of learning. In our country it was claimed that the explorations and studies on 5E learning cycle had intensified.

CHAPTER 3

METHODOLOGY

This chapter includes research design, participants, measuring instruments, treatment, procedure, variables, analyses of data, assumptions and limitations, and validity of the present study.

3.1. Research Design of the Study

In the present study one-group pretest-posttest design was used (Frankel and Wallen, 1996). In order to assess mathematics achievement and students' attitudes toward mathematics before and after the instruction based on 5E learning cycle model, mathematics achievement test and mathematics attitude scale was administered. The achievement test was also administered as a retention test 6 weeks later after the treatment. The researcher was the teacher of the participants of the study.

3.2. Participants of the Study

The participants of the present study were consisted of the sixth-grade elementary school students of public school in one of the towns of the Central Anatolia Region-Turkey in 2008-2009 academic years. In the present study we utilized a convenient sampling (Frankel & Wallen, 1996). There were twenty eight students. The frequencies of female and male student were equal.

3.3. Measuring Instruments

In the present study, the data collected by using Mathematics Achievement Test (MAT) and Mathematics Attitude Scale (MAS). They were explained below.

3.3.1. Mathematics Achievement Test

The mathematics achievement test (MAT) was developed by the researcher to determine the students' mathematics achievement over three time periods: pre-intervention, post-intervention, and follow-up (see Appendix A).

The process pursued in the development of the MAT is outlined below:

1. The content of the course was determined by taking into account the textbook delivered by the Ministry of National Education.
2. An item bank was formed with 40 multiple-choice questions.
3. The table of specification was prepared (see Appendix B).
4. Twenty one problems were chosen from the item bank by utilizing table of specification and expert opinion.
5. The content validity is tested with the mathematics teacher and mathematics educator.
6. The MAT was administered to seventh and eighth grade students in three different public schools in one of the towns of the Central Anatolia Region-Turkey for the pilot study.
7. The pilot study was also used to determine whether or not there were any grammatical mistakes or ambiguities and unclearness in the items of the MAT. One of the items was removed from the test because there was a problem in the item.
8. An item analysis was accomplished with 20 items by using the statistical package program. In this program, item discrimination power was shown as biserial coefficient and item difficulty power was shown as the percentage of correct responses to each item. While item discrimination power was

acceptable if it was greater than or equal to 0.20, the Item difficulty power was appropriate if it was between 0.2 and 0.8. According to these criteria, the item analyses were performed. The coefficients were given in Table 3.1.

Table 3.1. The results of item analysis for the MAT Pilot Study

Questions #	Item Difficulty Power	Item Discrimination Power
1	0.78	0.36
2	0.88	0.42
3	0.64	0.42
4	0.71	0.42
5	0.64	0.33
6	0.62	0.28
7	0.86	0.35
8	0.28	0.15
9	0.58	0.53
10	0.47	0.50
11	0.61	0.56
12	0.53	0.48
13	0.57	0.58
14	0.54	0.11
15	0.24	0.13
16	0.46	0.47
17	0.48	0.49

Table 3.1 (Continued)

Questions #	Item Difficulty Power	Item Discrimination Power
18	0.51	0.45
19	0.27	0.35
20	0.28	0.20

As seen in Table 3.1 item discrimination powers for 8^{th}, 14^{th} and 15^{th} question were less than 0.20. However, they were not removed from the MAT, owing to content validity of the test. There were no problems in other coefficients.

1. The same expert and mathematics teacher checked the content validity of MAT with 20 items by using the table of specification.
2. The alpha reliability coefficient of the MAT with 20 items was found as 0.69 by using statistical package program.

Consequently, in the final form of the MAT there were 20 questions. The maximum score was 20 points because of grading procedure. When the answer of item was correct, it was scored as 1. Otherwise it was scored as 0.

3.3.2. Mathematics Attitude Scale

The Mathematics Attitude Scale (MAS) was administered to determine participants' attitudes toward mathematics. It was developed by Askar (1986) (see Appendix C). To develop this scale it was administered to 204 English Preparatory School students at METU. It consisted of 10 positively and 10 negatively worded items about attitudes toward mathematics. The five-point Likert-type scale was used. It consists of "Strongly Agree", "Agree", "Undecided", "Disagree", and "Strongly Disagree". Positively worded items were coded starting from "Strongly Agree" as 5 to "Strongly Disagree" as 1. Negatively worded items were coded from 1 through 5. The scale was in Turkish and its alpha reliability coefficient was found as 0.96 with SPSS. One factor was determined by using factor analysis, labeled general attitudes toward mathematics. In the present study, the alpha reliability coefficient of the MAS was found as 0.82. The total score of MAS is between 20 and 100.

3.4. Treatment

Throughout the instruction based on 5E learning cycle, the activities were used to and carried out by twenty-eight sixth-grade elementary school students in 2008-2009 academic years. The lesson plans were given in the Appendix E. These lesson plans developed by Gogun (2008) were reorganized according to 5E learning cycle. The instructional activities used in this study are quoted from the sixth-grade mathematics book of elementary school and were performed two days in a week in mathematics course and one course in extracurricular for evaluation. The duration of the lessons was 40-minutes periods per week. In this study, the teacher who was the researcher attempted to provide students with opportunities to participate in diverse instructional activities and assessments. During the treatment, students participated in a number of diverse instructional activities. I also utilized various materials such as posters, photographs, coloured cartoons, work-sheets, two coloured tiles, symmetry mirrors, and coloured sheets and so on. Moreover, I also gave examples from daily life and made students active in the class. New elementary mathematics curriculum offered teachers to follow 5 learning cycle (MoNE, 2008). Its stages are engage, explore, explain, elaborate, evaluate. That students' following these five stages will support mathematical understanding and support the lesson to reach its goal. According to 5E learning cycle, the lesson's implementing stages were carried out like that;

Engage: In this stage, to draw the students' attention, they were asked considerable questions about daily life, and an amazing event or they were given the chance of thinking about some visual elements without making any explanation about the topic. And the questions were asked about these topics and they were made to think about questions together. So, they were made to give their ideas to each other and make connections about the new topic. Students' ideas were not intervened, so students were let consider about their own ideas. However, their attentions were taken to the subjects while discussing. While they were telling their ideas, they were made free to tell their ideas, ignoring the 'true or false'. Or the students were required to compose a story by looking the pictures they were given. In this way, they were provided to compose a story by using their imaginations and creations. The stories that students told made the teachers have ideas about their pre-knowledge. Or any game was taught to students and questions were asked about the game and they were wanted to reveal the answers. Therefore, the students' attentions were drawn to lesson and they were motivated in this way by participating in the lesson. After focusing on the subject, the students were provided to go towards the other stage.

The classroom conditions were prepared for the effective learning environment. The students were good at considering about abstract things, and have positive minds on learning new things and about acquiring new skills. In sixth grade mathematics students, it was observed that they were engaged in developing mathematical concepts in real and relevant contexts. The problems chosen were determined by considering the situations which the students could meet in daily life. The students were expected to use their pre-knowledge with the thinking ability. The researcher made the students be motivated towards the lesson and intensify on the subjects given. The researcher gave examples which were selected considerably and comprehensible. These examples were related with the daily life situations and were appropriate for preparing students to the lesson.

Explore: In this stage, students were offered activities about the subject and they were provided to reach the information on their own (see Appendix F). The activities were in the book written by Gogun (2008). About the activities, short explanations were made before the activities. All the activities were performed by the students and they were provided to be in contact with the materials directly so they were given the chance of gaining the knowledge on their own. The teacher guided them only to gain the knowledge on their own, only by controlling something with the questions that gave them directions. During the activities, the students were given enough time. They were required to study both individually and in groups.

In the activities, the students explained their ideas. It appeared that allowing students to use concrete objects helped them to have the idea concretely instead of abstractly. When the learners observe what they will learn, it is much probably that they will keep in mind or at least keep it for a longer time in mind than if it was just said to them. Students developed their learning about how mathematics works by concrete materials. According to my observation by the help of concrete materials, children learned mathematics and also mathematics became very enjoyable for them. While using concrete materials, from first one to the last, the child developed many logical ideas. Students improved themselves in perceiving conceptions about real life by being involved in mathematical practices. During the group study the teacher wandered in classroom for the aim of guiding. But the teacher did not intervene in the discussions directly. The role of the teacher was to guide. The teacher was not a knowledge source in the classroom. The teacher generally gave directions during the lesson. The teacher did not intervene directly but the teacher asked the questions in a different way when students did not understand instead of giving the correct answers. Teacher guided student to discover the topic and the principle underlying the procedure by utilizing manipulatives. The exploration stage was explained in detail by giving sample activities.

The first sample activity titled as "Let's Find the Rules in the Patterns" was used to provide students to notice number patterns to determine the different ways of diagram patterns, and to provide them to see that they could put across the relationships of the number patterns with letters. Teacher wanted students to compose the table (see Appendix F) to see the relationship between the numbers in the patterns the composed. After composing the table, their attention was taken to the relationship between the order of the number and the number of squares used. Students examined the numbers of squares corresponding to each step number. When they examined the each number, they explored that the numbers of squares used for each number were 3 times of the order of the number in the pattern. Then they were wanted to find out a general rule. Teacher gave students a clue by saying ‘I wonder that how many squares are used in 100th figure in this pattern but it takes too much time to count all of them. There should be an easy way to find it ‘Students found out a general rule that the order of the number in the pattern was 3 times of the squares used. So there should be 300 square in the 100th square. They said if we call the order of the number in the pattern ‘a’ the number of squares should be 3.a.

The second sample activity titled as “Let’s Compose Number Patterns” was given to let students get the objective of determining the value of natural numbers’ repeated multiplication. The activity started with the work of finding the rule of the pattern and reached the basic purpose of finding the rule of pattern and its’ expression of letters. The teacher wanted students to compose the pattern (see Appendix F) with counting stamps wanted students to point out how much stamps they used in each step. In the first step 1 stamp was used, in 2^{nd} step 4 stamps were used; in 3^{rd} step 9 stamps were used. As a clue teacher asked students if there was a relationship between the step number and the number of stamps used corresponding to each step. After that, teacher wanted students to compose the 4^{th} and 5^{th} steps with stamps and look at the relationship between the step number and the number of stamps used. Students examined the step numbers and number of stamps used. At this point they explored that number of stamps was equal to the square of the number of steps. The teacher asked students if they composed the 7^{th} step how much stamps they would use (without composing with the stamps). Students answered that it was equal to the square of step number. So, it was 49. Then, teacher asked if we called the step number with a letter ‘a’ how much stamps we would use. Students answered it was equal to the square of number of step so it is a^2.

The third sample activity titled as “Let’s Examine the Rectangles” was given to let students get the objective of determining the factors and multiples of national numbers. Students made rectangles with unit squares the areas of which were 6, 12, 15 and 18. The teacher wanted students to examine the areas and edge lengths of the rectangles. For example the area of first rectangle was 6 and the edges of it were 2 and 3. 2 times 3 were equal to 6, students explored that 2 and 3 were factors of 6. Then they were required to find the other factors of 6, 12, 15 and 18. Teacher asked ‘What could you say about the number and its factors’? Are they less than the number or equal to it? What do you say?’ At this point students explored that factor of a number was either equal to or less than it. Then, teacher wanted students to draw rectangles the areas of which were 2,3,4,5 times 6. They were the multiples of 6. Students examined the factors and multiples of 6 and explored that factors of a number were either equal to or less than it and multiples of a number were either equal to or bigger than it.

The fourth sample activity titled as activity of “Division Rules” was administered to provide the students to explore the patterns and rules of division between 2, 3 and 5’s multiples. Students were provided to find the patterns between the numbers which were painted yellow and red. And students were required to express their ideas about these numbers. In this activity students determined the multiples of 2 and 4 by painting them different colors. First, teacher wanted them to look at the numbers with one digit and the numbers with two digits which are the multiples of 2 and asked students the relationship between them. 2, 4, 6, 8, 10; 12, 14, 16, 18, 20…; 92, 94, 96, 98, 100. Students realized that the last digits of the numbers which were with 2 digits were the numbers with one digit which were the multiples of 2.

The fifth sample activity titled “Let’s Find the Different One” was used to provide students to notice the rules of prime numbers. In this activity teacher wanted students to make rectangles which had the same areas and wanted them to write the edge lengths of them. For example the dimensions of the rectangle the area of which was 3 units square were 1 and 3. Teacher asked students if they could write the dimensions of it another form. Students realized that they could not. Then teacher wanted them to make rectangles with 4 unit squares. They could make 2 different rectangles with different dimensions 1, 4 and 2, 2. Then teacher wanted them to make rectangles with 7 unit squares. Students said that they could make only one rectangle dimensions of which are 1 and 7. Teacher asked students what they could say about the numbers 3, 4 and 7. Students answered that factors of 3 were 1 and itself (3) and said the same thing about 7 (factors: 1 and itself). But the factors of 4 were 2, 2 and 1, 4. They made rectangles with different unit squares. Then students explored that the factors of some numbers were 1 and themselves.

The sixth sample activity titled “Let’s Find out Prime Numbers” was given to provide students to determine prime numbers. While applying this activity, prime numbers were related to the subjects of multiplier and multiples. In this activity students circled the number 2 and painted the multiples of 2 in a hundred numbers. Then they made the same thing for the numbers 3, 5 and 7. Teacher wanted them to examine the numbers one by one that were not painted (the numbers left). As a clue the teacher asked students if these numbers that were not painted were the multiples of any number. Students explored that multiples of them were only themselves. Then teacher asked students what the factors of these numbers were. Students explored that the factors of these numbers were 1 and themselves. Students realized that some numbers could be divided by only 1 and themselves. Teacher said that they are called prime numbers.

Explain: The students were required to explain what they learned by their own sentences after the activity, by asking the results they reached, the observations they made and their ideas as well as the things that they noticed. Moreover, the teacher wanted the students to explain their thoughts with proofs, namely, the teacher wanted them to support their ideas by giving examples from the activities. In that way, the activity was made to reach a conclusion. In classroom, a discussion atmosphere was made about the conclusions that were reached. Probable misunderstandings and deficient learning were asked to groups and students and their true versions were tried to be shown to students. Namely, they were provided to reach the required information by activities. The teacher asked questions to students to help them recognize the information that was to given and notice them by making them meaningful in their minds. After that, the teacher made some explanations and corrections in the definitions by using correct and clear expressions and making connections with the students' explanations.

The students were not intervened during the studies; they were just let to explain their ideas whether true or false. Students learnt to compose numerous answers, asked questions, and solved problems. They learnt from their mistakes with the help of this cooperative learning, they were eager to study and gave confidence each other.

There was a social interaction among students. Learning had lots of things to do with communication. In this way students learnt adequately from each other because they spoke the same language. They learnt analyzing things and looking events from different situations and thinking over quickly. They encouraged each other and had contact with each other by working together. Moreover, the students were not anxious in expressing their ideas and were relaxed. They learned successfully from each other because they shared the same mathematics language.

The teacher told her students to listen carefully to their classmates they were expressing themselves during whole-class discussions. The teacher revoked the students so as to provide them with setting their thoughts into words. The students learnt new strategies by listening to each other's clarifications. The role of the teacher was to give cues instead of correct answers directly, and to make connections between pre-knowledge and new knowledge. The aim of the teacher was to compose a healthy learning environment in which the students were happy and were not avoiding from being criticized. The classroom atmosphere was formed by the teacher and the students were active in the lesson, almost all the students raised their hands when asked questions. So, the social interaction of the classroom was awesome. The teacher provided the students to find their own mistakes on their own, instead of correcting them on their own. In this way, the students were performing learning on their own by taking an active role in the lesson. As the teacher did not punish students for what they had said and gave importance to each student's ideas, the students would not avoid from telling their ideas. These were all to motivate students and to improve positive attitudes towards the mathematics.

Elaborate: The students were made to solve the problems in the classroom, they were provided to see new question types about the new taught subject and the students were expected to give answers to these questions. So, the students performed what they learned, and developed their understandings. The students were provided to put what they learned into practice, in new situations and events. The teacher shared the alternative explanations and alternative problem solving that students could not reach with them. Students tried to answer the questions by giving their ideas to each other in groups.

The students were interested in the lesson with the effect of 5E learning cycle model. With the help of this learning model, the students were active in the lesson. The students were enthusiastic to go to the blackboard and willing to ask questions by raising their hands.

Evaluate: By examining the studies that students made in their school and workbooks, the students' learning levels were observed. These observations were made by considering all the learning process. Student's performance and his developing degree in the process were taken into consideration. Moreover, the students' situations were assessed by observing their performances in the class in the direction of school and workbooks. The teacher wanted to see if the students understand the concepts of the subject correctly and whether or not they learned the subject and if they could put them into practice in new situations. In some classes, the students were evaluated by making them perform developing activities and observing their performances in the activities. Their mistakes were noticed and corrected. Furthermore, the teacher handed out 'Activity Self-

Assessment Form' to each student and provided them to evaluate their development on their own.

3.5. Procedure

At the beginning of the first semester of 2008, the researcher did a short description to students enrolled in the instruction based on 5E learning cycle courses, and then asked the students to have the permission form signed by their parents in order to be involved in the study. Merely information from students who returned the permission form with their parents' signature was used in the study. At the beginning of the study, before any use of the instruction based on 5E learning cycle in the classroom environment, before administered the MAT and MAS, the goal of the study and how to reply the MAT's questions and fulfill the MAS's items were described with all the specifics. MAT and MAS were administered twenty eight sixth-grade students as pretest by the researcher. Instruction based on 5E learning cycle was applied 15 weeks to sixth-grade primary students in their classroom environment by the researcher. MAT and MAS were carried out as pre treatment to the students.

After pre-test, the instructional activities used in this study were performed two days in a week in lesson time and one course in extracurricular for evaluation. In this study, I attempted to provide students with opportunities to participate in diverse instructional activities and assessments. During the study, students participated in a number of diverse instructional activities. I did supervision of the students throughout 15 week season in their learning surroundings to understand students' opinion about the activities. Students were observed while they were performing their activities. MAT and MAS were carried out as post treatment to the students.

Six weeks later, the last the MAT was applied to the students to inspect retention influence.

3.6. Variables

The variables of this study could be categorized in two parts. The first part includes the variables of the first sub-problem-" Does 5E learning cycle have an impact on sixth grade students' mathematics achievement?" They were the pre-test, post-test and retention test scores of the students obtained from the MAT.

The variables for the second sub-problem of the present study –" Does 5E learning cycle have an impact on sixth grade students' attitudes toward mathematics?" were the pre-test and post-test MAS scores.

3.7. Analyses of the Data

Item discrimination power and item difficulty power were calculated. The relaibility coefficients of mathematics achievement test and mathematics attitude scale were also computed. In addition, the assumptions of the statistical techniques were tested. Lastly, the hypotheses were analyzed by utilizing repeated measures one-way analysis of variance and paired t-test.

3.8. Assumptions and Limitations

In this section, there are assumptions and limitations in the present study.

3.8.1. Assumptions

The assumptions of the present study are given below:

1. Measuring instruments were applied under standard conditions.
2. The measuring instruments were answered by all subjects correctly and honestly.
3. There was no interaction between the subjects to influence the results of the present study.

4. The subjects understood items and the items were explained correctly.

5. The items were comprehensible to the participants.

6. There was no outside event which would affect the results throughout the study.

7. The students were motivated enough to answer the questions in the tests.

8. The researcher was objective in the application of treatment and in the process of interpreting the study.

3.8.2. Limitations

The limitations of the present study are as listed below:

1. This study was limited to the sixth-grade students in a public elementary school in one of the towns in the Central Anatolia Region in fall semester of 2008-2009 academic years. The generalizability of the results of this study was restricted.

2. The study was planned as pre-test and post-test control group but as the new mathematics program did not offer traditional instruction, our control group was removed and we carried out our study as one group pre-test and post-test design.

3. Other limitations were the exam administered by the Turkish Ministry of National Education at the end of each academic year because the participants of the present study might have studied the topics presented in the treatment after the treatment was finished.

4. Both the researcher and the instructor in the treatment was the same.

3.9. Validity of the Study

In this section internal and external validity of the study is discussed.

3.9.1. Internal Validity

Internal validity of a study means that observed differences on the dependent variable, not due to some other unintended variable (Fraenkel & Wallen, 1996). In the present study, the students were at the same grade level thus the participants' ages were close to one another and the number of girls and boys were the same and also approximately all of the participants were from knowledgeable families and their socioeconomic levels were the same. Therefore those traits did not influence research results accidentally. Some of the students were lost during the study so; mortality effect was not eliminated. The location in which pre-test, post-test, retention test and instruction based on 5E learning cycle were administered at the same school and nothing was effect to students' answers and study process. Therefore, the history threat was controlled. The location was regular during the study so history threat was eliminated. To all students, the test and scale were administered almost at the same place and same time controlled location threat. Instrumentation was another threat. All the instruments that were used were carefully examined to eliminate instrument decay. Furthermore, measurement instrument wasn't changed throughout the study that controls the instrumentation effect. Data collector characteristics were eliminated by using same data collector. However, training implementers didn't control the application of instruments and treatment so data collector bias was eliminated. Another threat was because of the small sample size. This study began with 32 pretest participants; some of them were lost during the study. The ability was limited by such a small sample to generalize the results to the other sixth grade school students. Each activity over the same period of time was performed by the instructor to eliminate maturation effect. It was the first control group that students perceived that they were getting any kind of special attention. Therefore; attitude of subjects eliminated. Furthermore, extremely low or high scores on test weren't got by any student; so, the effect of regression was eliminated.

Lastly, between pre-test and post-test was given 15 week period of time and there was a 6 week break between post-test and retention to eliminate the effect of testing. Implementation effect was the last one. That was the last instructors perform treatment by monitoring instruction so implementation effect was not eliminated.

3.9.2. External Validity

External validity is extending to which the results of a study could be generalized (Fraenkel & Wallen, 1996). The external validity consists of population and ecological validities. The participants of the study were selected from one of the public schools in a town of the Central Anatolia Region. In other words, the convenience sampling was used (Fraenkel & Wallen, 1996). The generalizations of the findings of the study were limited because of the small sample size. But, generalizations could be done on subjects having the same characteristics mentioned in this study. The treatments and tests were given in regular classroom settings. Similar to this study, generalizations could be made to classroom settings according to the results of the present study.

CHAPTER 4

RESULTS

In this stage, the results were analyzed to acquire statistical evidence for our hypothesis. This chapter includes three sections. In the first section the results of descriptive statistics were given. In the next section the results based on inferential statistics were explained. Lastly, the conclusions of the study were mentioned.

4.1. Results of Descriptive Statistics

Some results of descriptive statistics of mathematics achievement were given in Table 4.1.

Table 4.1 Results of Descriptive Statistics for the MAT

Tests	Minimum	Maximum	Mean	Std. Deviation
PreMAT	3	9	6.18	1.945
PostMAT	4	20	10.64	4.365
RetMAT	3	16	10.89	3.705

As seen in Table 4.1 subjects' prior mathematics achievement (M_{preMAT}=6.18, SD_{preMAT}=1.945) was less than post achievement ($M_{postMAT}$=10.64,$SD_{postMAT=}$4.365); and follow up achievement (M_{erman}=10.89, SD_{RetMAT}= 3.705). In addition, the post and follow up mathematics achievement were very close to each other. Furthermore, there was slightly increase in the retention test score.

Some of the results of descriptive statistics for attitudes toward mathematics were given in table 4.2 The MAS consisted of 20 items and was five-point Likert type.

Table 4.2 Results of Descriptive Statistics for the MAS

Tests	Minimum	Maximum	Mean	Std. Deviation	Item Index
PreMAS	51	100	90.46	10.305	4.52
PostMAS	51	100	85.21	13.742	4.26

As seen in Table 4.2 at the beginning of the treatment subjects' attitudes toward mathematics was slightly higher than their attitude after the treatment ($_{PreMAS}$=90.46, SD_{PreMAS}= 10.305; $M_{PostMAS}$=85.21, $SD_{PostMAS}$=13.742). However, their attitudes were positive (II $_{PreMAS}$=4.52; II$_{PostMAS}$=4.26).

4.2. Results of Inferential Statistics

The main problem was "What is the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics?" One of its sub-problem was "Does 5E learning cycle have an impact on sixth grade students' mathematics achievement?" To examine the problem the null hypothesis was stated as "There is no statistically significant change in mathematics achievement of sixth grade students who participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up)". To test this hypothesis, firstly, the assumptions one-way repeated measures analysis of variance was tested. For example, the normality assumptions were tested by Kolmogorov-Smirnov statistics. The results were given in Table 4.3.

Table 4.3: Tests of normality by Kolmogorov-Smirnov statistics

Scores	Statistic	df	p
PreMAT-PostMAT	0.121	28	0.200
PreMAT-RetMAT	0.123	28	0.200
PostMAT- RetMAT	0.171	28	0.035*

* p<0.05

As seen in Table 4.3 according to Kolmogorov-Smirnov statistics the normality assumptions were only satisfied for Pre Mat-PostMAT and preMAT-RetMAT scores. The histograms and normal Q-Q plots of these scores were given in Appendix D.

After the analysis, it was found that there was a statistically significant change in students' mathematics achievement over three time periods (pre-intervention, post-intervention, and follow-up) [Wilks' Lambda= 0.293; F (2, 26) =31.32; p=0.000). In addition, multivariate eta-squared was found as 0.707. Using guidelines proposed by Cohen (1988), these results revealed a very large effect size. To find out which pairs of time periods caused the mean difference scores of mathematics achievement, least significant comparisons were used. The results were given in Table 4.4

Table 4.4 Pairwise Comparisons of MAT scores with respect to time.

(I) factor1	(J) factor1	Mean Difference (I-J)	P
preMAT	postMAT	-4.464	0.000*
	retMAT	-4.714	0.000*
postMAT	retMAT	-0.250	0.660

*p<0.05

As seen in Table 4.4 at the level of significance 0.05 mean score of postMAT (*M*= 10.6429, *SD*= 4.365) was statistically significantly higher than mean score of preMAT (*M*=6.18, *SD*=1.945). Moreover, mean score of preMAT was statistically significantly lower than mean score of retMAT (M=10.892=, SD=3.705). Finally, it was found that there was no statistically significant mean difference between postMAT and retMAT scores ($p>0.05$).

Another sub-problem of the study was stated as "Does 5E learning cycle have an impact on sixth grade students' attitudes toward mathematics?" Its hypothesis was stated as a null hypothesis-"There is no statistically significant mean difference between prior and post attitudes toward mathematics scores of sixth grade students who participated in the instruction based on 5E learning cycle".

A paired-samples t-test was conducted to evaluate the impact of the instruction based on 5E learning cycle on students' scores on attitudes toward mathematics. Before analysis, normality assumptions are tested by Kolmogorov-Smirnov. The results are given in Table 4.5.

Table 4.5 Tests of Normality with Kolmogorov-Smirnov

Scores	Statistic	Sig.
PreMAS-PostMAS	0.159	.069

As seen in Table 4.5 the normality assumption was satisfied for PreMAS-PostMAS. The histogram and normal Q-Q plot of this score were given in Appendix D. The results of paired-samples t-test were given in Table 4.6

Table 4.6: The results of paired-samples test for MAS

	Mean	SD	T	Df	p
preMAS-postMAS	5.25	12.483	2.225	27	0.035

As seen in Table 4.6 it was found that there was a statistically significant mean difference between prior and post attitudes toward mathematics scores of sixth grade students who participated in the instruction based on 5E learning cycle. Moreover, there was a statistically significant decrease in MAS scores from prior intervention (*M*=90.46, *SD*= 10.305) to after intervention (*M*=85.21, *SD*=13.742). The eta squared statistics (.16) indicated large effect size according to guidelines of Cohen (1988).

4.3. Conclusions of the Study:

In the light of the above result obtained by examining of each hypothesis,

the following conclusions could be obtained:

It was found that there was a statistically significant change in mathematics achievement of sixth grade students participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up). There was only no statistically significant mean difference between post-intervention and follow-up mathematics achievement. Moreover it was found that there was a statistically significant mean difference between prior and post attitudes toward mathematics scores of sixth grade students who participated in the instruction based on 5E learning cycle. Furthermore, there was a statistically significant decrease in the MAS scores from prior intervention to after intervention.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

This chapter includes a discussion and interpretation of the results and some recommendations. The first section of this chapter presents a restatement of some of the results and the second section consists of some recommendations for further research.

5.1. Discussion of Findings

The findings of the present study are discussed under two categories: mathematics achievement and attitudes toward mathematics.

5.1.1. Discussion of Findings on Students' Mathematics Achievement

This study had two purposes: to investigate the impact of 5E learning cycle on sixth grade students' mathematics achievement on and attitudes toward mathematics. The results of the study indicated statistically significant change in mathematics achievement of sixth grade students who participated in the instruction based on 5E learning cycle over three time periods (pre-intervention, post-intervention, and follow-up) by using one way repeated measure ANOVA at the level of 0.05 significance level. In other words, there was a statistically significant mean difference between prior achievement and post achievement in the favor of post achievement. Moreover, there was a statistically significant mean difference between prior achievement and retention achievement in the favor of retention achievement. Finally, it was found that there was no statistically significant mean difference between postMAT and retMAT scores. However, the mean scores of retMAT scores were higher than the postMAT. This finding was consistent with Hiccan (2008) who reported that the 5E learning cycle had a statistically significant effect on conceptual and procedural knowledge, Baser (2008) who reported that the students who studied with the activities of 5E model learnt better than the students who studied with traditional teaching methods and Ozdal, Unlu, Catak and Sari (2006) who found that the students understood Pi and could apply it to new situation when taught using the sequences of 5E. When they compared the result of the present study with another study conducted in science, they also found that the 5E learning cycle had a positive effect on achievement (e.g. Balci, 2005; Campbell, 2000; Cardak, Dikmenli & Saritas 2008; Demircioglu, Ozmen & Demircioglu 2004; Lee, 2003, Lord, 1999; Ozsevgec, Cepni & Bayri, 2007; Saygin, Atilboz and Salman, 2006; Whilder & Shuttleworth, 2004; Yildirim, Er Nas, Senel & Ayas, 2007). For example, the study of Lee (2003) found that the students were found to acquire knowledge about plants in daily life easier and to understand the concepts better. Lord (1999) reported that in the questions about interpreting, analyzing and thinking critically, the control group students showed lower performances. Balci (2005) stated that the students of experimental group were more successful. Moreover, the methods applied in the experimental groups were impressive in eliminating students' misconceptions.

The reasons for the difference between pretest and post-test and between pretest and retention test can be explained mainly with the researcher experience. To show that each student could learn mathematics based on the principle that "every student could learn mathematics", the researcher used 5E learning cycle to make learning mathematics easier. In the activities based on the 5E learning cycle sequence, the teacher created interest and curiosity to draw the students attention and to excite them in the phase of engagement; provide opportunities for students to make them discover the topic and create a situation of "need to know" setting in the phase of exploration; and allowed them to explain the topics in their own words with a further description in the explanation phase. The teacher encouraged students to examine the presented situations further in the topic in elaboration phase, and the teacher observed the students to evaluate their knowledge and skills in the phase of evaluation. In this way, the students were engaged in more meaningful and permanent learning. The basic advantage was that the students were not taught the mathematical facts directly; rather students constructed the knowledge in the discussions with their peers in this constructivist instruction. Social interaction was also important for the students who could not reach all the facts on their own. Moreover, other people's knowledge was helpful in getting information if it appealed to their understanding and thinking. Hence the teacher created such a learning environment that students felt free in expressing their pre-knowledge and realized their present conceptions. While students were sharing their ideas with their peers, the students made an association between their pre-knowledge and present conceptions. The students took part in constructing knowledge in an active manner. In every phase of 5E learning cycle, the students were engaged; in this way, the students interacted with and analyzed the materials however much they wanted to, and also commented on their findings and finally foresaw the data. The students were allowed to create discussions with their classmates, and the discussion was in all phases to maximize the interaction of student-student and student-teacher. Concerning the analyses outcomes, we could reach a conclusion that a better understanding of mathematics subjects was provided by 5E learning cycle. Moreover the students' pre-misunderstandings were removed. During instruction, the teacher noticed students' misunderstandings and tried to remove them from their students' thoughts.

The results showed that the students' mathematics achievement improved after the instruction of 5E learning cycle. In fact, the activities implemented in the present study could be one of the reasons for this development. Clements (1999) suggests that meaningful conceptions about mathematics are provided by the activities. There is an importance in the students' activities in class while formalizing the beliefs of self-proficiency and self-sensation of the teachers to help students be motivated and interested (Antencio, 2004). That the students made the activities on their own helped them to learn the subject by doing and experiencing it. The lesson was prepared to maximize students' thinking abilities by initiating students to explore and comment about the explorations, and to analyze and evaluate the process of applying activities. Meaningfulness was given importance to in this process.

The other reason is the concrete materials used in doing activities. The benefit and usefulness in increasing student development and their understanding about mathematical conceptions was provided largely by using the manipulatives in primary schools. The materials used helped to draw the students' interest and attention throughout the lesson and increased their curiosity about the subjects in the lessons. Moreover, the materials used made the students' learning easier and made them have fun. The materials used with activities were always on students' tables where they could easily reach them. Doing the activities by using the materials made them love the lesson. On the other hand, if traditional instruction has been utilized, the teacher would have lectured and though some students would have listened many would have also pretended as if they were listening. When a 5E learning cycle is implemented, on the other hand, all the students had to take part in the lesson actively and not simply passively listen. Moreover the abstract subjects were made concrete by the materials used. Hence, students were made to construct relations between the subjects and real-life by interacting with the hands-on material.

In this study, the students were presented with opportunities to participate in diverse instructional activities and assessments. During the treatment, students participated in a number of diverse instructional activities. Various materials such as posters, photographs, coloured cartoons, work-sheets, two coloured tiles, symmetry mirrors, and coloured sheets were used in the activities. The positive effects of manipulatives on the mathematical achievement of students could be seen. According to the results of the Fennema's (1972) research the students had the ability of learning by both concrete and symbolic representational model and learned in either ways. Nevertheless, according to Fennema (1972) there must be more findings to have a clear idea about the effects of manipulatives on the mathematical achievement of students. Using manipulatives to teach mathematics based on theories supporting that children require physical symbols helping to improve intangible thoughts has been supported by instructors (Burns, 1996b; Sowell, 1989).

In the present study, post and retention mathematics achievement were very close to each other. Furthermore, there was a slight increase in the retention test score. The reason of high retention test scores is that students usually revise the old subjects because of student's preparation for MoNE test.

5.1.2. Discussion of Findings on Students' Attitudes toward Mathematics

The other concern of the present study is the attitudes toward mathematics. A paired-samples t-test was conducted to evaluate the impact of the instruction based on 5E learning cycle on sixth grade students' scores on the students' attitudes toward mathematics. It was found that there was a statistically significant mean difference between prior and post attitudes toward mathematics scores. Moreover, there was a statistically significant decrease in MAS scores from prior intervention to after intervention. This result can be accepted as consistent with the results of Hiccan (2008) who studied 5E learning cycle in mathematics. She found that this instruction increased 7th grade students' interests, motivations and participations. In contrary to mathematics, there are many studies on 5E leaning cycle and different science disciplines in both Turkey and other countries (e.g. Ceylan, 2008; Lord, 1999; Ozsevgec, 2006; Whilder & Shuttleworth, 2004). In some of these studies no statistically significant effect of 5E learning cycle was found on attitudes toward the subject which was studied like the present study (e.g. Ersahan, 2007; Kaynar, 2007; Keskin, 2008; Ozsevgec, 2006). In contrast, there are some studies which found a positive effect of 5E on attitude (e.g. Ceylan, 2008).

Because of the lack of studies on both the 5E learning cycle and mathematics the findings of the present study was compared with the findings on both 5E and mathematics and with findings of the study which investigated the effect of instruction based on the active involvement of the students in teaching/learning mathematics in Turkey. There are some studies which had consistent findings with the present study such as Bayram (2004) who examined the effect of instruction based on concrete models on students' attitudes toward geometry, and Gursul's (2008) study which investigated the effect of the online problem-based learning group on students' attitudes toward mathematics. In contrary to these studies, some research studies found the positive effect on attitudes toward mathematics such as Akman (2005) who investigated the effect of instruction with analogy-enhanced models on attitudes toward mathematics, and Bayrak (2008) who studied the effect of virtual treatment on students' attitudes toward spatial ability problems.

At the beginning of the treatment subjects' attitudes toward mathematics was slightly higher than their attitude after the treatment. The reason of decrease is that students have to study hard to prepare for the entrance examination administered by MoNE and intensive mathematics program. Moreover, students found it difficult to get accustomed to the lesson and were afraid of receiving low grades. Finally, students were afraid of not being successful as they stopped studying in the previous years. This may be because they had to study questions that required the production of comments rather than one way questions. Students used to solve one way questions before but now they have to try to find their own solution ways based on their previous experiences with similar questions. Moreover 5E learning cycle treatment took fifteen weeks. This period of time may not be sufficient to alter or improve students' attitude in this process. The results of the study supported by the findings of Kaynar (2007), who focused on the importance of 5E learning cycle on sixth grade students' attitudes toward science.

The reasons for difference between pre and post MAS scores can be explained mainly with the researcher experience as in the discussion on achievement.

According to present study findings students' attitudes were positive because the scores were out of 100. The reason of positive attitudes toward mathematics is that the students used to participate in the lesson by listening to teachers and copying notes from the board into their notebooks and to raise their hands when the teacher asked questions in the previous years. Now, however they were active in every phase of learning, they did not only listen but also participated in the lesson both mentally and physically to initiate learning. They took responsibilities in this way and by using activities and materials, they learnt interactively by touching and seeing. Namely, materials and activities took the students' interest so they did not get bored of studying mathematics and the lessons were fun. The study of Lord (1999) supported the results of the present study. According to him while the control group students found the lessons boring, the experimental group students found them interesting and had a lot of fun. Namely, students used the materials how they wanted. They were creative with the material; they loved utilizing them during lessons. Also with the help of materials, they understood the subjects better and reached the capability of applying what they had learnt to different situations. Now, the students did not have stereotyped knowledge, but could understand the subjects easily. In addition the acquired knowledge and the students' experiences increased their self-confidence in their capability of solving mathematical problems. As self-confidence increased their attitudes toward mathematics took a positive stance. Hence, rather than running away from mathematics, they believed they could succeed and wanted mathematics to be a part of their lives. Students' positive attitudes toward mathematics would be a big plus in their educational lives and in this way their educational quality would increase.

Moreover, the 5E cycle created an atmosphere in which the students felt free in that they expressed their ideas freely and there was no time to get bored. The researcher observed that the students benefitted more from student's acquisition of knowledge through students' interaction among themselves rather than learning just from the teachers' lectures. In this way they could learn the knowledge by discussions even if they did not know in the beginning. These outcomes are consistent with the Hiccan (2008) study. Hiccan (2008) performed a study concluding that instruction based on 5E learning cycle increased 7th grade students' interest, motivation and participation. In a traditional class, students were already in a passive position. In this kind of atmosphere they did not have the chance to share their ideas with their friends and teachers. However, while the students were discussing and helping each other to learn, they were actually provided with the opportunity to identify their weaknesses and deficiencies in their mathematical knowledge and then improve themselves making learning more permanent. Moreover, the idea of having the knowledge at the level of having discussions made them improve themselves in mathematics and they wanted to have discussions in mathematics.

Moreover in many mathematical approaches, the affective domain is given highest priority as whether the students enjoy the lesson or not is of utmost significance. Learning according to 5E learning cycle and the teachers' approach to students might initiate these positive attitudes toward mathematics. In addition, the 5E cycle creates an atmosphere of learning that is easier and better; hence, understanding mathematics becomes fun.

In addition, the students' positive attitude might be a result of the teacher's approach, attitude and beliefs. The students needed a teacher with understanding but not who was annoying and, who tells the lesson the level of the student. The teacher should treat students in respect to their interest, ability and characters besides the lessons taught. Moreover with the impact of the application which was carried out, enjoyable class environments were composed and with the help of learning more knowledge and solution strategies, their self-esteem in mathematics increased by the permanent learning which told them they could live the mathematics. Thus, they were given the opportunity to develop positive attitudes toward mathematics.

As a result of the findings in this study, it could be concluded that a better understanding of the mathematics subjects was provided by 5E learning cycle. Moreover the students' pre-misunderstandings were removed. During instruction, the teacher noticed students' misunderstandings and tried to remove them from their students' thoughts.

5.2. Recommendations

According to the results of the study obtained from the statistical analysis and experience of the researcher during the treatment, the following recommendations can be stated.

Appropriate learning environments should be provided for the students in order for the effective application of 5E learning cycle method in the classroom. To implement an activities based learning cycle, this requirement needs to be met in all schools.

There are five phases in the 5E learning cycle: such as; engagement, exploration, explanation, elaboration and evaluation. While preparing lesson plans, the teachers must consider the transitions between the phases. Significance must be given to these phases while teaching. For example, teachers should prepare class environments by considering the student levels and their characteristics. Activities must be planned by determining the pre-knowledge of students before implementing the instruction and by taking required precautions. The instruction of 5E learning cycle requires the students to be active in the lesson by nature. Hence, the students could get bored from the lesson after some time, and their interest to lesson and their motivation could decrease. To increase students' concentration and get them focused on the lesson, competitions should be prepared with prizes after them. Also, the teachers must give attention to the connection between the subjects taught and daily life because examples must be connected with daily life situations to be vital, otherwise, they will not arouse curiosity and interest. If the students are given examples connected to daily life, they will make connections between the subjects taught and the daily life, which will encourage them to study. Thus, the relation made between vital examples and their daily usage will increase students' enthusiasm and love of the lesson. Finally, while evaluating what the students learnt in the lessons based on 5E learning cycle, students are evaluated from all aspects. For example, if they performed well or not during the lesson could be important. Moreover, the questions could be both written and verbal.

A longitudinal study of the effect of 5E in mathematics would also have its benefits. The effect of 5E learning cycle on attitudes toward mathematics could be encountered with different teaching approaches. So far, most studies investigated the effects of 5E learning cycle in the field of science and technology. Hence, some findings must be collected to see if 5E is effective in the field of mathematics by increasing the number of investigations made. The teachers should pay attention to the appropriacy of the learning activities and work sheets which will be used during the application of 5E model by considering the match between the activities' level and the students' capabilities, how interesting students find the activities and whether or they help the students construct knowledge by using their own strategies.

Teacher educators and Ministry of National Education should need to equip teachers/prospective teachers with the necessary skills and knowledge. This can be done by providing them with opportunities to experience the utilization of 5E learning cycle in mathematics course.

Finally, the effect of 5E learning cycle should be investigated by taking into consideration different grade levels and topics in mathematics course.

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APPENDICES

APPENDIX A

Mathematics Achievement Test

1.

Şekilde verilen sayı doğrusunun -7 noktasında karınca, 12 noktasında buğday vardır. Buna göre aşağıdaki ifadelerden hangisi yanlıştır?

A) Karıncanın başlangıç noktasına uzaklığı 7 birimdir.

B) Buğdayın başlangıç noktasına uzaklığı 12 birimdir.

C) Karıncanın buğdaya uzaklığı 19 birimdir.

D) Buğdayın karıncaya uzaklığı -19 birimdir.

2. Mert, eşi ve iki çocuğu her hafta sonu tiyatro, sinema, sergi vb. etkinliklere katılırlar. Bu hafta sonu ''Ferhat ile Şirin'' adlı eseri izlemek için tiyatroya gidecekler. Tiyatroya giriş ücreti yetişkinler için 6 YTL, çocuklar için 4 YTL'dir. Yukarıdaki verileri kullanarak aşağıdaki soru cümlelerinden hangisi yazılamaz?

A) Giriş ücreti olarak kaç YTL öderler?

B) Tiyatronun bir günlük toplam hasılatı ne kadardır?

C) Çocukların giriş ücreti ne kadardır?

D) Mert ve eşinin giriş ücreti çocukların giriş ücretinden ne kadar fazladır?

3. Aşağıdaki ifadelerden hangisi <u>her zaman</u> doğrudur?

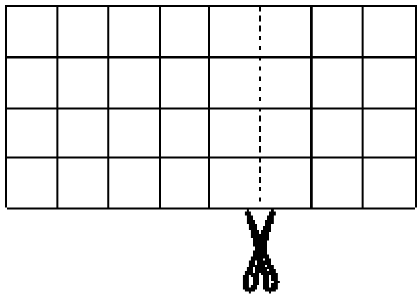
A) İki asal sayının toplamı bir asal sayıdır.

B) İki asal sayının çarpımı bir asal sayıdır.

C) İkiden büyük asal sayılar tek sayıdır.

D) İki asal sayın toplamı bir çift sayıdır.

4. Bir dosya kâğıdı şekildeki gibi eş karesel bölgelere ayrılıyor ve belirtilen çizgi boyunca kesilmek isteniyor. Büyük parçanın kaç eş karesel bölgeden oluşacağı, aşağıdaki işlemlerden hangisi ile bulunabilir?



A)4.(8-3) B)8.3-4.4 C)8.8-4.3 D)3.(8-4)

5. Ayşe, beden eğitimi dersi için eşofman ve ayakkabı alacaktır. Spor mağazasına gidip, 3 tane eşofman takımı, 5 çift ayakkabı beğendi. Ayşe bir tane eşofman takımı ve bir çift ayakkabıyı kaç farklı şekilde alabilir?

A) 8 B) 10 C) 12 D) 15

6. Tablo: Filiz'in Yıllara Göre Boy Uzunlukları

Yıllar	2002	2004	2006	2008
Filiz	150 cm	154 cm	156 cm	161 cm

Yukarıdaki tablodaki verilere göre ağacın yüksekliği 2010 yılında yaklaşık olarak kaç cm olacaktır?

A) 164 B) 175 C) 180 D) 200

7. Türkiye İstatistik Kurumu verilerine göre ülkemizde 2001 - 2005 yılları arasındaki tiyatro seyirci sayıları aşağıdaki grafikte gösterilmektedir. Grafiğe göre, aşağıdaki ifadelerden hangisi yanlıştır?

A) 2004 yılındaki seyirci sayısı bir önceki yıla göre artmıştır.

B) 2002 yılındaki seyirci sayısı 2,5 milyondan fazladır.

C) Seyirci sayısının en fazla olduğu yıl 2002'dir.

D) 2003 yılındaki seyirci sayısı 2,5 milyondan azdır.

8.Kerem $4\frac{1}{8}$ x $3\frac{4}{5}$ işleminin sonucunu 12 olarak tahmin etmiştir. Buna göre Kerem aşağıdakilerden hangisi gibi düşünmüş olabilir?

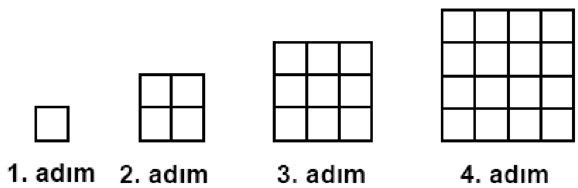
A) $\frac{1}{8}$ i 0 $\frac{4}{5}$ i 1 kabul etmiştir.

B) $\frac{1}{8}$ i 0 $\frac{4}{5}$ i 0 kabul etmiştir.

C) $\frac{1}{8}$ i 1 $\frac{4}{5}$ i 1 kabul etmiştir.

D) $\frac{1}{8}$ i 1 $\frac{4}{5}$ i 2 kabul etmiştir.

9.



Eş karelerden oluşturulan örüntünün ilk 4 adımı yukarıda verilmiştir. Aşağıdakilerden hangisi bu örüntünün kuralını ifade eder?

A) n^2 B) 2n-1 C) 2^n D) 3n-2

10. $\frac{1}{6}, \frac{2}{3}, \frac{3}{10}$ ve $\frac{4}{15}$ sayılarının küçükten büyüğe doğru sıralanışı hangisidir?

A) $\frac{3}{10} < \frac{4}{15} < \frac{1}{6} < \frac{2}{3}$ B) $\frac{1}{6} < \frac{4}{15} < \frac{3}{10} < \frac{2}{3}$

C) $\frac{4}{15} < \frac{3}{10} < \frac{1}{6} < \frac{2}{3}$ D) $\frac{2}{3} < \frac{1}{6} < \frac{3}{10} < \frac{4}{15}$

11. $[(5 \text{ x } 4^2) + (8 \text{ x } 3^0)] : 2^3$ işleminin sonucu kaçtır?

A) 11 B) 13 C) 15 D) 17

12.

İller	Sıcaklık Değerleri
Ankara	-8 °C
Rize	-14 °C
Erzurum	-23 °C
Mersin	+2 °C

Yukarıdaki tabloda, bazı illerin hava sıcaklıkları verilmiştir. Tabloya göre, aşağıdakilerden hangisi yanlıştır?

A) Ankara, Erzurum'dan 15 °C daha sıcaktır.

B) En soğuk il Erzurum'dur.

C) Rize, Mersin'den 12 °C daha soğuktur.

D) Mersin, Ankara'dan 10 °C daha sıcaktır.

13. $\left(\frac{4}{3} : \frac{4}{9}\right) + \frac{1}{2}\left(\frac{4}{3} - \frac{1}{2}\right)$ işleminin sonucu kaçtır?

A) $3\frac{1}{2}$ B) $3\frac{4}{9}$ C) $3\frac{2}{5}$ D) $3\frac{5}{12}$

14. Bir okulda her 45 dakikalık dersin sonunda 10 dakika teneffüs yapılmaktadır. İlk derse başlama saati 8.35 olduğuna göre, dördüncü ders saat kaçta biter?

A) 11.15 B) 11.45 C) 12.05 D) 12.15

15. 42a9b sayısı, rakamları birbirinden farklı 5 ile bölünebilen beş basamaklı bir çift sayıdır. Bu sayı 3 ile bölünebildiğine göre, a yerine kaç farklı rakam yazılabilir?

A) 1 B) 2 C) 3 D) 4

16. Bir turist kafilesinin $\frac{3}{5}$ ü 90 kişidir. Bu kafilenin $\frac{5}{6}$ i yemeğe gittiğine göre, kaç kişi yemeğe gitmiştir?

A) 125 B) 130 C)150 D) 250

17. Ahmet ile Aslı kalemliklerine kalem koyuyorlar. Ahmet'in kalemliğinde 5 tane siyah kalem, Aslı'nın kalemliğinde ise 2 tane kırmızı, 1 tane yeşil ve 3 tane siyah kalem vardır. Bu kalemler rastgele seçildiğine göre aşağıda verilenlerden hangileri yanlıştır?

I. Ahmet ve Aslı'nın kalemliklerinden seçilen bir kalemin siyah olma olasılığı kesindir.

II. Aslı'nın kalemliğinden seçilen bir kalemin kırmızı olmama olasılığı $\frac{4}{6}$ dür.

III. Ahmet'in kalemliğinden seçilen kalemin kırmızı olma olasılığı kesindir.

IV. Ahmet ve Aslı kalemlerini birleştirseler çekilen herhangi bir kalemin siyah olma olasılığı $\frac{8}{11}$ dir.

V. Aslı'nın kalemliğinden seçilen bir kalemin pembe olma olasılığı imkansızdır.

A) I ve II B) I ve III C) II ve IV D) IIIveV

18.

Tablo: Cumhuriyet Gezileri

İller	Kişi sayısı
Çanakkale	84
Samsun	76
Afyon	...
Ankara	...
Erzurum	72

Cumhuriyet gezileri kapsamında gidilen 5 ayrı il tabloda verilmiştir. Bu illere yapılan gezilere ortalama 80 kişi katıldığına göre, Afyon'a ve Ankara'ya gidenlerin sayıları aşağıdakilerden hangisi olabilir?

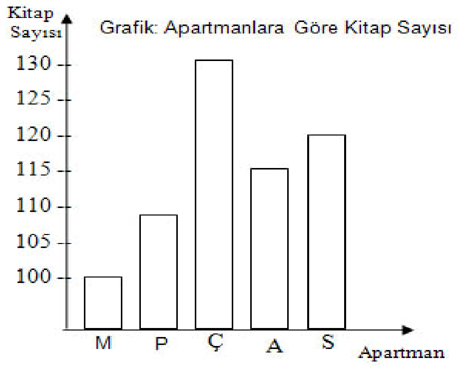
	Afyon	Ankara
A)	82	70
B)	94	54
C)	71	97
D)	70	88

19. Bir çiçekçi, sekiz düzineden az olan elindeki gülleri üçerli, beşerli ve dokuzarlı demet yaptığında her defasında 2 gül artıyor. Çiçekçi bu güllerle dörderli en fazla kaç demet yapabilir?

A) 23 B) 24 C) 25 D) 26

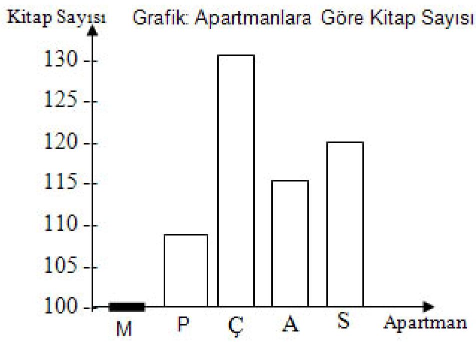
20. Bülbül Sokağında kitap toplama kampanyası düzenlenmiştir. Bu sokakta bulunan M, P, Ç, A ve S apartmanlarında toplanan kitap sayıları sırasıyla 100, 110, 130, 115 ve 120'dir. Aşağıdaki sütun grafiklerden hangisi yanlış yorumlara yol açmayacak şekilde çizilmiştir?

A)



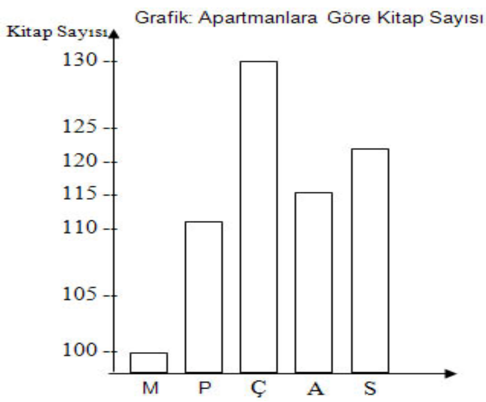
Kitap Sayısı
Grafik: Apartmanlara Göre Kitap Sayısı
130
125
120
115
110
105
100
M
P
Ç
A
S
Apartman

B)



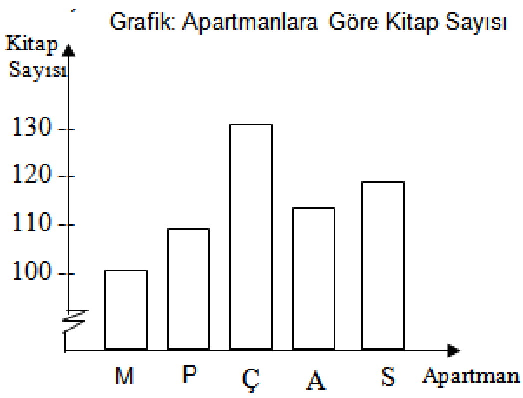
Kitap Sayısı
Grafik: Apartmanlara Göre Kitap Sayısı
130
125
120
115
110
105
100
M
P
Ç
A
S
Apartman

C)



Grafik: Apartmanlara Göre Kitap Sayısı
Kitap Sayısı
130
125
120
115
110
105
100
M
P
Ç
A
S

D)



Grafik: Apartmanlara Göre Kitap Sayısı
Kitap Sayısı
130
120
110
100
M
P
Ç
A
S
Apartman

APPENDIX B

Table of Specification for MAT

Objectives	Question Numbers
Add and subtract the integers.	1
Solve problems which requires natural numbers.	2
Determine prime numbers.	3
Apply distributive property of multiplication over subtraction in operations with natural numbers.	4
Compare fundamental counting principles and use in problems.	5
Make predictions based on data.	6
Interpret statistical representations.	7
Estimate results of operations with fractions by using the strategy.	8
Develop a model for number patterns and algebraic expressions of pattern.	9
Compare fractions, order them and represent them in a number line.	10
Compute natural numbers with exponents.	11
Compare and order integers. Add and subtract integers.	12

Objectives	Question Numbers
Perform four operations with fractions.	13
Solve problems on time.	14
Explain divisibility rule for natural numbers.	15
Solve problems which requires operations with fractions.	16
Solve problems on probability.	17
Compute arithmetic mean and range of data.	18
Apply the least common multiple to problems.	19
Explain the conditions which cause misinterpretations of bar graph.	20

APPENDIX C

MATHEMATICS ATTITUDE SCALE

Adınız Soyadınız: ………………………..

Genel Açıklama: Aşağıda öğrencilerin matematik dersine ilişkin tutum cümleleri ile her cümlenin karşısında "Tamamen Uygundur", "Uygundur", "Kararsızım", "Uygun Değildir" ve "Hiç Uygun Değildir" olmak üzere beş seçenek verilmiştir. Lütfen cümleleri dikkatli okuduktan sonra her cümle için kendinize uygun olan seçeneklerden birini işaretleyiniz.

	Tamamen Uygundr	Uygundur	Kararsızım	Uygun Değildir	Hiç Uygun Değildir
1. Matematik sevdiğim bir derstir.	O	O	O	O	O
2. Matematik dersine girerken büyük sıkıntı duyarım.	O	O	O	O	O
3. Matematik dersi olmasa öğrencilik hayatı daha zevkli olur.	O	O	O	O	O
4. Arkadaşlarımla matematik tartışmaktan zevk alırım.	O	O	O	O	O
5. Matematiğe ayrılan ders saatlerinin fazla olmasını dilerim.	O	O	O	O	O
6. Matematik dersi çalışırken canım sıkılır.	O	O	O	O	O
7. Matematik dersi benim için angaryadır.	O	O	O	O	O
8. Matematikten hoşlanırım.	O	O	O	O	O
9. Matematik dersinde zaman geçmez.	O	O	O	O	O

	Tamamen Uygundr	Uygundur	Kararsızım	Uygun Değildir	Hiç Uygun Değildir
10. Matematik dersi sınavından çekinirim.	O	O	O	O	O
11. Matematik benim için ilgi çekicidir.	O	O	O	O	O
12. Matematik bütün dersler içinde en korktuğum derstir.	O	O	O	O	O
13. Yıllarca matematik okusam bıkmam.	O	O	O	O	O
14. Diğer derslere göre matematiği daha çok severek çalışırım.	O	O	O	O	O
15. Matematik beni huzursuz eder.	O	O	O	O	O
16. Matematik beni ürkütür.	O	O	O	O	O
17. Matematik dersi eğlenceli bir derstir.	O	O	O	O	O
18. Matematik dersinde neşe duyarım.	O	O	O	O	O
19. Derslerin içinde en sevimsizi matematiktir.	O	O	O	O	O
20. Çalışma zamanımın çoğunu matematiğe ayırmak isterim.	O	O	O	O	O

APPENDIX D

THE HISTOGRAM AND NORMAL Q-Q PLOTFOR THE VARIABLES

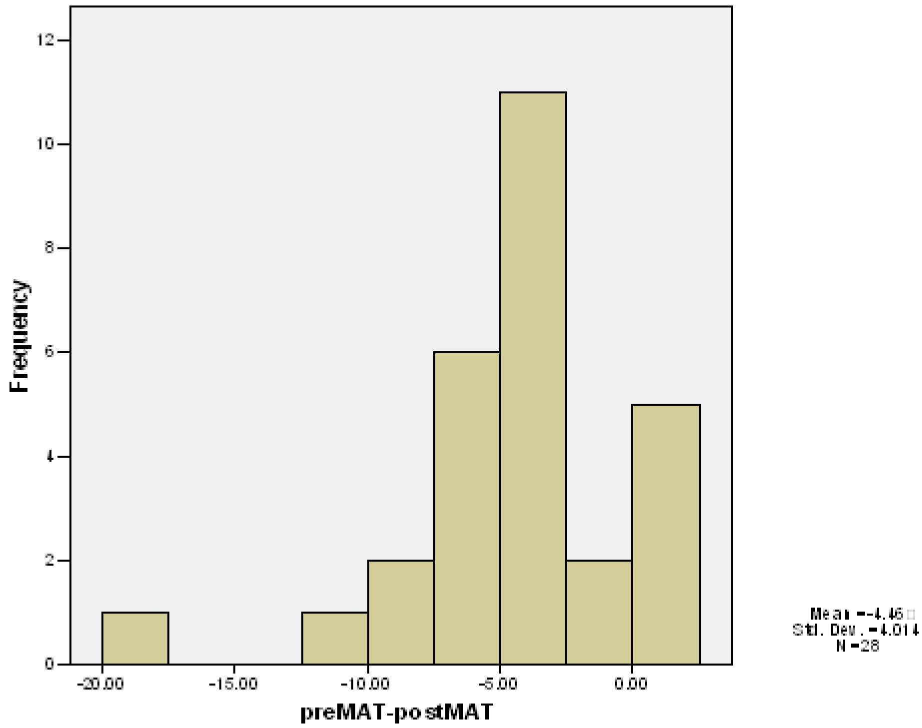


Figure 1. Histogram of PreMAT-PostMAT

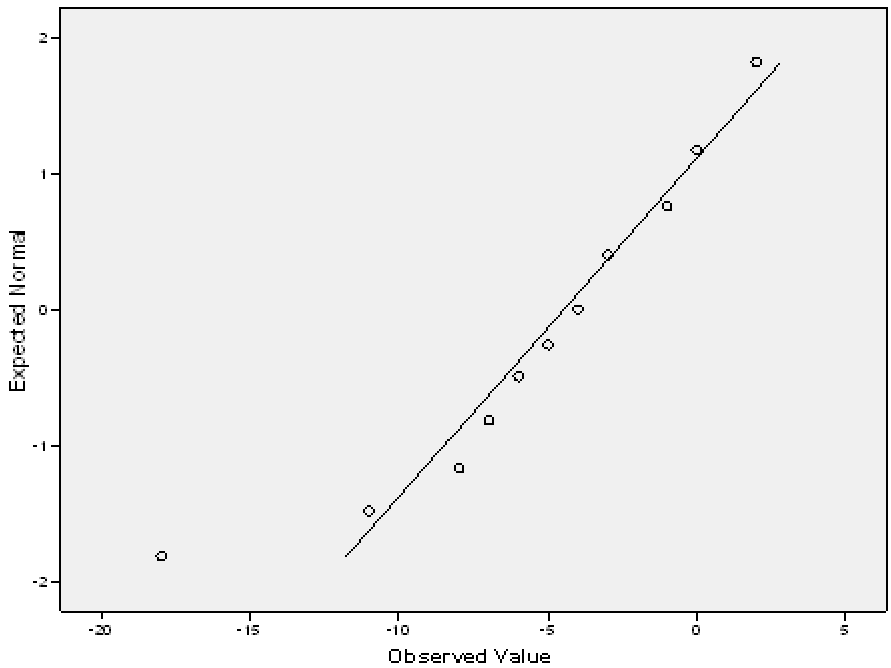


Figure 2. Normal Q-Q Plot of PreMAT-PostMAT

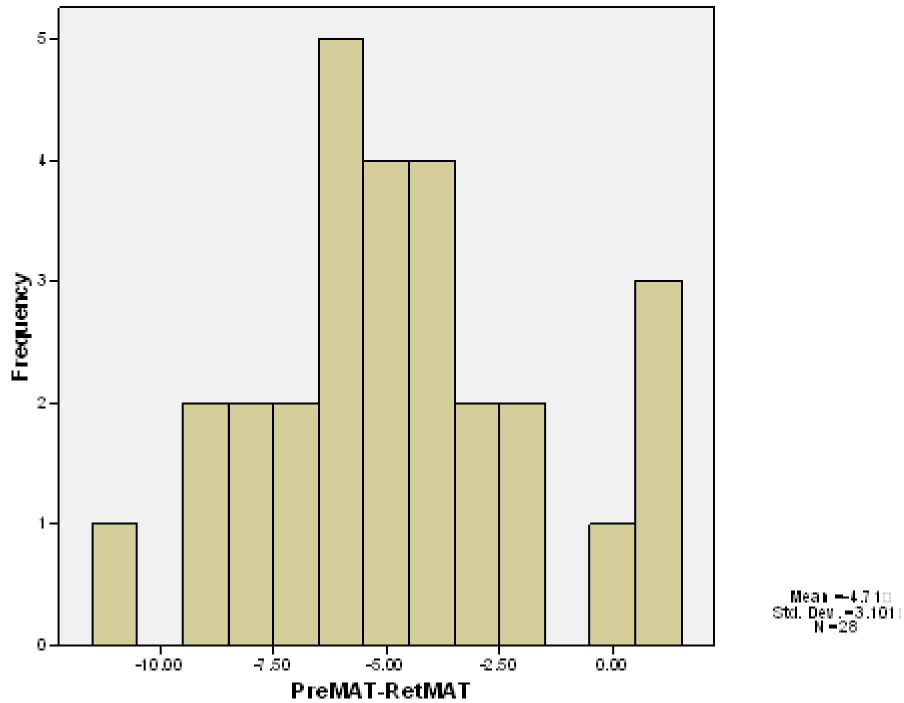


Figure 3. Histogram of PreMAT-RetMAT

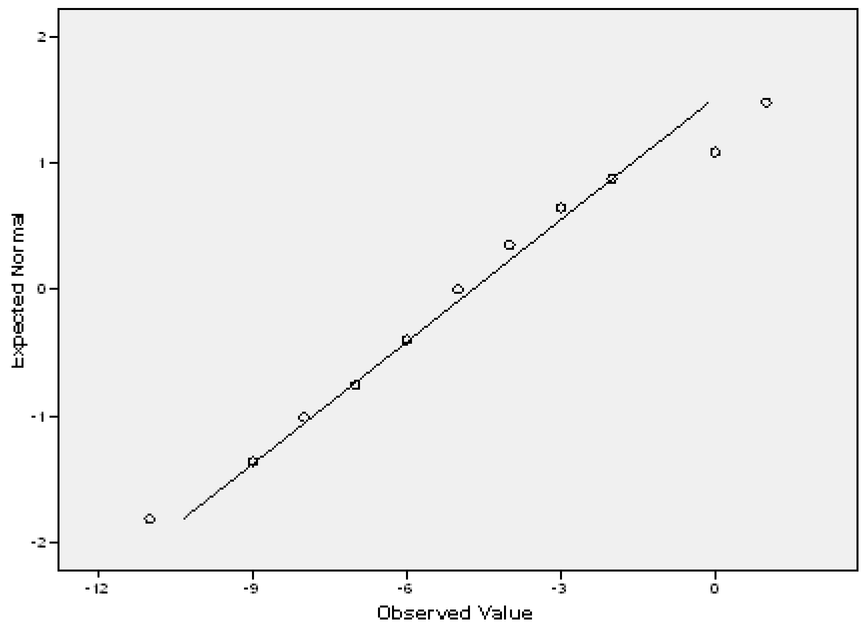


Figure 4. Normal Q-Q Plot of PreMAT-RetMAT

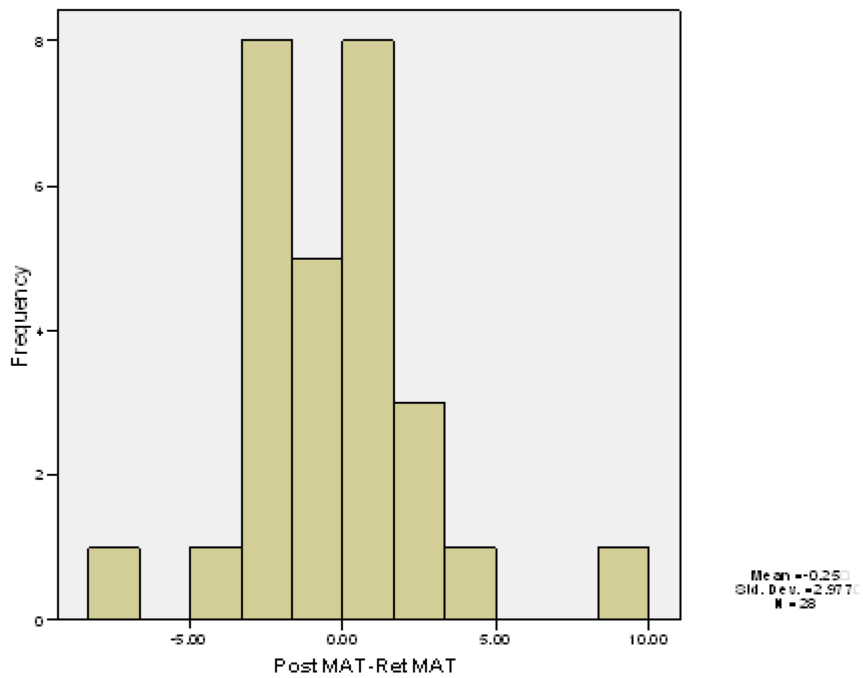


Figure 5. Histogram of PostMAT-RetMAT

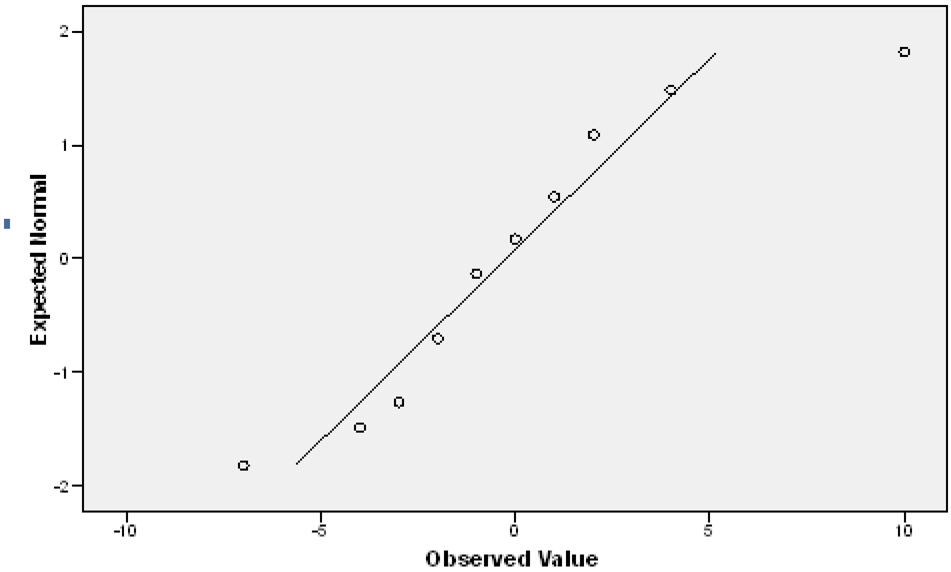


Figure 6. Normal Q-Q Plot of PostMAT-RetMAT

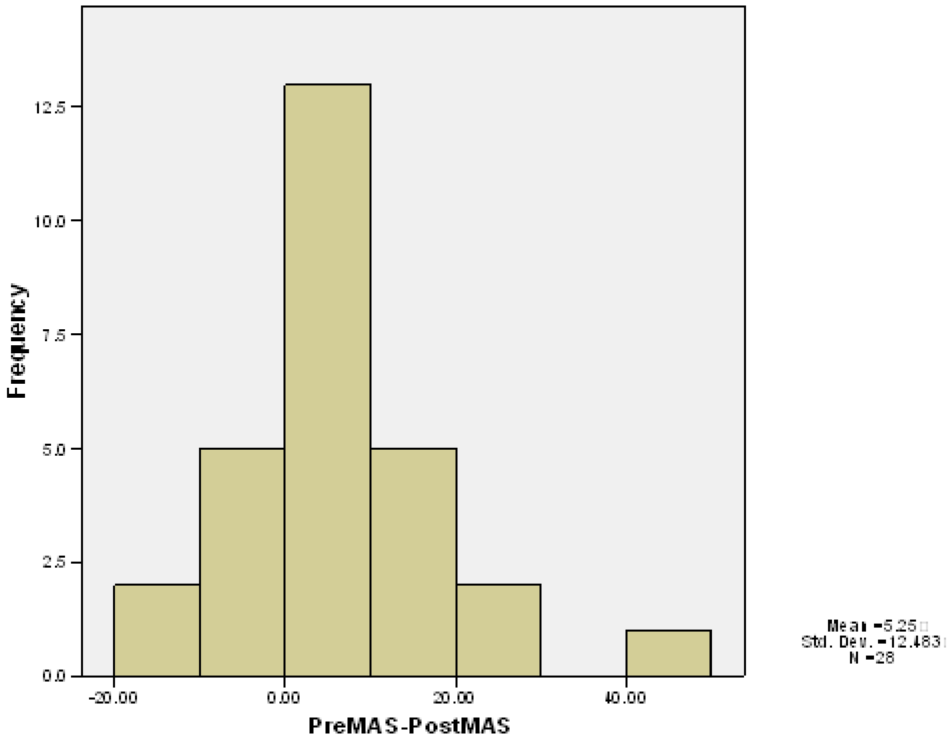


Figure 7. Histogram of PreMAS-PostMAS

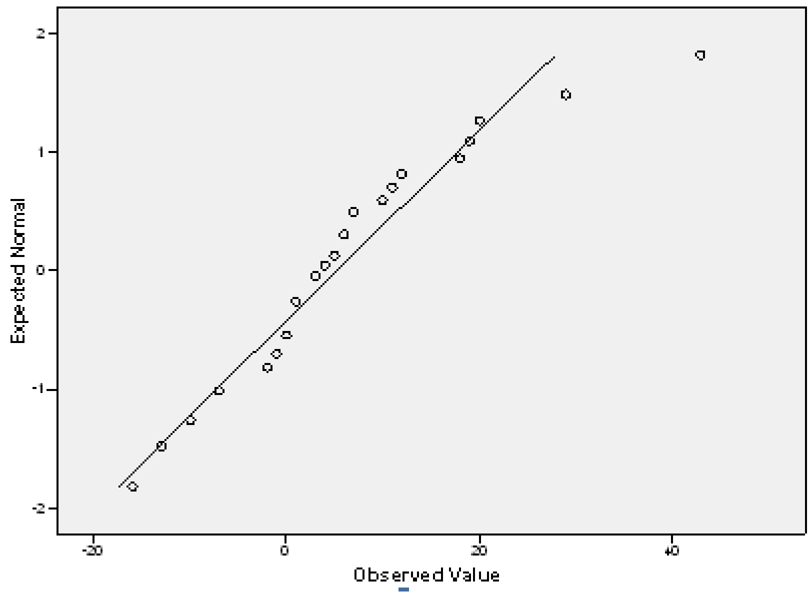


Figure 8. Normal Q-Q Plot of PreMAS-PostMAS

APPENDIX E

SAMPLE LESSON PLANS

Öğrenme Alanı: İstatistik ve Olasılık

Alt Öğrenme Alanı: Olası Durumları Belirleme

Süre: 1 ders saati

Beceriler: Akıl yürütme, ilişkilendirme, iletişim

Kazanımlar: Saymanın temel ilkelerini karşılaştırır, problemlerde kullanır.

Yöntem ve Teknikler: Sorgulama ve keşfetme, yaparak ve yaşayarak öğrenme.

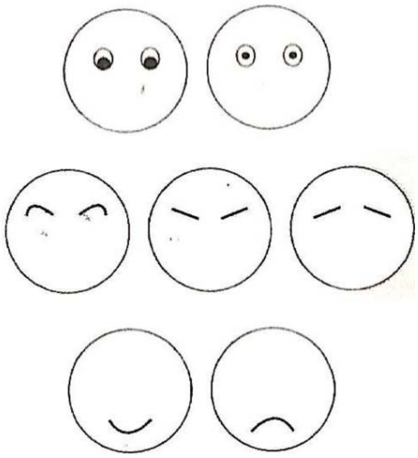
1. Güdüleme: Olasılık ile ilgili neler hatırladıkları sorularak ön bilgileri yoklanır. Fotoğraf ile ilgili sorulan soruların cevabını sayma yaparak bulmaları sağlanır.

‘’

Oğuz, babasına hediye almak için gömlek ve kravat satan bir dükkana girdi. 2 gömlek ve 3 kravat beğendi. Sadece tek parça alırsa kaç farklı alternatifi var?” sorusu öğrencilere yöneltilir ve cevaplarını açıklamaları istenir. Öğrencilerin dikkatleri saymanın temel ilkelerine çekildiğinde etkinliğe geçilir.

2. Keşfetme:

"Kaç Farklı Yüz Oluşur?'' etkinliği saymanın temel ilkelerini fark etmeleri amacıyla verilmiştir.



Etkinlik: Kaç Farklı Yüz Oluşur?

Araç ve Gereçler: Kalem, kağıt, makas

Öğrencilerden karton veya kağıttan yandaki gibi farklı göz, kaş ve ağızlar çizmeleri ve 2 farklı göz, 3 farklı kaş, 2 farklı ağız çizimlerini değişik şekillerde bir araya getirerek farklı yüz tiplerini oluşturmaları istenir. "En fazla kaç yüz oluşturulabilir?" sorusu öğrencilere yöneltilir. Öğrencilerden şema çizerek farklı yüzlerin sayısını bulmaları ve bu yüzleri çizmeleri istenir. "Oluşacak yüz sayısını daha kolay nasıl sayabiliriz?" sorusu öğrencilere yöneltilir ve arkadaşlarıyla tartışmaları istenir. Etkinliğin sonunda neleri fark ettikleri sorulur. Elde ettikleri sonuçları matematik cümlesi olarak ifade etmeleri istenir. Saymanın temel ilkelerinin toplama ve çarpma kuralları içerdiği vurgulanır. Gerekli görülürse tamamlayıcı etkinlik uygulanabilir.

Tamamlayıcı Etkinlik: Kaç Sayı Oluşur?

Araç ve Gereçler: karton, makas, kalem, kağıt

- Kartondan 10 tane eş kare kesilir.

- Karelerin üzerine 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 rakamları yazılır.
- Amaç 3 basamaklı doğal sayılar oluşturmaktır.
- Oluşturulacak sayıların yüzler basamağında 2 ve 3, onlar basamağında 4, 5 ve 6, birler basamağında ise 7, 8, 9 ve 0 rakamları kullanılacaktır.

Y	O	B

2	4	7
3	5	8
	6	9
		0

- Sayıları oluştururken şema kullanılarak bulunan sayılar kaydedilir.
- Etkinlik sürecinde kullanılan yöntemler tartışılır. Oluşacak tüm sayıların sayısını kolay saymak için nasıl bir yöntem kullanılabileceği tartışılır.

3. Açıklama:

Tahtaya aşağıda verilen problemler yazılır ve öğrencilerin olası çözümleri üzerinde durulur. Öğrencilerin cevaplarını nedenleriyle açıklamaları istenir. Diğer öğrencilerinde arkadaşlarının açıklamaları hakkında eleştirel sorular sormalarına ortam sağlanır. Öğrencilerin verdikleri cevaplar doğrultusunda tartışma ortamı yaratılıp bütün öğrencilerin düşüncelerini dillendirmeleri sağlanır.

Efe bakkala gitti. Şekerli sakız, şekersiz sakız, çikolata, gofret ve bisküvi almak istedi. Çikolata, gofret ve bisküviden sadece birini ve bir sakız almaya yetecek kadar parası var. Efe kaç farklı şekilde alışveriş yapabilir?

Ahmet'in 2 kırmızı, 3 mavi, 4 kahverengi kravatı var. Bu kravatlardan bir tanesini takmak istediğinde kaç alternatifi olur?

4. Derinleştirme:

Öğrencilerin daha önceki aşamalardaki öğrenmeleri yeni durumlarda kullanmaları için ortam sağlanır. Öğrencilere farklı yollardan da soruların çözülebileği alternatif soru çözümleri ve açıklamalarını oluşturacak sınıf ortamı sağlanır.

Aşağıda verilen alıştırmaların öncelikle öğrencilerin bireysel olarak cevaplandırmaları istenir. Daha sonra sınıf ortamında öğrencilerle birlikte alıştırmalar çözüme ulaştırılır.

1. Sınıfımızdaki öğrencilerin hangi aylarda doğduklarını belirlemek için bir araştırma yapsak kaç farklı sonuca ulaşırız? Neden?

2. Okul kantininde simit, poğaça, tost, ayran, süt ve meyve suyu satılmaktadır. Kantinden bir çeşit yiyecek ya da içecek alan kişinin kaç alternatifi vardır? Bir içecek ve bir yiyecek alacak olan kişinin kaç şansı vardır? Nasıl bulduğumuzu hem işlem yaparak hem de modelleyerek açıklayınız.

3. Evimizin yanındaki küçük büfede 3 çeşit dergi, 5 çeşit gazete var. Bir dergi ve bir gazete alacağımıza göre kaç farklı şekilde alabiliriz? Nasıl bulduğunuzu açıklayınız.

4. Sınıfımızı güzelleştirmek için bir saksı alıp çiçek dikeceğiz. Çiçekçide lale, papatya, açelya ve karanfil var. Saksı olarak seramik ve plastik olmak üzere iki farklı seçenek var. Kaç farklı biçimde çiçek dikebiliriz?

5. Spor akademisi 1. sınıfta okuyan bir üniversite öğrencisi iki seçmeli ders seçmek zorundadır. Bu derslerden birisi bölüm içi, birisi bölüm dışı olmalıdır.

Bölüm İçi Seçmeli Dersler….Basketbol, atletizm, ilkyardım, jimnastik

Bölüm Dışı Seçmeli Dersler….İngilizce, Almanca, ekonomi

Bu öğrencinin seçebileceği iki ders için kaç farklı alternatifi vardır?

6. Gülen Piknik pazar günleri gözleme günü yapmaktadır. Gözlemelerin içine peynir, ıspanak veya patlıcan konulabilmektedir. Gülen Piknik’ten gözleme siparişi vermek isteyen Sena, karışık gözleme yapılabildiğini öğrenir. Kaç farklı şekilde karışık gözleme siparişi verebilir?

Daha fazla uygulama için öğrencilerin çalışma kitabında bu konuyla ilgili soruları matematik defterlerine yapmaları istenir.

5. Değerlendirme:

Bu aşamada öğrenciler saymanın temel ilkelerinin toplama ve çarpma işlemlerini içerdiğini fark etmelidirler. Öğrencilerin çalışma ve ders kitabındaki alıştırmaları cevaplama durumları ve sınıf içindeki performansları gözlemlenir. Sonuçlar değerlendirilir.

[Note: This lesson plan was utilized from the book written by Gogun (2008, p.36-37)]

Öğrenme Alanı: Sayılar

Alt Öğrenme Alanı: Tam Sayılar

Süre: 2 ders saati

Beceriler: Akıl yürütme, ilişkilendirme, iletişim.

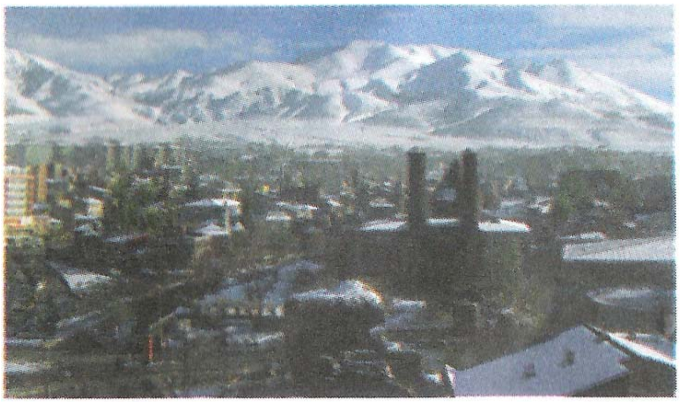
Kazanımlar: 1. Tam sayıları açıklar

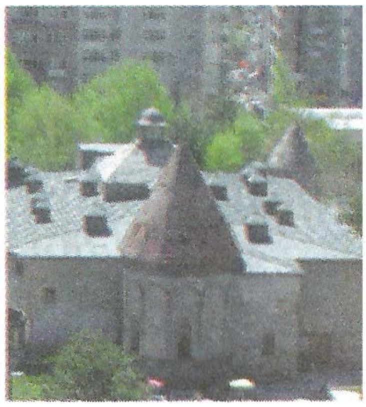
2. Mutlak değerin anlamını açıklar.

Yöntem ve Teknikler: Yaparak, yaşayarak öğrenme, sorgulama ve keşfetme.

Ön hazırlık: Yerleşim yerinin geçmiş yıllara ait sıcaklık değerleriyle ilgili bilgi toplanır.

1. Güdüleme:





Aşağıdaki Erzurum ile ilgili bilgiler okutulup Erzurum hakkında kısa bir tartışma yapılır.

"Erzurum denince Palandöken ve Oltu taşı dışında akla gelen ilk şey ikliminin sert olmasıdır. Erzurum il merkezinde 1929'dan bu yana meteoroloji istasyonu görev yapmaktadır. Yaklaşık 75 yılı bulan gözlem sonuçlarına göre ilde en soğuk ay ortalaması -8 °C, en sıcak ay ortalaması 19 °C , en düşük sıcaklık -35°C ve en yüksek sıcaklık 35 °C olarak ölçülmüştür.'' Öğrencilerin dikkatleri çekildikten sonra Erzurum'un ortalama hava sıcaklık değerleri hakkında yorum yapmaları istenerek sayıların önünde yer alan (+) ve (-) işaretlerinin anlamları tartışılır.

5. sınıfta sayıların önünde yer alan (+) ve (-) işaretlerin anlamları öğrenilmişti. Bu konuda neler hatırladıkları sorularak ön bilgiler ortaya çıkarılır.

Öğrencilerden sıcaklıkların gösteriminde (-) işaretinin anlamını açıklamaları ve (-) işaretinin kullanıldığı alanlara örnekler vermeleri istenir.

Öğrencilerin ilgileri tam sayılara çekildikten sonra etkinliklere geçilir.

2. Kesfetme :

"Sayma Cetveli Yapalım'' etkinliği" Tam sayıları açıklar.'' kazanımı için verilmiştir. Bu etkinliğin amacı tam sayıları tanımalarını sağlamak, negatif ve pozitif tam sayıların sayı doğrusunda yerlerini görerek anlamlı bir şekilde zihinlerinde yapılandırmalarına yardımcı olmaktır. Her öğrenci etkinliği bireysel olarak yapacaktır.

Etkinlik1: Sayma Cetveli Yapalım

Araç ve Gereçler: Karton, makas, cetvel, kalem, simetri aynası

Öğrencilerden;

- kartonu uzun bir şerit halinde kesmeleri,
- şerit üzerine bir doğru çizmeleri,
- elde ettikleri şeridi ortadan ikiye katlayarak doğru üzerinde oluşan kat izine bir çentik atıp üzerine "0" yazmaları,
- cetvel yardımı ile "0" ın sağında ve solundaki 1 cm'lik uzaklıkları işaretlemeleri,
- ''0'' ın sağ tarafındaki işaretlere sırayla 1, 2, 3,… yazmaları,
- simetri aynasını sıfır noktasına yerleştirmeleri,
- oluşan sayma cetvelindeki noktaların simetriğini 0'ın sol tarafına işaretlemeleri,
- 0'ı referans noktası kabul edip, sıfırın sağ tarafını ''ilerlemek'' sol tarafını ''gerilemek'' olarak adlandırmaları istenir.

- “0” ın sol tarafındaki sayıların işaretlerini nasıl yazmalıyız? Sorusu yöneltilip, tartışma ortamı yaratılır.
- “0” ın sağındaki ve solundaki sayıları karşılaştırmaları istenir.

Tam sayıların sayı doğrusu üzerinde 0 noktasına göre simetrik olduğu fark ettirilir. Etkinliğin sonunda öğrencilerden tam sayılar ile ilgili neleri fark ettikleri sorgulanır.

“Sıfıra Hangisi Daha Yakın?” etkinliği “Tam sayıların mutlak değerini bulur.” kazanımı için verilmiştir. Bu etkinlikte amaç mutlak değer kavramını kazandırmaktır.

Etkinlik2: Sıfıra Hangisi Daha Yakın?

Araç ve Gereçler: Karton, cetvel, kalem, makas, silgi, simetri aynası

Öğrencilerden;

- “Sayma Cetveli Yapalım” etkinliğindeki sayma cetvelini tekrar oluşturmaları,
- Cetvelimizdeki 0’ın üzerine bir silgi yerleştirip, silgiyi 0 noktasından önce -3 birim, sonra +3 birim kaydırmaları istenir.
- Daha sonra öğrencilere “Silgimizin son konumu ilk konumundan kaç birim uzaktadır?” sorusu yöneltilir ve silginin cetvel üzerindeki hareketlerini ve konumundaki değişimleri açıklamaları istenir.
- -2 ve +2’nin de ayrı ayrı sıfıra kaçar birim uzaklıkta olduklarını bulmaları ve sıfıra uzak olanı belirlemeleri,
- simetri aynasını 0 noktası üzerine doğruya dik olacak şekilde yerleştirmeleri,
- aynanın iki ayrı yanından bakarak eksi ve artı işaretli sayıların görüntülerini incelemeleri ve düşüncelerini açıklamaları,
- cetveli sıfır çizgisinden ikiye katlamaları ve üst üste gelen sayılar hakkında yorum yapmaları istenir.

Gerekli görülürse tamamlayıcı etkinlik sınıf tartışması yöntemiyle uygulanabilir.

Tamamlayıcı Etkinlik: (-) İşaretli Sayılar

- (-) işaretli sayılara neden ihtiyaç duyulmuş olabileceği üzerine bir tartışma ortamı oluşturulur.
- Bazı sorularla tartışmanın odak noktası vurgulanabilir.

Örnekler:

- (-) işaretli sayıların kullanıldığı durumları hatırlayın. Bu durumlarda sadece doğal sayıları kullanmak yeterli olabilir mi? Dünya üzerindeki herhangi bir yerin yükseklik veya derinliğini göstermek için deniz seviyesi referans alınır. Bunun sebebi ne olabilir?

3. Açıklama:

"Sayma Cetveli Yapalım" etkinliğiyle öğrencilerin tam sayılar ile ilgili neleri fark ettiklerini ve "Sıfıra Hangisi Daha Yakın?" etkinliği ile öğrencilerden mutlak değer ile ilgili öğrendiklerini açıklamaları istenir. Öğrencilerin etkinlikler sonucunda elde ettikleri bulguları açıklamalarından sonra öğretmen gerekli düzeltme ve açıklamalarda bulunur.

Sayıların önüne konulan "+" ve "-" işaretlerinin, sayıların yönünü belirten işaretler oldukları hatırlatılır. Pozitif ve negatif tam sayıların, "0" ile birleşim kümesine "Tam Sayılar Kümesi" denildiği ve Z harfi ile gösterildiği belirtilir.

-3 ve +3 gibi sayılar sıfıra eşit uzaklıktadır. Bu ortak uzaklık iki sayının "mutlak değeri" olarak adlandırılır. Mutlak değer daima pozitiftir. Mutlak değer sembol ile $|-3|$ = $|+3|$ şeklinde gösterilir. $|-3|$, "eksi üçün mutlak değeri" şeklinde okunur. $|-3| = |+3| = 3$

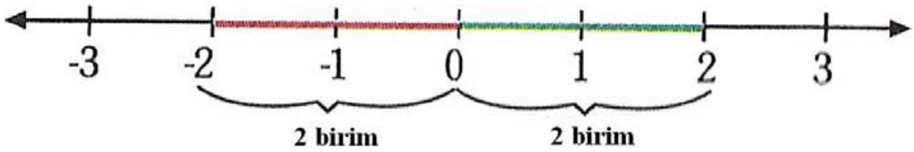
Örnek1:

Sıfırın sağındaki ve solundaki sayıları sayı doğrusu yardımı ile tanıyalım. Kullanım alanlarına örnekler verelim.

Tam sayıların kullanım alanlarına örnekler:

- Sıcaklık sıfırın altında 6 °C: -6 °C
- 40 YTL borç: -40 YTL
- 10 YTL kar: + 10 YTL gibi.

Örnek2:



-2 ve +2 sayıları sıfıra eşit uzaklıktadır.

$|-2| = |+2| = 2$

4. Derinleştirme:

Tahtaya aşağıda verilen alıştırmalar yazılır ve öğrencilerin olası çözümleri üzerinde durulur. Öğrencilerin cevaplarını nedenleriyle açıklamaları istenir. Diğer öğrencilerinde arkadaşlarının açıklamaları hakkında eleştirel sorular sormalarına ortam sağlanır. Öğrencilerin verdikleri cevaplar doğrultusunda tartışma ortamı yaratılıp bütün öğrencilerin düşüncelerini dillendirmeleri sağlanır.

Aşağıda verilen alıştırmaların öncelikle öğrencilerin bireysel olarak cevaplandırmaları istenir. Daha sonra sınıf ortamında öğrencilerle birlikte alıştırmalar çözüme ulaştırılır.

1-5. sorulardaki ifadeleri tam sayılarla gösteriniz.

1. Sıcaklık sıfırın altında 5 derece
2. Sıcaklık sıfırın üstünde 12 derece
3. 45 YTL borç
4. 62 YTL kar
5. Deniz seviyesinin 6m altı

Bir sayı doğrusu çizerek aşağıdaki sayıları gösteriniz.

6. +4

7. -3

8. -2

9. +3

10. $|-4|$, $|-8|$, $|+7|$, $|+15|$ sayılarının değerlerini bulunuz.

Aşağıdaki noktalı yerlere ‘’<’’, ‘’>’’ veya ‘’=’’ sembollerinden uygun olanı yerleştiriniz.

11. $|-4|$..............$|-3|$

12. $|-8|$................$|-6|$

13. $|-8|$................$|+4|$

14. $|+12|$..............$|-5|$

Daha fazla uygulama için öğrencilerin çalışma kitabında bu konuyla ilgili soruları matematik defterlerine yapmaları istenir.

5. Değerlendirme:

Bu aşamada öğrenciler tam sayılar ve mutlak değer kavramlarını tanımış olmalıdır. Öğrencilerin çalışma ve ders kitabındaki alıştırmaları cevaplama durumları ve sınıf içindeki performansları gözlemlenir. Sonuçlar değerlendirilir.

[Note: This lesson plan was utilized from the book written by Gogun (2008, p.69-70)]

Öğrenme Alanı: Sayılar

Alt Öğrenme Alanı: Kesirler

Süre: 2 ders saati

Beceriler: Akıl Yürütme, ilişkilendirme, iletişim.

Kazanımlar: Kesirlerle bölme işlemini yapar

Yöntem ve Teknikler: Sorgulama ve keşfetme, iş birliğine dayalı öğrenme.

1. Güdüleme:

Yukarıdaki tartışan çocuklar resmi inceletilerek hangi çocuğun düşüncesinin doğru olduğunun nasıl bulunacağı sorulur.

‘’Bu çocukların tartışmaları matematikteki hangi işlem ile ilişkilidir?’’ diye sorularak kesirlerle bölme işlemine öğrencilerin odaklanmaları sağlanır.

Kesirlerle bölme işlemi ile öğrenciler ilk kez karşılaşacaklar bu nedenle doğal sayılarla bölme, kesirlerle bölme arasındaki ilişki gibi konularda daha önce neler öğrendikleri, neleri hatırladıkları sorularak ön bilgileri ortaya çıkarılır.

Öğrencilerin konuya odaklanması sağlanınca etkinlik uygulanır.

2. Keşfetme:

''Kesirlerle Bölme''etkinliğinin amacı öğrencilerin kesir takımı gibi somut materyalleri kullanarak kesirlerle bölme işlemini keşfetmelerini sağlamaktır. Etkinlik gruplar halinde yapılacağından dolayı öğrenciler gruplara ayrılır. Etkinlikte yaptıklarını matematik cümlesi olarak ifade etmeleri istenir.

Etkinlik: Kesirlerle Bölme İşlemi

Araç ve Gereçler: Kesir Takımı

Her grup;

- 2 tam içinde kaç tane $\frac{1}{3}$ kesri bulunduğunu kesir takımıyla bulur.
- $\frac{1}{4}$ kesrinin içinde kaç tane $\frac{1}{8}$ olduğunu kesir takımını kullanarak bulur.
- $\frac{1}{4}$'ün içinde kaç tane $\frac{1}{8}$, kaç tane $\frac{1}{12}$ olduğunu kesir takımı ile bulur.

Öğrencilere bu yaptıklarını ardışık çıkarma ile gösterip gösteremeyecekleri sorulur. Başka bir işlemle nasıl gösterebilecekleri tartışılır. Hangi işlem ile ifade edebilecekleri sorulur.

Her grup;

- $\frac{3}{4}$'ün içinde kaç tane $\frac{1}{12}$ olduğunu bulur.
- $\frac{2}{3}$'ün içinde kaç tane $\frac{1}{12}$ olduğunu bulur.

Öğrencilerden bu işlemleri matematik cümlesi olarak ifade etmeleri istenir. İşlemlerin nasıl yapıldığı tartışılır.

<table><tr><td colspan="3">1</td></tr><tr><td>1/3</td><td>1/3</td><td>1/3</td></tr></table>

<table><tr><td colspan="4">1</td></tr><tr><td>1/4</td><td></td><td></td><td></td></tr></table>

<table><tr><td colspan="8">1</td></tr><tr><td colspan="2">1/4</td><td colspan="2">1/4</td><td colspan="2">¼</td><td colspan="2">¼</td></tr><tr><td>1/8</td><td>1/8</td><td>1/8</td><td>1/8</td><td>1/8</td><td>1/8</td><td>1/8</td><td>1/8</td></tr></table>

Tamamlayıcı Etkinlik: Kesirlerle Bölme

Araç ve Gereçler: Kağıt

Bir kağıttan kaç tane $\frac{1}{5}$’lik parça elde edilebileceği tartışılır.

2 kağıttan kaç tane $\frac{1}{4}$’lük parça elde edilebileceği tartışılır.

$1 : \frac{1}{5}$ ve $2 : \frac{1}{4}$ işlemlerini kağıt katlayarak yapmaları istenir.

Bir kağıdın $\frac{1}{2}$’sinden kaç tane $\frac{1}{4}$’lük parça elde edilebileceğini kağıt katlayarak bulmaları istenir. Benzer bir yöntem ile kağıdın $\frac{3}{4}$’ünden kaç tane $\frac{1}{8}$’lik parça elde edilebileceği gerekli katlamalar yapılarak bulunur.

Yapılan katlamaların bölme işlemi ile ilişkisi açıklatılır.

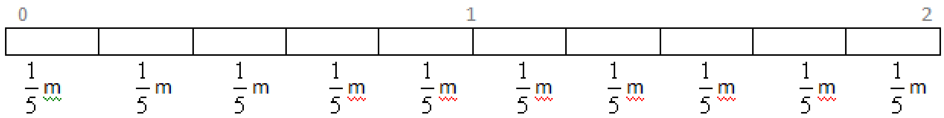
3. Açıklama:

Yapılan etkinliğin daha iyi anlaşılabilmesi için öğrencilerden etkinlikteki deneyimlerini paylaşmaları istenir. Öğrencilerden ulaştıkları sonuçları açıklamaları istenir ve daha sonra öğretmen tarafından gerekli düzeltme ve açıklamalar yapılır.

Bir kesri başka bir kesre bölmenin, birinci kesrin içinde ikinci kesrin kaç tane olduğunu bulma olduğu vurgulanır. Ortak payda algoritmasında, kesirlerin paydaları eşitlenerek birinci kesrin payının ikinci kesrin payına bölündüğü vurgulanır. Bölme işleminde, “ters çevir çarp” algoritması ortak payda algoritmasından sonra tanıtılır. Bölme işlemine bir doğal sayının kesirlerle bölünmesi ile başlanır.

Aşağıda verilen örnekler inceletilip sorgulatılarak etkinlikte yapılanlar pekiştirilir. Modelleme yapılan örnekler sayesinde bölme işleminin anlamı vurgulanır.

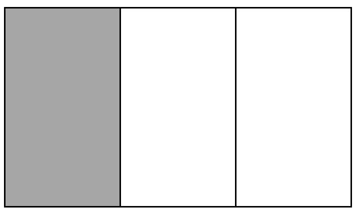
1. Canan kurdeleden kestiği $\frac{1}{5}$ m’lik parçalarla toka yapıyor. 2m kurdeleden kaç tane toka yapabilir?



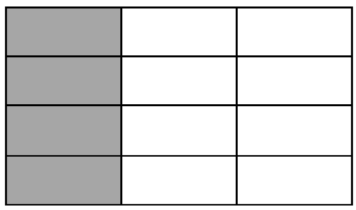
$2 : \frac{1}{5} = \frac{10}{5} : \frac{1}{5} = 10 : 1 = 10$ $\qquad$ $\frac{10}{5}$ içinde 10 tane $\frac{1}{5}$ vardır.

2. 4 girişimci, $\frac{1}{3}$ hissesi satılan şirkete birlikte ortak olmaya karar verdi. Her birinin sahip olacağı hisse tüm şirketin kaçta kaçı olacaktır?

$\frac{1}{3} : 4$ işlemi yapılacaktır. Bu işlemi model yardımı ile yapalım.



$\frac{1}{3}$



$\frac{1}{3} = \frac{4}{12}$

$\frac{1}{3} : 4 = \frac{4}{12} : 4 = \frac{1}{12}$

3. Bölme işlemi ile çarpma işlemi arasındaki ilişkiyi inceleyelim.

6 : 2 işlemini $\frac{6}{2}$ olarak ifade edebiliriz.

$\frac{6}{2}$ kesrini de 6 tane $\frac{1}{2}$ anlamına gelen 6 x $\frac{1}{2}$ şeklinde gösterebiliriz. Bu durumda 6 ÷ 2 = $\frac{6}{2}$ = 6 tane $\frac{1}{2}$ = 6 x $\frac{1}{2}$ şeklinde gösterebiliriz.

Bu durumda:

6 ÷ 2 = 6 x $\frac{1}{2}$ şeklinde bir ilişki ortaya çıkar.

Benzer bir ilişkiyi kesirlerle bölme işleminde de kullanabiliriz.

$\frac{3}{4} \div \frac{4}{5} = \frac{3}{4} \times \frac{5}{4} = \frac{15}{16}$

4. $8\frac{3}{11} : 3\frac{4}{5}$ işleminin sonucunu tahmin edelim.

$8\frac{3}{11} : 3\frac{4}{5} \approx 8 : 4 = 2$

4. Derinleştirme:

Öğrencilerden aşağıda verilen alıştırmaları bireysel olarak yapmaları sağlanır.

Aşağıdaki bölme işlemlerinin sonucunu önce tahmin ediniz. Daha sonra tahmininizi işlem sonucuyla karşılaştırınız.

1. $3 : \frac{4}{7}$

2. $\frac{6}{9} : \frac{1}{5}$

3. $\frac{14}{21} : \frac{3}{5}$

4. $\frac{7}{8} : \frac{2}{7}$

5. Aynur sınıfa $\frac{42}{4}$ m ip getirdi. Sınıfta ip atlamak için 5 gruba ayrılan arkadaşlarına bu ipi eşit uzunluklarda keserek vermek istiyor. Her gruba kaç m ip vermeli?

6. Bu sene tarladan $\frac{32}{3}$ ton pamuk toplandı. Tarlanın 3 ortağı var. Her birine kaç ton pamuk düşer?

7. Bakkala çuval ile $\frac{27}{2}$ kg bulgur geldi. Bakkalın sahibi $\frac{3}{5}$ kg'lık paketler yapmak istiyor. Kaç paket bulgur olur?

Öğrenciler çalışma kitabındaki alıştırmaları matematik defterlerine yapmaları için yönlendirilirler.

5. Değerlendirme:

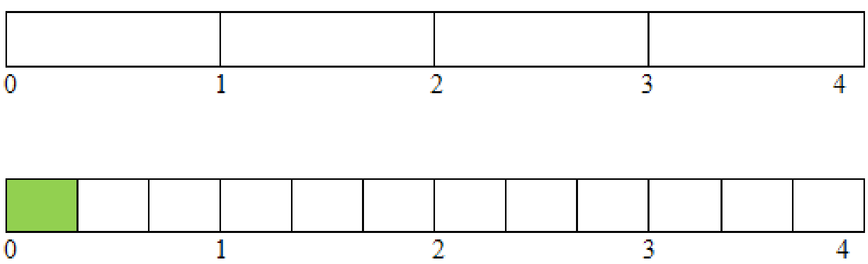
Kesirlerle bölme işleminin bu aşamada kazanılmış olması gerekmektedir. Öğrencilerin etkinliklere katılımları ve verdikleri cevaplar dikkate alınarak değerlendirme yapılır.

Aşağıda verilen geliştirici etkinlik uygulatılıp öğrencilerin performansları gözlenerek değerlendirme yapılır.

Geliştirici Etkinlik: Bölelim

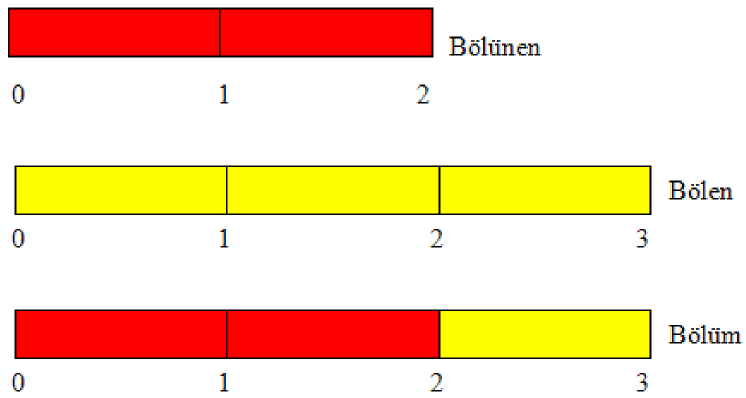
Araç ve Gereçler: Kalem, kağıt

- Aşağıdaki modellemeler incelenir.
- Her bir modellemedeki işlemler açıklanır.



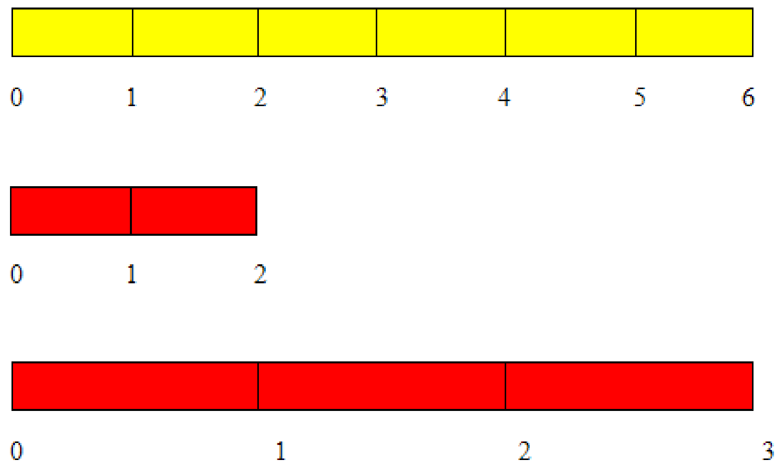
$4 : \frac{1}{3}$

- 2 : 3 işlemini modelleyelim.



$$2 : 3 = \frac{2}{1} \cdot \frac{1}{3} = \frac{2}{3}$$

- 6 : 2 işlemini modelleyelim.



$$6: 2 = \frac{6}{1} \cdot \frac{1}{2} = \frac{6}{2} = 3$$

- $\frac{2}{5}$: 4, 3:5, 8:2 işlemleri örneklerde olduğu gibi modellenir.
- Yapılan modellemelerle bölme kavramı kazandırılarak işlemsel özellikleri keşfettirilir.

[Note: This lesson plan was utilized from the book of (Gogun, 2008, p.115-116)]

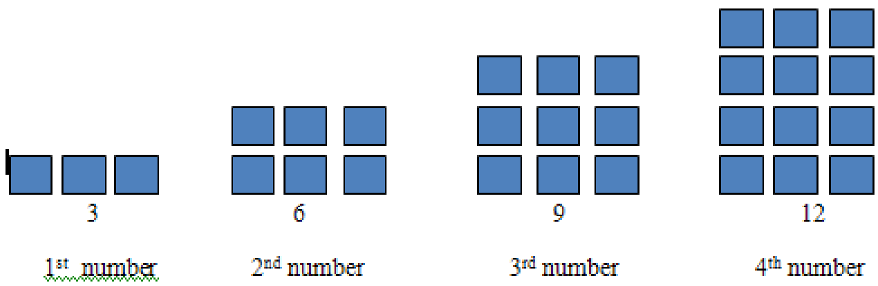
APPENDIX F

SAMPLE ACTIVITIES

Activity1: Let's Find the Rules in the Patterns (Gogun, 2008, p.65).

Instructional Materials: paper, scissors

- Students were wanted to get equal, square-shaped places from the papers.
- Students were wanted to compose the square-shaped patterns below.



- Students were wanted to form a table to see the relationship between the numbers of the patterns general composed.

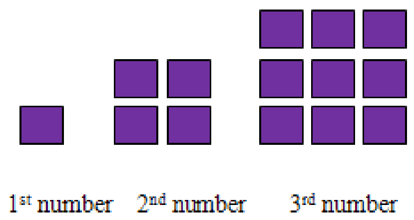
The number's number in the pattern	The number of rectangular areas used with the number	The relationship between the number of rectangular areas used for number		
		1. option	2. option	Another
1	3	1+1+1=3	3·1=3	...
2	6	2+2+2=6	3·2=6	...
3	9	3+3+3=9	3·3=9	...
4	12	4+4+4=12	3·4=12	...
...	...	...	...	...
N	...	n+n+n	3n	...

- Students were made to find a rule about the patterns.
- Students were wanted to reckon how many square-shaped place would occur in the 100th diagram by the help of the rule.
- Students were wanted to show how to represent the number of square-shaped places when any of the number of the pattern was represented with "n".

The activity "Let's Compose Number Patterns" was given to let students get the acquisation of determining the value of natural numbers' repeated multiplication. The activity started with the work of finding the rule of the pattern and reached the basic purpose of finding the rule of pattern and its' expression of letters. After noticing that this pattern was composed by square numbers, students were wanted to show these numbers as 1^2, 2^2, 3^2, 4^2. Students were made to notice that exponent demonstration was not only for square- shaped numbers, and all the numbers multiplied with them could be put across as exponents. The counting stamps were made from colourful papers.

Activity 2: Let's Compose Number Patterns (Gogun, 2008, p.66).

Instructional Materials: counting stamps



- Students were wanted to compose the pattern above by using counting stamps.
- Students were wanted to express the patterns with numbers.
- Students were made to express the relationship with letters.
- To control whether the demonstration of letters was correct or not it was wanted to try the 4th letter demonstration.
- Students were wanted to explain the relationship of the natural numbers' repeated multiplication with the activities.

Students were wanted to make the activity with groups. Students were wanted to express the knowledge after the activity with mathematical sentences.

Activity 3: Let's Examine the Rectangles (Gogun, 2008, p.96)

Instructional Materials: cartoon, scissors, ruler, pencil, square-shaped paper

- Students were wanted to compose groups with two people.
- Students were wanted to acquire equal square shapes from 20 papers.
- Students were wanted to compose different rectangles whose areas are 6, 12, 15, 16, 20.
- Students were wanted to connect the areas of rectangles with their edge lengths.
- Students were wanted to find how many multiples had got each number.
- Students were wanted to paint the rectangles and explain the composition.
- Students were wanted to find the multipliers.
- Students were wanted to examine the connection between 6's multiples and 6's multipliers.

The aim of the activity of "Division Rules" was to provide the students to explore the patterns and rules of division between 2, 3 and 5's multiples. Students were provided to find the patterns between the numbers which were painted yellow and red. And students were wanted to express their ideas about these numbers. Students were wanted to discuss in a given time to provide class dicipline after that students were wanted to explain the results found in each group. Students were made to explore the features which divide the determined numbers multiples from the others. After the activity, the students were wanted to explain the results with their own sentences. By the help of the rules of division to 2, 3 and 5 without remaining, the rules of division to 4, 6, 9 and 10 is also explored.

Activity 4: Division Rules (Gogun, 2008, p.98).

Instructional Materials: A table of 100 or square-shaped paper

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

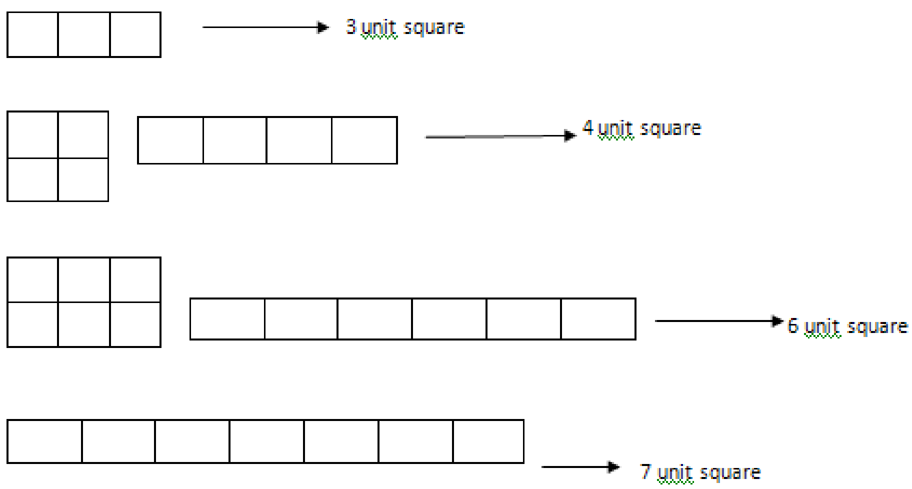
- Students were wanted to paint red the number patterns of 2 and its multiples and paint yellow the number patterns of 4 and its multiples.
- Students were made to explain each colour's common features.
- Students were wanted to write down these features and discuss them.
- Students were wanted to examine the number patterns which were composed of 3, 6, 9's and 5, 10's multiples.
- Students were wanted to determine the numbers of the colours in the table.
- Students were wanted to explain the relationship between the numbers 2, 3, 4, 5, 6 and 9.

The aim of the activity of "Let's Find the Different One" was to provide students to notice the rules of prime numbers. This activity could be made by using counting stamps. In this activity, students were wanted to compose different square-shapes and rectangles whose areas were 7, 8, 9, 10, 11. It was noticed that some of the rectangle-shaped areas were composed from one figure.

Students were wanted to express the knowledge by written and verbally. Whether 1 was prime number or not was discussed. 2's being a prime number and even number was emphisized.

Activity 5: Let's Find the Different One (Gogun, 2008, p.100).

Instructional Materials: square-shaped paper, scissors



- Students were wanted to compose groups with 2 people.
- Students were wanted to acquire equal squares from the papers.
- Students were wanted to compose rectangles which had the same areas.
- Students were wanted to arrange the different areas of rectangles.
- Students were wanted to explain which areas' values could be written as the multiplication of just 1's and its own.

The aim of activity "Let's Find out Prime Numbers" was to provide students to determine prime numbers. While applying this activity, prime numbers was related to the subjects of multiplier and multiples. It was questioned how this applied method provided to find prime numbers.

Activity 6: Let's Find out Prime Numbers (Gogun, 2008, p.101)

Instructional Materials: square-shaped paper, colourful pencils;

- A table of 100 was composed with the numbers from 1 to 100 on a square-shaped paper.
- In the table 2 was circled and all 2’s multipliers were painted.
- The same process was made for 3, 5, 7, too.
- The numbers which were not painted are observed subsequently.
- The students were wanted to explain their thoughts of numbers by connecting them with the results acquired previously.