THE EFFECT OF USING GAME-BASED LEARNING ACTIVITIES IN ALGEBRA ON SEVENTH-GRADE STUDENTS' ALGEBRA ACHIEVEMENT, ATTITUDE TOWARDS MATHEMATICS AND OPINIONS ABOUT GAME-BASED LEARNING ACTIVITIES

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

THE EFFECT OF USING GAME-BASED LEARNING ACTIVITIES IN ALGEBRA ON SEVENTH-GRADE STUDENTS' ALGEBRA ACHIEVEMENT, ATTITUDE TOWARDS MATHEMATICS AND OPINIONS ABOUT GAME-BASED LEARNING ACTIVITIES

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The purpose of the present study was to investigate the effect of using game-based learning activities in algebra on seventh-grade students' algebra achievement, attitudes towards mathematics, and opinions about game-based learning activities. The study sample included 19 seventh-grade students at a public middle school in İstanbul, and the sample was chosen by convenience sampling method. The study was a one-group pretest-posttest experimental design. During the intervention of the study, 5 lesson plans that included game-based learning activities were implemented, and these plans took 10 class hours in 5 weeks including the administration of the tests. Algebra Achievement Test (AAT) was implemented as a pretest and posttest to measure students' algebra achievement. Moreover, Mathematical Attitude Scale (MAS) was implemented as a pretest and posttest to investigate students' attitudes towards mathematics. After the intervention, semi-

structured interviews were carried out with 10 purposefully selected students to understand their opinions about the lessons that used game-based learning activities. The result of the study showed that there was a significant mean difference between pretest and posttest scores for AAT and MAS. Moreover, almost all students interviewed stated that they developed positive opinions towards mathematics in this intervention process and wanted game-based learning activities to be used in mathematics lessons.

Keywords: Game, Game-Based Learning, Game-Based Learning Activities and Mathematics Education, Algebraic Achievement and Thinking

ÖZ

OYUN TEMELLİ ÖĞRENME ETKİNLİKLERİNİN YEDİNCİ SINIF ÖĞRENCİLERİNİN CEBİR BAŞARISI, MATEMATİĞE KARŞI TUTUMLARI VE OYUN TEMELLİ ÖĞRENME ETKİNLİKLERİ HAKKINDAKİ GÖRÜŞLERİNE ETKİSİ

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Bu çalışmanın amacı, cebirde oyun temelli öğrenme etkinliklerinin kullanılmasının yedinci sınıf öğrencilerinin cebir başarılarına, matematiğe yönelik tutumlarına ve oyun temelli öğrenme etkinliklerine ilişkin görüşlerine etkisini araştırmaktır. İstanbul ilinde bir devlet ortaokulunda öğrenim görmekte olan 19 yedinci sınıf öğrencisinden oluşan çalışma örneklemi, uygun örnekleme yöntemi ile seçilmiştir. Araştırma tek gruplu ön test-son test deneysel desendir. Araştırmanın müdahalesi sırasında, oyun temelli öğrenme etkinlikleri içeren 5 ders planı uygulanmış ve bu planlar 5 haftada test uygulamaları da dahil olmak üzere 10 ders saati sürmüştür. Cebir Başarı Testi (CBT) öğrencilerin cebir başarısını ölçmek için ön test ve son test olarak uygulanmıştır. Ayrıca, öğrencilerin matematiğe yönelik tutumlarını araştırmak için Matematiksel Tutum Ölçeği (MTÖ) ön test ve son test olarak uygulanmıştır. Müdahaleden sonra, oyun temelli etkinliklerin kullanıldığı derslere

ilişkin görüşlerini anlamak amacıyla, amaçlı olarak seçilen 10 öğrenci ile yarı yapılandırılmış görüşmeler yapılmıştır. Çalışmanın sonucu, CBT ve MTÖ için ön test ve son test puanları arasında anlamlı bir fark olduğunu göstermiştir. Ayrıca, görüşme yapılan öğrencilerin neredeyse tamamı, bu müdahale sürecinde matematiğe yönelik olumlu görüşler geliştirdiklerini ve matematik derslerinde oyun temelli öğrenme etkinliklerinin her zaman kullanılmasını istediklerini belirtmişlerdir.

Anahtar Kelimeler: Oyun, Oyun Temelli Öğrenme, Oyun Temelli Öğrenme Etkinlikleri ve Matematik Eğitimi, Cebirsel Başarı ve Düşünme

To My Beloved Family

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ABBREVIATIONS

AAT: Algebra Achievement Test

MAS: Mathematics Attitude Scale

MoNE: Ministry of National Education

Pre-AAT: Pretest of Algebra Achievement Test

Post-AAT: Posttest of Algebra Achievement Test

Pre-MAS: Pretest of Mathematics Attitude Scale

Post-MAS: Posttest of Mathematics Attitude Scale

CHAPTER 1

INTRODUCTION

“Games are as old as the existence of civilization, so we can say that games and civilization are coetaneous”(Yılmaz, 2015, p. 4). According to Huizinga (1938), game is an older concept than civilizations since we mean humankind while talking about civilizations; however, animals have discovered the game long before human civilization (as cited in Yılmaz, 2015). Although games exist in every period of our lives, it is not possible to define ‘‘games’’ exactly. Until now, many people have provided definitions for games. Gross (1901) defines games as an exercise to prepare people for their future life and activity to develop their skills. According to Vygotsky (1966), a game is a discovery and a new formation (as cited in Sevinç, 2004). When considered from this point of view, games gain importance for the learning process.

Along with the beginning of the school-age, the purposes of playing games change, and games are used as a teaching method. The main purpose of teaching by using game techniques is to maximize the physical and mental development of the children, social adaptation, and emotional maturity (Tural, 2005). Also, teaching by using games was found out to improve performance, achievement, and motivation (Uğurel & Moralı, 2008). In addition to this, games enable development of problem solving and decision-making skills. Moreover, games allow children to get in contact with their environment actively and to make sense of their existing knowledge. Also, games were found to help with learning by the help of their sensuous aspects, such as visual and aural aspects. When we consider all of these, we can say that games provide many advantages in learning and teaching

processes, so they are so essential for education. Although the importance of the games has been known for a long time, it has begun to be used in education recently, and one of the subjects in which games are used is mathematics.

Mathematics has been perceived as a challenging course in Turkey, and OECD data showed that the mean performance of Turkey in mathematics in PISA 2018 was below average. In this problematic situation, teaching methods might have a role. As Pink Floyd (1979) mentioned in the song “Another Brick in the Wall,” stereotype educational system and the teachers should set the students free, and so the students can each be unique and differ from a brick in the wall.

The question of ‘‘How can a mathematics instruction be designed which set the students free in their learning process and break down the prejudices against mathematics education?’’ is searched for a long time. The only answer to this question is that an active classroom environment and particular teaching methods that help students be more active are required for effective mathematics teaching. When we talk about the teaching methods which make the students more active, the first thing that comes to mind is using game-based learning activities as a teaching method in mathematics education.

Mathematics and games are interrelated concepts contrary to what is believed. For example, moving from concrete to abstract, from simple to complex, and making interpretations of these used for mathematical knowledge generation and learning of it can also be observed in the games we play (Uğurel & Moralı, 2008). So, it is possible to find mathematics in the games and to find the games in mathematics. As Umay (2002) says, ‘‘games are mathematics largely, and mathematics is a game totally’’ (p. 275).

If real achievement is desired for a mathematics course, the students desist from memorizing mathematics rules and are guided for reasoning. This goal can be made real by putting the students in the center of the teaching process with the help of

game techniques. According to Nesin (2005), instead of focusing on learning knowledge in the mathematics course, mathematics courses should focus on searching, thinking, asking appropriate questions, and self-learning. Also, Nesin says that “mathematics topics should be presented in the form of a game without being boring” (Nesin, 2001, p. 13). In such a learning environment, mathematics will not be a tedious course, and many students will enjoy and be eager to be successful in mathematics. In this way, permanent learning of mathematical concepts could be realized.

Until today, researchers (e.g., Chiang & Qin, 2018; Kebritchi, 2008; Köroğlu & Yeşildere, 2002; Tural, 2005; Uğurel & Moralı, 2008; White & McCoy, 2019) conducted studies related to games and mathematics education, and these studies showed the effect of games in learning some mathematical concepts. Algebra is also an area of mathematics that includes many important concepts to learn, and also the effect of games should be considered in learning algebra.

When we focus on specific mathematics concepts apart from talking about math in general, some of the most important mathematics concepts can be related to algebra. Kriegler (2008) stated that algebra is one of the essential learning areas of mathematics which includes two components as mathematical thinking tools and the study of fundamental algebraic ideas. While mathematical thinking tools focus on problem-solving, representation, and reasoning skills, fundamental algebraic concepts focus on algebra as generalized arithmetic, algebra as a language, and algebra as a tool for functions and mathematical modelling (Kriegler, 2008).

Most of the learners have substantial difficulties understanding algebraic concepts. The most important difficulty for students in algebra is related to the transition from arithmetic to algebra. As Filloy and Rojano (1989) stated, some studies also showed some conceptual changes which mark a difference between arithmetic and algebraic thinking in the individual.

To discuss these difficulties related to understanding algebra, how algebra is presented in mathematics classrooms should be observed. The traditional image of algebra, a gateway to higher mathematics, can lead people to love to hate algebra, as Kaput (1999) stated. Teaching methods might affect this image of algebra, difficulties, and misconceptions about algebra. Therefore, as Erdem and Sarpkaya Aktaş (2018) put forward, to prevent these difficulties and misconceptions in algebra, teachers should choose the appropriate instructional methods in mathematics lessons and prefer new approaches other than traditional ones to minimize the misconceptions. Selected instructional methods to reduce difficulties related to algebra should facilitate easy learning.

One of the reasons for facilitating easy learning for selected instructional methods, such as using game-based learning activities, is the effects of this kind of method on attitudes towards mathematics and algebra. Many studies investigated the effect of using game-based instruction on attitudes towards mathematics and algebra (e.g., Erickson, 2015; Ezeugwu et al., 2016; Kebritchi, 2008; Siew et al., 2016). These studies showed that game-based math learning increased the motivation and interest of the students for algebra, and this affected their attitudes towards mathematics and algebra positively.

Recent studies related to teaching algebra emphasized using some activities, games, and game-based learning activities that help students construct basic concepts themselves (e.g., Gürbüz & Toprak, 2014; Rondina & Roble, 2019). These studies showed significant differences in the algebra achievement and attitudes towards algebra of students taught with game-based learning activities and without game-based learning activities.

1.1 Research Questions

The purpose of this study was to investigate the effect of using game-based learning activities in algebra on seventh-grade students' algebra achievement, to investigate their attitude towards mathematics, and to investigate their opinions about using game-based learning activities. As a result, the research questions that will be the basis for this study are as follows:

1. What is the effect of using game-based learning activities on seventh-grade students' achievement in algebra?
2. What is the effect of using game-based learning activities on seventh-grade students' attitudes towards mathematics?
3. What are seventh-grade students' opinions about the use of game-based learning activities in mathematics lessons?

1.2 Significance of the Study

This study is critical in highlighting the exciting and student-oriented aspects of mathematics that will change the general opinion that mathematics is difficult and boring. The purpose of this study was to investigate the effect of using game-based learning activities on students' algebra achievement, attitudes towards algebra, and opinions about game-based learning activities. Focusing on the impact of using game-based learning activities on all of these is the most significant contribution of this presented study.

There are several studies related to teaching and learning algebra in Turkey and other countries (e.g., Akkaya & Durmuş, 2010; Anthony et al., 2002; Bruins, 2014; Çağdaşer, 2008; Çaylan, 2018; Gürbüz & Toprak, 2014; Rondina & Roble, 2019).

Some of these studies differ from the presented research because of the grade level they are applied to, some because of the instructional method used, or by using only attitude or only achievement tests to collect data.

This study was important for bringing engaging and student-oriented sides of mathematics and algebra into the forefront. Mainly, the effect of teaching by using game-based learning activities was observed by the help of adaptation of game-based learning activities into selected algebra topics in which students have difficulty and have some misconceptions. Moreover, unlike the studies mentioned above, this study contributes to the literature in terms of measuring algebra achievement and attitude towards algebra of the seventh-grade students, and obtaining students' opinions on implementing game-based learning activities.

In the light of this study, how game-based learning activities can be integrated into mathematics classrooms can be seen. Therefore, the study's findings provide information to this integration for researchers, teachers, teacher candidates, and teacher educators.

1.3 Definition of the Important Terms

Algebra Achievement: Seventh-grade students' achievement scores on the algebra achievement test (AAT) which the researcher prepared and included 23 items based on mainly seventh-grade algebra objectives of MoNE (2018).

Algebraic Thinking: "Algebraic thinking can be interpreted as an approach to quantitative situations that emphasizes the general relational aspects with tools that are not necessarily letter-symbolic" (Kieran, 1996, p. 275).

Attitude towards Mathematics: "Having the components of emotional response, beliefs, and behaviour towards mathematics" (Di Martino & Zan, 2001, p. 26).

Game: "An entertaining activity surrounded by one or more mechanics, performed based on a certain rule or rules, for a specific purpose or purposes, with an element of struggle and a measurable result" (Arkün Kocadere & Samur, 2016, p. 398).

Game-Based Learning: "Game-based learning is the process in which children have the opportunity to learn in unstructured free play environments and with semi-structured games planned to achieve certain gains" (Erbil Kaya et al., 2017, p. 803).

Game-Based Learning Activities: Activities that include some existing games integrated instructional content or digital or non-digital games developed according to the goal and content into the learning process. In the present study, non-digital game based learning activities were used. The games and activities used in this study were developed for the learning content or were adapted from some existing games according to the objectives. Group work was also used in these activities.

1.4 Motivation for the Study

After graduating from the Elementary Mathematics Education Program at the Middle East Technical University in 2016, I participated in a teacher seminar about using games in learning environments. I realized the importance of the game-based learning instruction method with the help of this training.

Based on my three years of teaching experience, I observed algebra as one of the most tedious and challenging mathematics topics for students, and they have many prejudices about algebra. Because of this reason, students do not give any chance to

learn algebra effectively. By using my opinions related to game-based learning and students' opinions related to algebra, I decided to integrate game-based learning activities into algebra.

CHAPTER 2

LITERATURE REVIEW

This part will include a review of the studies directly or closely related to the topic of the effect of using game-based learning activities on mathematics achievement, students' attitudes towards mathematics, and students' opinions about game-based learning activities. The review will be presented in five sections: games, game-based learning, game-based learning and mathematics education, and lastly, algebraic achievement and algebraic thinking.

2.1 Games

Games have been played for centuries worldwide, from the Arctic to Africa, from Tibet to Trinidad. For example, traces of games such as hopscotch can be found in Roman ruins (Hatcher et al., 1988). A game is a form of cultural expression that describes the cultural values of the society to which it belongs. As Pehlivan (2014) stated, research findings reveal that children usually play games related to the people's occupations. Hampton (1989) conducted a study group to understand this situation. Children in the study group were observed to play the games such as singing, housekeeping, cooking, dancing, going to town, knitting, going shopping, and sweeping most frequently (as cited in Pehlivan, 2014).

Uğurel and Moralı (2008) stated that games occur in every period of our lives, and they are used for various purposes. Also, in their study, they focused on definitions of games and game theories while explaining the importance of games for our

lives. They stated that games could not be defined exactly since there were many definitions related to games. For example, while Plato (340 BC) was defining games as some formative activities, Aristoteles (344 BC) defined them as tools that allow people to explore unexpected things (as cited in Sezgin, 2015). Until today, there have been some changes or additions in the definition of games. Piaget (1962) discussed the games under three titles: practice games, symbolic games, and games with rules. Practice games are categorized as repetitive activities from birth to age two. Symbolic games are pretend games played between the ages of 2 and 7-8. On the other hand, games with rules are games that require a higher mental level and are played after the age of 7-8. Moreover, Piaget (1962) also touched on the sociocultural sides of games. Although Vygotsky's treatment (1967) of play as a social activity is deeper and more sophisticated than Piaget's, Piaget's approach has important aspects to recommend for any sociocultural analysis (as cited in Nicolopoulou, 2004). Sennent (1996), a sociologist, summarized two main approaches related to games in the literature when all approaches are considered. These approaches were game as behavior and game as a form of cognitive activities.

In addition to these definitions, according to Juul (2003), a game is a rule-based system with a measurable outcome in which the players strive to influence the outcome (as cited in Özkan & Samur, 2017) Prensky (2007) stated that the game is a system that includes rules, goals, feedback, results, competition, challenge, interaction (as cited in Özkan et al., 2017). In other words, there are game mechanics and elements that make games and are the building blocks of games, which make games both fun and an integral part of the development process (Özkan, 2018; Samur, 2016). According to Samur et al. (2019), game mechanisms are active and entertaining verbs and actions in the game. “Game elements are other elements of game design such as characters, goals, obstacles, rules, feedback, and environment”(Samur et al., 2019).

There are many examples of using classic game elements such as rules, goals, and awards to motivate in history. Some of these examples are getting a gift by collecting coupons in the newspaper, selecting the employee of the month, getting one free coffee for ten coffees, squatting in Moscow for free subway ticket, speed camera lottery in the USA, bottle bank arcade, and London monopoly running challenge (Yılmaz, 2017). These examples show that games can take place in every area of life.

With the computer becoming an increasingly part of daily life in recent years, computer games have created a virtual game and entertainment environment that appeals to all walks of life. Through computers, children also can test some skills and gain mastery in these skills (Pehlivan, 2014). Kaya (2019) stated that children's games evolve from the X and Y generations to the Z generations from traditional to technological, but traditional games such as hide and seek, handkerchief snatch, steel stick, blindfold, and jump rope are played in all generations. Also, Samur et al.'s study (2019) showed that there are many traditional games, such as football, basketball, dodgeball, and hide and seek, in addition to some digital games such as Minecraft, Fifa, and GTA among the most played games by children. While all these studies focus on digital games that have entered our lives with the development of technology, traditional non-digital games also attract attention in every period.

While considering all of these opinions, many games were generated to embody cognitive activities or produce information from concrete activities from past to present. In the past, when people talk about games, firstly, traditional games were taken into consideration; today, we are in a period in which technological games, as well as traditional games, dominate (Sezgin, 2015). At this point, while Kaya (2019) , Samur and Özkan (2019) were also considering digital games, Özsoy (2010) and Alper (2017) focused on traditional games in their studies.

When focused on the present study, non-digital game-based learning activities were used in this study. In the next part of the literature review, studies related to game-based learning activities and their effect on learning will be reviewed.

2.2 Game-Based Learning

Throughout the history, there have been many educators and researchers who have pointed out the importance of games in education. In the book of ‘‘Republic,’’ Plato explained his thought related to child education and emphasized that we shouldn’t put the screws on children and enable instruction to be a game for them. While explaining his thoughts on the education of children, Plato (340 BS) stated,

> Because every person should not learn anything like a slave. Even if what is forced on the body is not bad for it, what is forced into the head will not be remembered. So, you will not use force on happy children. You will make education become a game for them (as cited in Sezgin, 2015).

From here, it can be observed that the idea of teaching through games is essential in every period of history.

According to David and Alice Kolb (2010),

> Students realize intellectual, physical, moral, and spiritual values by playing games in a free and safe environment. Moreover, they explained the game and the deep learning relationship, indicating that it has provided three ways of learning as an experiential learning tool. These are to encourage one's own learning, grant the learning process and the result of equal value, and have a chance to ripen and deepen it while experiencing experience (as cited in Sezgin, 2015, p. 105).

The three learning ways mentioned here, in particular, encouraging one's learning and deepening the learning experience, can be realized by putting the learner at the center of the learning process and enabling them to take responsibility for their learning. Wilson et al. (2009, p. 220) stated, "In recent years, the study of learning has moved away from the traditional model toward a learner-centered approach, which encourages and even requires more active participation on the part of the learner." Active participation and a free and safe environment of games mentioned above enable learners to manage their learning processes. Although educators have varying conceptions about activity-based instruction or game-based learning, as Suydam (1977, p. 1) stated, "the common definitions appears to be student involvement in the process of learning."

Game-based learning has gained importance as an effective and innovative teaching method in the 21st century. Wilson et al. (2013, p. 588) defined game-based learning as "an innovative learning approach that uses appropriate tools in order to allow games to be constructed to support learning and teaching" (as cited in Chiang & Qin, 2018). According to Johnson et al. (2011), game-based learning enables learners to improve some skills such as active engagement, information-based skills, decision-making skills, innovation, problem-solving skills, knowledge construction, and discovery learning.

Learning designs that are presented with games increase motivation. Concerning that, Yılmaz (2015) stated,

> If the participants are involved in the game and are motivated, games provide an environment that allows all participants' perceptions levels to increase. This increase in the perception level is a big opportunity for learning and teaching. So, game environments are always attractive for education (p. 174).

At this point, the effect of digital games to provide an enjoyable learning environment can be mentioned. Games could support the academic motivation of the students by using technology. The concept of ‘‘gamification’’ is discussed as equivalent to game-based learning in the digital world (Sezgin, 2015, p. 105). As Yılmaz (2015) mentioned, the Z-generation who lives with technology since they were born says that this generation wants to see a digital and enjoyable environment in their education and training. Also, according to Yılmaz (2015), technological and interactive educational games create an enjoyable learning environment. Although the effect of digital games on the learning environment is mentioned here, it is not necessary for the games to be digital to affect learning environments.

In addition to using digital games in the education environment, some researchers supported non-digital materials. According to Montessori (1966), the game was the most natural business of the child. Also, the games played using the materials developed learning more critically than the imagination-based games (as cited in Sezgin, 2015). Also, according to Suydam (1977), activity-based instruction frequently involved the use of manipulative materials.

After focusing on using digital and non-digital games and game-based learning materials in learning, we need to focus now on how to use these games and materials in education. Van Eck (2006) stated that games could be used in various ways in the learning process. The first way is to include games in the lessons by integrating teaching content into existing games. The second way to benefit from games in the learning environment is to develop educational games suitable for the learning goal and content. Samur and Özkan (2019) stated that board games like Taboo or Cranium could be revised and designed as board games that can be played in the classroom by adapting according to the objectives.

Until today, many experimental studies were conducted to analyze the effects of game-based learning activities on learning. Randel et al. (1992) examined the reviews from 1963 to 1984 and the literature from 1984 to 1991, which investigated the effect of educational games on students' achievement, the permanence of learned information, and attitude. Thirty-eight of these 67 studies could not observe any significant difference between game-based learning and traditional methods, but mathematics was the subject area with the highest percentage of favoring games. Also, the analysis of some studies were questionable. Since then, there has been a positive increase in the number of studies in this field and the quality of the implementations and controls.

It is seen that the studies in this field have increased in the last 10-15 years. With the effective implementation of game-based learning, there have been some changes in the results of the studies. In the studies carried out, it was seen that game-based learning increases student motivation, improves students' attitudes towards the lesson, increases students' success and facilitates learning, is effective in giving feedback, and increases students' engagement (e. g. Duran & Kaplan, 2014, Garris et al., 2002; Hacısalioğlu Karadeniz, 2017, Rondina & Roble, 2019).

For the active implementation of game-based learning in schools, some changes should occur in the countries' educational systems. According to Solomon (2016), school reform is important. Gee (2014) stated in an interview, "…if we want deep games and deep game-based learning, we would have to change the policies in our schools…"(p. 10). Making radical changes in the educational system can be started by teachers integrating game-based learning into their lessons. The present study also supported these changes by integrating game-based learning activities into the lessons. In the present study, as Van Eck (2006) mentioned, game-based learning activities were used by integrating teaching content into existing games and developing some game-based learning activities suitable for the objectives. Non-

digital manipulative materials were used in the present study, and a step was taken for changing the educational system includes traditional instructional methods by game-based learning activities.

In the next section, the relationship between game-based learning and mathematics education will be discussed.

2.3 Game-Based Learning and Mathematics Education

When the relationship between games and mathematics is thought about, the words of the historian George Vigarello (2004) can be considered. He touched upon the relationship between ballet and geometry while talking about the culture of the game. He mentioned that in the 17th century, the principles of developing mathematics and geometry were used in dance arrangements and that ballet choreographies were arranged in accordance with geometric shapes (as cited in Sezgin, 2015).

As Tural (2005) mentioned, mathematics offers a systematic approach to reveal the structures hidden behind models or rules in all fields of life. Going from concrete to abstract, reaching from simple structures to complex structures, and making comments on them, which is followed in the production and learning of mathematical knowledge, can also be observed in the games we play from childhood to adulthood (Uğurel et al., 2008). In other words, as Umay (2002) stated, there is mathematics in games, and there are games in mathematics. According to Dienes'(1960) Principle of Dynamics, the correct understanding (comprehension) of a new concept is a three-stage evolutionary process, where the first stage is the game stage. At this stage, the student first meets the concept with less structured activities, in other words, as a game (Görgün, 2017). Since

mathematics and games are closely related, and since the first step of correct understanding of a new concept is a game stage, games should be used more in mathematics teaching.

Using games in mathematics teaching was offered as a new method for especially breaking down the prejudices about mathematics. Concerning this, Resnick (2019) stated,

> Game wrights and people who tend to learn by scrutinizing often get the message that mathematics are not for them. It doesn't have to be like that. Problem is not about the discipline itself, but how it is presented and taught (p. 150).

Making use of games in the mathematics teaching process is shown as one of the methods that can help people to learn mathematics with pleasure (Beyhan & Tural, 2007), and this prevents students from getting the wrong messages about mathematics. Many games which are created by mathematicians contribute to developing mathematics and enable people to enjoy mathematics. The most crucial reason to enjoy mathematics with the help of games is that games offer beautiful things for learners. Bragg (2006) stated that games develop children’s interest in learning mathematics providing competition, challenge, and fun. She further said that their desire to win encourage them to study advanced mathematical concepts. So, learners develop positive attitudes towards mathematics by being motivated with fun to participate in the lesson actively.

The fun world of games positively affects students' attitudes towards mathematics, their motivation to learn, and their active participation in the lesson and contributes to making learning environments interesting (Torun & Duran, 2014) and cognitive development with the help of this environment. The reasoning, creative thinking, making inferences, and similar interactions in the basic structure of mathematics

are also seen in the design of games, making it convenient to include games in the mathematics teaching process (Hacısalihoğlu-Karadeniz, 2017).

At this point, it can be discussed whether the games can only be seen as fun or can also be used to learn mathematical concepts and add fun to mathematics classrooms. Ernest (1986) starts the article ‘‘Games: A Rationale for Their Use in the Teaching of Mathematics in School’’ by asking the question of ‘‘Are games just an enjoyable interlude or can games be used to actually teach mathematics?”. There is an answer to this question in the article. According to some studies mentioned in the article, appropriate mathematics games incorporated into the teaching program effectively practice and reinforce skills.

Before looking at why adding games to mathematics programs is important for developing some skills, it is also helpful to look at what the mathematics programs aim to bring to students. It can be said that some of the expected objectives in the mathematics curriculum can be supported by games and game-based learning activities.

In the Turkish middle school mathematics curriculum (MoNE, 2018), some of the general objectives which can be achieved by the help of games and game-based learning activities can be listed as follows:

- Students should be able to understand mathematical concepts and use these concepts in daily life.
- Students should be able to easily express their thoughts and reasoning in the problem-solving process. They will be able to see the deficiencies or gaps in the mathematical reasoning of others.
- Students should develop their metacognitive knowledge and skills and consciously manage their own learning processes.

- Students should develop a self-confident approach to mathematical problems by developing a positive attitude towards mathematics with their experiences in learning mathematics.
- Students should develop the characteristics of being systematic, careful, patient, and responsible.
- Students should develop the skills of conducting research, producing and using information (MoNE, 2018, p. 9).

As also mentioned in Ernest's article (1986), appropriate mathematics games incorporated into the curriculum and mathematics lessons is a possibly effective way of gaining the above objectives since games help children prepare for real-life by teaching them to follow directions, make decisions, look for examples and draw logical conclusions (May, 1993). Many studies were conducted to investigate the effect of games on mathematics achievement, attitudes towards mathematics, and opinions of learners. These studies are listed below.

The purpose of the study, which was was done by Woodward and Baxter (1997), was to examine the effect of an innovative approach to mathematics instruction on the academic performance of students with learning disabilities and academically low achieving third-grade students. As a result of this study, this approach's positive effect, which includes math games related to adding or subtracting the numbers, was observed on achievement. In addition to Woodward and Baxter's study (1997), O'Brien et al.'s study (2004) showed that academically weak students are just as active and successful in games as academically strong students.

According to Grabowski et al. (2003), "it was observed that from the student perspective there are many advantages to using games such as rather than passive regurgitation of concepts, games allow students to engage in an interesting deviation from the classroom norm" (p. 2).

Moreover, Tural (2005) conducted a study to investigate teaching mathematics through games and activities on achievement and attitude in elementary school. As a result of this research which applied to third-grade students for five weeks in the rhythmic count, natural numbers, addition, subtraction, multiplication, and division. He observed that game-based learning increased students' mathematics achievement and developed positive attitudes toward mathematics.

In her study, Harkness (2009) focused on a mathematics course designed for a university-related to problem-solving, and in this course, students were active participants in their learning. The course met 3 days per week, two hours each day, for one semester. During the semester, the "Believing Game" was the course's focal point, and the researcher observed increasing motivation at the end of the semester.

Afari et al.'s (2013) study is related to students' perceptions of the learning environment and attitudes in game-based mathematics classrooms. Their study aimed to examine the effectiveness of mathematics games in improving students' learning environment and their attitudes toward mathematics. According to this study, from the students' perspective, there were many advantages in using games in the classroom. The study results showed that perceptions of learning environment, self-efficacy and enjoyment were positively related. The effect of educational games on students' engagement and performance in mathematics was also shown in the study of Clark et al. (2016).

In addition to the studies done with the students, Gür and Demir's study (2016) was created for teacher candidates. At the end of their research, all teacher candidates determined that teaching a lesson in a mathematics laboratory will be beneficial since creating an appropriate game-based learning environment will be accessible in the laboratory.

The research study of White and McCoy (2019) supported the literature related to the positive effect of games on attitude and achievement. The results from this study showed that there is a strong relationship between game-based learning and students' attitude and achievement in mathematics.

Out of the traditional games, according to Randel et al. (1992), computer games are reported to be very effective in improving mathematics achievement. The findings revealed that 7 out of 8 studies showed that games improve mathematics achievement. Sedighian (1996) stated that the 1990s were important because of the research projects related to mathematics-oriented games. These games projects were Electronic Games for Education in Math and Science (E-GEMS) and Through the Glass Wall, and the games were Phoenix Quest and Super Tangrams. As technology advanced, mathematics games became more complex in graphics and interface (as cited in Kebritchi, 2008).

There was a significant difference in all three activities applied to seventh-grade students in the study of Köroğlu and Yeşildere (2002). As a result of the observations during these activities related to coordinate system and set of numbers, even the students who were academically weak, especially while playing the computer game, showed interest in the task and continued to play the mathematics game until the end of the lesson.

Also, in their study, Kebritchi et al. (2010) examined the effects of incorporating serious game-based learning into the pre-algebra math classroom. According to the classroom teachers in this study, serious gaming was effective since the games had an experimental nature, alternative teaching and learning, experiential learning, motivation, and fun to learn mathematics concepts.

Lastly, the meta-analysis of Tokac et al. (2018) investigated the contribution of video games' learning on mathematics achievement compared with traditional instructional methods and found that mathematics video games were slightly more

effective in contributing to mathematics achievement compared with traditional instructional methods by considering 24 studies.

All of these studies showed significant positive effects of using digital or non-digital games and game-based learning activities on mathematics education. Games were found to have a positive impact not only on achievement but also on attitudes towards mathematics and participation in classes. Particularly, the positive change in attitude and motivation enabled the games to be effective for students with a learning disability or who were academically weak. Also, it can be said that game-based learning activities create a suitable learning environment not only for young students but for all age groups from primary school to university and many mathematics topics. In the present study, similar to the studies mentioned, the effects of the game-based learning activities (with the help of some developed or adapted activities) on mathematics achievement were investigated. Additionally, group work was used in these game-based learning activities.

In the literature, some studies also used group work in the process of learning mathematics. For example, Webel (2013) stated that solving problems in a group involves each person in the group contributing and listening to each other. It is not important that the answer is correct; it is important to develop ideas together through a good discussion. These are the benefits of working in small groups that will not come from a teacher-centered or lecture-style classroom setting.

Additionally, Balt (2017) found a causal relationship between seventh-grade students' assessments before receiving small group instruction and after the instruction is implemented. In this study, formative assessments using Google Form to determine the effectiveness of the study and a student survey to better understand the students' perspectives on math and small group instruction processes were used.

After mentioning the related studies about the effect of group work on mathematics education, it is necessary to note the relationship between group work and game-based learning and the effects when both are used together.

All members of the learning group are responsible for the learning of other members; the members feel that they need to be connected to each other in order to achieve the goal of a game (Doymuş et al., 2005). Additionally, most of the students stated that they prefer multiplayer games versus single-player games since the collaborative nature of the games made the games more attractive for students (Kebritchi et al., 2010).

When focused on the studies related to both game-based learning and group work, what is realized is that studies combining these two methods are still limited despite a large number of studies about the use of instructional games alone and group work alone. Some of the studies combining two methods are presented below.

In O'Brien et al.'s study (2004), children in mixed peer groups collaborated. In this study, different groups found different methods, leading or persuading other groups through discussion and explanation. In this persuasion process, academically weak students were found to offer more solutions and were more persuasive. These findings show how important and effective teaching with games, including group work, is, especially for unsuccessful students in mathematics (Tural, 2005).

Some of the game-based learning activities used in the presented study were designed to encourage group members to cooperate when competing with another group. As Jong et al. (2013) stated, incorporating competition motivates participants to win, and the factors, such as cooperation, competition, and different skills attributed to different roles make the game and learning process appealing to students. These findings supported to findings of Bilicioğlu's (2003) study related

to the effect of competitive group work on students' success, concept learning, and level of remembering in mathematics.

To sum up, using game-based learning activities and supporting these activities by using some group works affect learning mathematics, attitudes towards mathematics, and opinions about the mathematics of the students from primary school to university.

2.4 Algebraic Achievement and Thinking

The history of algebra goes back to old civilizations such as Assyrians, Babylon, Egypt, and Chinese, and in these civilizations, people used algebra in riddles, entertainment problems, and in everyday life (Sfard, 1995; Van Emoram, 2011).

Algebra is a mathematical language expressing itself with symbols, words, and graphs (Stacey & MacGregor, 2000), and algebra is one of the essential learning areas in mathematics.

In the curriculum of MoNE in Turkey (2018), the algebra learning area is handled as follows;

> The objectives related to the algebra learning area are first included in the 6th-grade. Students are asked to find the desired term in the number patterns and make sense of the algebraic expressions at this grade level. In the 7th-grade, there are two sub learning areas: algebraic expressions and equality and equation. At this grade level, they are expected to perform addition and subtraction operations with algebraic expressions, understand the concept of equality, and solve equations with first-order unknown and related problems. In the 8th-grade, algebra is given more attention. At this level,

> algebraic expressions and identities, linear equations, inequalities are focused on. Students' understanding of algebraic expressions and identities and factoring algebraic expressions is expected. In addition to these, examining the linear relationship between two variables and solving equations are important. Middle school algebra topics conclude with the study of inequalities with one unknown. (p. 13)

At this point, it would be good to focus on what algebraic thinking is and to review studies that highlight some common conceptions and misconceptions about algebraic thinking at the middle and high school levels.

According to Van de Walle et al. (2011), algebraic thinking is the generalization and formalization of operations with numbers and symbols. Also, Windsor (2010) stated that algebraic thinking is the basis of mathematical thinking and reasoning, and it consists of reasoning with patterns and mathematical relationships among numbers, objects, and geometric shapes.

Many students have difficulty related to algebraic thinking strategies, and they can have many misconceptions.

According to the findings obtained in the study of Akkaya (2006), the misconceptions of the students were determined as follows:

- Letters do not have any meaning in mathematics.
- Letters are not like numbers, and they could do nothing with other letters.
- Lettters are used for unknown digits of numbers like in arithmetic.
- Letters represent objects, not the quantity of them.
- Letters take value according to their alphabetical order, such as c=3 and e=5.
- Meaning of an equal sign is producing a result.
- “+” and “-“ sign always produce a result (as cited in Çağdaşer, 2008).

These were also supported by Kuchemann's (1981) classification of students' interpretations of algebraic letters as ignoring letters and using letters as specific unknown numbers.

When focused on "variable," which is one of the important terms in algebra and classified as algebraic letters until now, one could realize the importance of understanding the concept of variables by now. As Soylu (2008, p. 239) stated, "It is essential for learning algebra and advanced mathematical concepts. However, students at all levels were found to have difficulties in understanding the concept of variable." In a question of Soylu's study (2008), most of the students answered the question of " $5x + 4 = ?$" as "9" by converting them to the addition operation of natural numbers without considering the variable x. In addition to problems in using variables in simple algebraic expressions and making sense of variables, according to this study, students had a problem related to "limiting variables to certain letters (thinking only as x)" (Soylu, 2008, p. 245). Also, the observations of MacGregor and Stacey (1994) were parallel with Soylu (2008) in terms of the statement that students ignore letters and replace them with numerical values.

In addition to ignoring letters, "wrongly interpreting an algebraic letter as the name of an object (e.g., interpreting r to mean 'red pencils', so $6r$ means 'six red pencils') is a well-known and serious difficulty to writing expressions and equations in certain contexts" (MacGregor, 1994, p. 2).

The other difficulty related to algebraic thinking for students was "interpreting equal sign as a do something sign" (Knuth et al., 2006). Students thought that the equal sign would give an answer as the result of a numerical operation. For example, when "5 + 3 =__ + 2" is given, students can think that they fill in the blank with 8 as the result of the operation of "5 + 3".

One of the reasons for these difficulties in learning algebraic notation could be poorly designed, and misleading teaching materials as MacGregor (1994) stated.

When considered all of these difficulties, the students could hate algebra. In this regard, Kaput (1999) said, “ The traditional image of algebra, based in more than a century of school algebra, is one of simplifying algebraic expressions, solving equations, learning the rules for manipulating symbols the algebra that almost everyone, it seems, loves to hate” (p. 3). However, it is possible to destroy this hatred with effective implementations**.** Achievement of the students in algebra, one of the most difficult topics in mathematics could be increased if appropriate learning environments are created. Some study examples related to algebra achievement of students after some implementations in which learning environment or learning materials were changed are presented below.

The study of Witzel (2005), implemented with 231 sixth and seventh-grade students, using a concrete-to-representational-to-abstract sequence of instruction (CRA) led to higher achievement than repeated abstract explicit instruction model. The CRA method begins by introducing students to a new topic using hands-on materials or manipulatives. In another study (Bruins, 2014) in which the CRA method was used, the differences in means and the effect size indicated that there might be small benefits to teaching algebra with the CRA method.

In the Çağdaşer’s study (2008), teaching algebra according to the constructivist approach made a significant difference in the algebraic thinking levels of 6th-grade students. Moreover, in the study of Işık and Çağdaşer (2009), the 'Attitudes Towards Mathematics Scale' was administered to 55 6th-grade students before and after the implementation of algebra teaching by the constructivist approach. As a result of the research, students' attitudes towards mathematics changed positively after teaching with the constructivist approach.

In the study of Jupri et al. (2015), the purpose was to investigate the effect of technology-rich intervention related to initial algebra on the achievement of 12-13-year-old Indonesian students by setting up pre-test post-test control group

experiment. During the implementation, four applets, such as Algebra Arrows, Cover-up Strategy, Balance Model and Balance Strategy were used. The study results showed the effectiveness of this type of technology-rich intervention for enhancing student achievement in algebra.

Akkaya and Durmuş (2010) did a research study by teaching with worksheets. The worksheets, which were prepared to structure the students' knowledge and eliminate their misconceptions, started with an interesting question or a real-life situation. At the same time, questions that allowed students to work in groups were included in the worksheets. According to the findings of Akkaya et al.'s research (2016), teaching with worksheets was found more effective than traditional teaching in reducing sixth-grade students' misconceptions about the use of letters in algebra and understanding the concept of equality.

Moreover, during her study related to teaching algebra, Çaylan (2018) used algebra tiles throughout seven class hours in three weeks for the experimental group while was not using any algebra tiles in the control group for the same objectives of algebra. Çaylan's study (2018) with sixth-grade students showed that algebra tiles have a limited but positive effect on students' algebraic thinking.

Also, as Gürbüz and Toprak (2014) mentioned, a successful transition from arithmetic to algebra with the help of activities will enable students to internalize knowledge and guide them to learn future abstract algebra subjects successfully. So far, the effects of different instructional methods and materials on algebra achievement and attitudes towards algebra have been examined. From now on, the focus will be on the studies investigating the effect of game-based or activity-based learning on algebra learning at different levels.

For instance, in the study of Okpube & Anugwo (2016), card games were used to teach algebraic expressions for junior secondary II students. The scores show that the experimental group achieved better than the control group when taught with

mathematical games. The result of this study was supported by the study of Ezeugwu et al. (2016). The junior secondary II students were encouraged to learn algebra using the game-based method, and there was a significant improvement in the achievement of students taught using the game-based method.

The study of Erdem et al. (2018) included 54 seventh-grade students, and the findings were supported by conducting unstructured interviews with 12 students selected from the experimental and control groups. The results showed that activity-based teaching was more effective in eliminating some misconceptions about accepting the value of letters with a coefficient of 1 as one and the lack of letters in mathematics.

Furthermore, the mathematics game-based design activities implemented by Rondina and Roble (2019) demonstrated a positive influence on high school students' learning gains in algebra. In this study, two games named as “Line To Win” and “Sliding a Picture” were used. The purpose of “Line To Win” played by two groups as a host and a players, was to develop mastery of two groups that took turns of serving as a host and a players. In the game “Sliding a Picture,” the purpose was mastering the sketch of the quadratic function graphs by using pre-cut graphs of quadratic functions with different colors.

The high level of abstraction in algebra can cause difficulty for some students, and some digital games can help students concretize algebra. Some studies investigated the effects of digital games on algebra achievement.

For example, Siew et al. (2016) aimed to examine the effects of an android app, the DragonBox 12+, on algebraic thinking and attitudes toward algebra among 60 eighth-grade students. Half of them were in the experimental group and half in the control group. Results showed that students who learned algebra using the DragonBox 12+ had significantly higher mean scores in the algebraic thinking achievement and attitude test towards algebra than the control group. In the light of

the findings of this study, Siew et al. suggested using DragonBox 12+ to adopt effective game-based learning for teaching algebra in schools.

In the study of Chiang and Qin (2018), the purpose was to examine the impact of Scratch-based games made by 89 seventh-grade students to solve equations on their equation-solving performance and attitudes towards learning mathematics with the assistance of technology. After quantitative and qualitative analyses, the study findings indicated that computer-based educational game making, using Scratch, had a significant positive effect on the equation-solving performance of seventh-grade students and on their attitudes towards learning mathematics.

Considering these studies related to game-based learning and algebra achievement or attitude towards algebra, we can claim game-based learning activities to have possible influences in overcoming the prejudices of many students against algebra.

To sum up, algebra is a mathematics learning area where many students face difficulties and misconceptions. However, applying the appropriate teaching methods and going out of the traditional methods reduces the negative attitudes towards algebra and increases algebra achievement. All of the studies and the articles related to games, game-based learning, game-based learning and mathematics education, and algebraic achievement and thinking have many contributions to observe the effects of game-based learning activities on algebra achievement, attitudes towards mathematics, and opinions related to game-based activities. The game-based learning activities discussed in this study are also critical because they are a different method used in the teaching of algebra effectively.

CHAPTER 3

METHODOLOGY

The aim of the present study was to investigate the effect of using game-based activities in algebra on seventh-grade students' algebra achievement, their attitude towards mathematics, and their opinions about using game-based activities. As a result, the research questions that were the basis for this study are as follows:

1. What is the effect of using game-based activities on seventh-grade students' achievement in algebra?
2. What is the effect of using game-based activities on seventh-grade students' attitudes towards mathematics?
3. What are seventh-grade students' opinions about the use of game-based activities in mathematics lessons?

This chapter will present the design of the study, sampling, context of the study, data collection methods, instruments, data analysis procedures, and issues related to the validity and reliability.

3.1 Research Design

In order to find answers to the research questions, a one-group pretest-posttest experimental design was used. The scores on the tools of the pretests and the posttests were statistically analyzed. The findings were supported by the interview data to provide further insights. The semi-structured interviews were carried out with 10 purposefully selected students to understand their opinions about the lessons that used game-based learning activities.

Since random assignment of the subject to the groups was impossible, an already existing class constituted the group. The study was a weak experimental design since there was not any control group. Specifically, the design used in the study was one group pretest-posttest design.

3.2 Population and Sample

In this study, target population was 7th-grade students in İstanbul. All 7th-grade students, who attended public middle schools in Sarıyer, İstanbul were the accessible population. Convenience sampling method was used in the study. The researcher chose one public middle school in Sarıyer which was convenient for her in terms of location. In the chosen school, there were four 7th-grade classes. One of these classes was chosen to implement the study according to the convenience to the researcher. This class had mathematics lessons at the times that the researcher could be at the school. There were 19 students; 10 girls and 9 boys whose ages ranged from 12 to 13 in the group. There was also an inclusive student in the group.

3.2.1 The Role of the Researcher

I designed the lesson plans and the materials that included game-based learning activities and implemented these plans during the 5 weeks, 2 hours each week in the 2019-2020 fall semester. During the intervention, I conducted and guided the activities in the lesson plans. By starting some lessons with game-based learning activities, I drew the attention of the students and made them warm up to the lesson and the subject. Afterward, I was in the position of leading the question-answers or in-class discussions while answering the questions posed with the help of worksheets or various game-based learning activity materials. The objectives

discussed in the worksheets and game-based learning activities were handled by me for the first time in this experimental group. Since I did not know the students in the group before, I had to observe them carefully. This made it easier for me to guide and mentor students. Also, while I was observing the classroom actively, I took some notes. By considering the notes, I made some changes according to the implementation each week, such as assigning some questions in the worksheets as homework.

3.3 Context of the Study

The school in which the study was implemented was a public school in Sarıyer, İstanbul. The school was a full-time school. The total number of the students the school was 381. Most of the students were coming from low or middle socioeconomic level families, according to the information I got from the mathematics teacher of the class. Class sizes ranged from 18 to 25. There were some academically weak students in the classrooms. For the selected class, mathematics teacher gave information related to those students. There were 39 teachers at the school, and four of them were mathematics teachers. The physical conditions of the classrooms were similar. There were double seat desks in the classrooms, and each of the classrooms had a smart board and a white board.

This study focused on teaching algebra through game-based activities. The objectives addressed in the Algebra Achievement Test, and the lesson plans will be detailed in the following sections.

3.4 Data Collection Tools

The purpose of this study was to investigate the effects of using game-based

activities on 7th-grade students' mathematics achievement, attitude towards mathematics and opinions about game-based activities in mathematics. An algebra achievement test, a mathematics attitude scale and an interview protocol to collect data regarding students' opinions about game-based activities were the data collection tools of the study, which will be explained next.

3.4.1 The Algebra Achievement Test

The Algebra Achievement Test (AAT) was constructed to learn about students' pre and post achievement about algebraic expressions by the researcher according to the literature considering the objectives in Turkish Middle Grades Mathematics Curriculum (MoNE, 2018) (See Appendix A for the instrument). The 6th-grade objectives were included to test students' prerequisite knowledge and the 7th-grade objectives in the mathematics curriculum which were included in the AAT are given in Table 3.1. The AAT included 6 open-ended questions, 5 of them with sub items. The test included 23 items in total was implemented within 30 minutes.

Table 3.1 Objectives Addressed by Each Item in the AAT

Question	Objectives
1	- **M.6.2.1.1** Students should be able to write an algebraic expression for a given situation in words and write a given situation in words for a given algebraic expression. - **M.6.2.1.2** Students should be able to calculate an algebraic expression for different values of a variable.

Table 3.1 (Cont'd)

2	- **M.7.2.1.1** Students should be able to make addition and subtraction operations with algebraic expressions. - **M.7.2.1.2** Students should be able to multiply a natural number by an algebraic expression.
3	- **M.7.2.1.1** Students should be able to make addition and subtraction operations with algebraic expressions.
4	- **M.7.2.1.1** Students should be able to make addition and subtraction operations with algebraic expressions - **M.7.2.1.2** Students should be able to multiply a natural number by an algebraic expression.
5	- **M.7.2.2.1** Students should be able to understand the principle of conservation of equality.
6	- **M.7.2.2.1** Students should be able to understand the principle of conservation of equality.

All questions except the 5th question in the Algebra Achievement Test were developed by the researcher. The 5th question, which asked "In the solution of the equation of $n + 15 = 31$, $n = 8$. What is "n" in the solution of the equation of $n + 15 – 9 = 31 – 9$ was adapted from Stephens (2006). Regarding the validity of the items in the achievement test, expert opinion was obtained from a mathematics teacher educator and an academic coordinator who worked as a mathematics teacher for 25 years at a private middle school.

3.4.2 Mathematics Attitude Scale

A five-point Likert type attitude scale was used in the study that was developed by Aşkar (1986, as cited in Duatepe, 2004). The test contained 20 items, 10 of which were positively worded (1, 4, 5, 8, 11, 13, 14, 17, 18, 20) and 10 of which were negatively worded (2, 3, 6, 7, 9, 10, 12, 15, 16, 19). Possible scores ranged from 20 to 100. Positive statements were scored from 5 (totally agree) to 1 (totally disagree), and for negative statements, scoring was reversed according to the order of alternatives. The Mathematics Attitude Scale is provided in Appendix B.

3.4.3 Interview Protocol

Semi-structured individual interviews were carried out with 10 students who were purposively selected after 5 weeks of implementation. These selected students were more active and more talkative students in the group. Five questions such as which are asked in the interviews to understand their opinions related to the lessons that used game-based activities. For example, one of the questions in interview protocol was *"Were game-based activities effective in your understanding of the topic? Why or why not?".* When needed, additional questions were asked to obtain further opinions. The Interview Protocol is provided in Appendix C.

3.5 Intervention

This study aimed to investigate 7th-grade students' algebra achievement, attitudes towards mathematics and opinions related to game-based activities after the lessons which used game-based activities. The study took 10 class hours in total for 5 weeks. The first and the last hours were allocated to the implementation of the

pretests and the posttests. I was the implementer of these tests. The remaining 8 hours were devoted to the intervention. There were five lesson plans in total. The main teaching method that lesson plans contained was game-based learning. During the intervention of the lessons in which used game-based learning activities, the students were intended to warm up to the lesson with mini activities at the beginning of the lessons. Then, the class talked about the basic information about the topic by question-answer method, and information about the activity instructions was provided. I guided the students by asking the necessary questions while the students deepened their knowledge with game-based activities, which were adapted from some existing games or developed according to the objectives. I also managed the class discussions related to activities when required. Also, it was ensured that the questions that were included in the activities and that were difficult to be answered were answered during the lessons. At the end of the lessons, exit cards were filled in for assessment. The schedule of the data collection and intervention are given in Table 3.2.

Table 3.2 The Schedule of the Data Collection and Intervention

Weeks	Implementations
1st Week (2 class hours)	- Implementation of the achievement and attitude pretests **Lesson Plan 1** - Reminding 6th-grade objectives ***M.6.2.1.1*** *Students should be able to write an algebraic expression for a given situation in words and write a given situation in words for a given algebraic expression.*

Table 3.2(Con't d)

	M.6.2.1.2 *Students should be able to evaluate an algebraic expression for different values of variable.* **Materials:** Algebra Achievement Test, Mathematics Attitude Scale, Taboo game cards, Worksheet, Exit card
2nd Week (2 class hours)	**Lesson Plan 2** ***M.7.2.1.1.*** *Students should be able to make addition and subtraction operations with algebraic expressions.* **Materials:** Algebra tiles, Worksheets, Activity sheet, Flashcards, Exit card
3rd Week (2 class hours)	**Lesson Plan 3** ***M.7.2.1.1.*** *Students should be able to make addition and subtraction operations with algebraic expressions.* ***M.7.2.1.2*** *Students should be able to multiply a natural number by an algebraic expression.* **Materials:** Algebra tiles, Worksheets, Bingo game cards and answer cards, Plickers
4th Week (2 class hours)	**Lesson Plan 4** ***M.7.2.1.1.*** *Students should be able to make addition and subtraction oprations with algebraic expressions.* ***M.7.2.1.2*** *Students should be able to multiply a natural number by an algebraic expression.* ***M.7.2.2.1*** *Students should be able to understand the principle of conservation of equality.* **Materials:** Uno game cards, Domino game cards, Worksheet, Activity sheet

Table 3.2(Con't d)

5th Week (2 class hours)	**Lesson Plan 5** ***M.7.2.1.1.*** *Students should be able to make addition and subtraction operations with algebraic expressions.* ***M.7.2.1.2*** *Students should be able to multiply a natural number by an algebraic expression.* ***M.7.2.2.1*** *Students should be able to understand the principle of conservation of equality.* -Implementation of the achievement and attitude posttests **Materials:** Algebra Path game, Algebra Achievement Test and Mathematics Attitude Scale

Next, each lesson plan will be explained in detail. Lesson plans are provided in Appendix D.

3.5.1 Implementation of the Pretests

At the beginning of the lesson, a few minutes were provided for introducing myself as the researcher. In addition to introducing myself, I indicated the purpose of the study and received students' approvals for the study verbally. Then, I gave the pretests of Algebra Achievement Test and Mathematics Attitude Scale, respectively. After giving 30 minutes for the Algebra Achievement test and 10 minutes for the Mathematics Attitude Scale, I collected the tests and thanked for the attendance.

3.5.2 The First Lesson Plan

At the beginning, students were expected to remember some terms related to algebra which they learnt in 6th-grade by the help of Taboo game. Some instructions were given for the rules of Taboo game. The students tried to find correct words by the help of instructions. After finding each clue word, possible unpermitted taboo words were tried to guess by the students. By the help of this process, students could define important terms related to algebra such as algebraic expression, variable, coefficient, and constant term. The Taboo cards which were used in this lesson are given in Figure 3.1.

MATEMATİK Sayı İşlem Ders Zor/Sıkıcı Öğretmen Adı	**SAYI** Matematik Rakam Hesap Doğal Sayı Rasyonel Sayı
CEBİRSEL İFADE Bilinmeyen X,Y Değişken Terim İşlem	**DEĞİŞKEN** Bilinmeyen Harf Cebirsel İfade Çarpım X,Y
KATSAYI Bilinmeyen Sayı Cebirsel İfade Çarpım Harf	**SABİT TERİM** Bilinmeyen Sayı Katsayı Sıfır Harfsiz

Figure 3.1 Taboo Cards

In the middle part of the lesson, *"3x – 4y + 11"* was written on the board and the students indicated the variables, coefficient, and constant term in this expression. Then, the worksheet related to these terms was distributed to each student. In the worksheet, they were asked the variables,

coefficient, constant term and the sum of coefficients for the given expression. Additionally, they answered a question related to writing a given situation in words as an algebraic expression and calculating an algebraic expression for different values of a variable in the worksheet. This question was taken from Çaylan (2018). The worksheet is given in Figure 3.2.

Aşağıda verilen soruları cevaplayınız.

1) Aşağıda verilen her bir cebirsel ifade için tabloyu doldurunuz.

Cebirsel İfade	Değişken(ler)	Terim(ler)	Sabit Terim(ler)	Katsayı(lar)	Katsayı(lar)Toplamı
3k					
-6xy+1					
2a+5b-8					

2) Aşağıdaki soruları cevaplayınız.

a) ''Bir akvaryumdaki balıkların sayısının 3 katının 7 fazlası'' ifadesine uygun bir cebirsel ifade yazınız.

b) Değişkenin 15 olması durumunda, yazdığınız cebirsel ifadenin değerini hesaplayınız.

Figure 3.2 Worksheet of the 1st Lesson Plan

At the end of the lesson plan, I summarized the lesson, and distributed individual exit cards related to objectives of the lesson and gave them a few minutes to answer.

During the first week, I observed that the academic level of the class was

low.

Although the academic level of the students in the class was observed to be low, the students were so active in the lesson, and their attitudes towards the implementation were positive. Additionally, during the Taboo game, giving the task of keeping the time with the hourglass to the inclusive student positively affected the student's interest in the lesson.

3.5.3 The Second Lesson Plan

At the beginning of the lesson, an activity was conducted. In this activity, the students were kept waiting at the classroom door and the question papers in Figure 3.3 which include one question were distributed to each student. Then, they were asked to find the desks in which the answer to the questions in Figure 3.4 were left, and to sit in those desks. The purpose of these questions was to remind them some terms, such as coefficient, constant term and variable, which were focused on in the previous lesson. The questions and the answers of this activity are given in Figures 3.3 and 3.4.

2xy-8y+6 ifadesinin sabit terimi	2xy-8y+6 ifadesinin katsayıları	2xy-8y+6 ifadesinin değişkenleri	2xy-8y+6 ifadesinin katsayılar toplamı
a+3w+8z-2c-30 ifadesinin sabit terimi	a+3w+8z-2c-30 ifadesinin katsayıları	a+3w+8z-2c-30 ifadesinin değişkenleri	a+3w+8z-2c-30 ifadesinin katsayılar toplamı
4f ifadesinin sabit terimi	4f ifadesinin katsayıları	4f ifadesinde f=3 olursa, ifadenin değeri	4f ifadesinin terim sayısı
13d+7e+8 ifadesinin sabit terimi	13d+7e+8 ifadesinin katsayıları	13d+7e+8 ifadesinin terim sayısı	13d+7e+8 ifadesinin katsayılar toplamı
k+25l+2m ifadesinde l'nin katsayısı	k+25l+2m ifadesinde katsayılar toplamı	k+25l+2m ifadesinin değişkenleri	3n-5 ifadesinde n=5 olursa, ifadenin değeri

Figure 3.3 The Questions of the Beginning Activity in the 2nd Lesson Plan

6	2, -8, 6	xy ve y	0
-30	1, 3, 8, -2, -30	a, w, z ve c	-20
0	4	12	1
8	13, 7, 8	3	12
25	28	k, l ve m	10

Figure 3.4 The Answers of the Beginning Activity in the 2nd Lesson Plan

In the middle part of the lesson, I showed a picture with some erasers and pencils in the two pencil boxes. Then, the I asked the following questions: "*How many pencils are there in total in the pencil boxes?", "How many erasers are there in total in the pencil boxes?"* After students answered these questions, I asked *"Could you add up the numbers of pencils and erasers?"* and *"Could you subtract the numbers of erasers from the numbers of pencils?".* Then, I asked whether we have 5 pencils after adding the 2 pencils to 3 erasers. Most of the students gave an expected answer, which was 5 pencils. At this point, I emphasized that we should make addition operation with similar things to each other. After that, I showed algebra tiles and asked whether they know how an algebraic expression can be modeled by the help of algebra tiles. Most of them did not know to model using algebra tiles. Then, I showed the algebra tiles which symbolized x and 1, and I modelled $2x + 3$. I distributed the instruction of the activity to each student and asked them to write algebraic expressions which were modelled by the algebra tiles and model the given algebraic expressions by algebra tiles which were distributed to them.

During this activity, desk mates helped each other and checked each other's answers. We had a whole-class discussion about their own models. I asked the inferences they made looking at the examples in the activity sheet. Expected responses such as similar terms can be added with each other, and grouped terms add to each other by the help of factorizing common bracket, was not given. To deduce these answers, I asked some direct questions such *as "Which terms can be added to each other?"*. Additionally, I wrote:

"*(ax+b) +(cx+d)=(a+c)x+(b+d)"*, "*2x+3x-2=5x-2",*and "*x-2+2x+1=3x-2"* as examples on the board. The students took note related to these addition operations on the worksheets. Then, they answered the 2nd and 3rd questions in the worksheet. The purpose of these questions was to define similar terms and make addition operation with similar terms. The lesson continued with the questions related to finding the simplest forms of *"3a-5a+12a"* and *"2a + 3 – a – 4".* After that, the students were created groups of four. I distributed flashcards to each group and stated that the answers of the questions in the cards will be written on given sheets or back face of the cards. The cards are given in Figure 3.5.

I indicated that the group which finished first would be the winner. Also, I said that if there was not any group that finished answering, the group with the most correct answers would win. During this activity, I guided the students by helping them when they asked any questions. After finishing the activity, we talked about the answers to the questions in the cards, and the correct answers were reflected on the board. At the end of the lesson, I summarized the lesson with the help of the students and gave them the exit card which was related to addition and subtraction operations of similar terms in algebra.

5x - 7x + 3y - y ifadesinin en sade halini yazınız. #1	**4a + 11b - 9b - 8a ifadesinin en sade halini yazınız.** #2
12k - 14k + 7 ifadesinin en sade halini yazınız. #3	**17a + 7b - 45a – 12 - 9b - 4 ifadesinin en sade halini yazınız.** #4
$\left(\frac{x}{2}-9\right)+\left(\frac{5x}{2}-4\right)$ **ifadesinin en sade halini yazınız.** #5	$2x^2 + 5xy - x^2 + 2xy + 5$ **ifadesinin en sade halini yazınız.** #6

Figure 3.5 The Flashcards of the 2nd Lesson Plan

During the implementation of the plan, I observed that there were students who were not inclined to group or partner work, and that there were students who tried to stand out in the groups. I encouraged the students who excluded their groupmates to include them in their work. I also observed that assigning some tasks to the students, such as assisting the teacher, were very valuable for most of the students and made them more active in the lesson. In addition to the difficulties in the group work, the fact that the lesson was the last lesson of the day, efficiency reduced considerably, especially in the last 5-10 minutes of the lesson.

3.5.4 The Third Lesson Plan

At the beginning of the lesson, I reflected a picture of a function machine on the board. I indicated that this function machine converts the given algebraic expressions to other algebraic expressions, and the machine's blank buttons must be filled with the algebraic expression or operation symbol so that each expression on the left changes to the one on the right. The picture of the function machine is given in Figure 3.6. For example, for "x + 4", an operation was made in the function machine by pressing the blank button and the button of "2x + 5", and "x + 4" changed to "3x + 9". In that case, the first blank button should be "+" operation symbol.

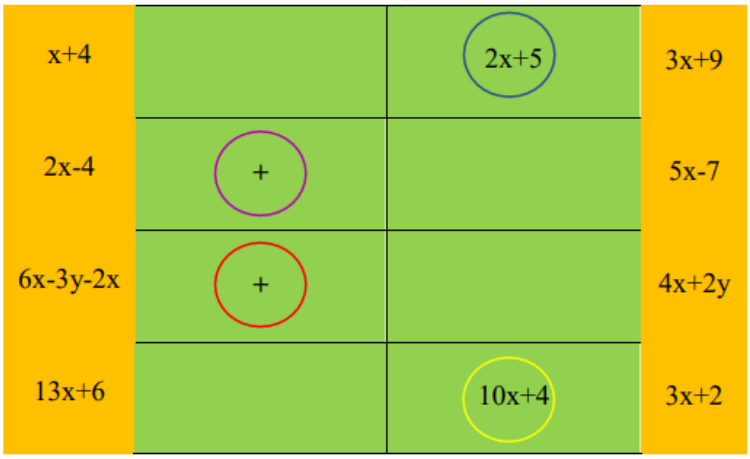


Figure 3.6 The Picture of the Function Machine in the 3rd Lesson

While voluntary students came to the board to fill in the blanks, the students in their desks thought about whether their friend's answers were correct. I asked the students raise their heads if they thought that the answer given by their friends was correct, and to bow their heads if they thought it was wrong, as in the day and night game. Then, I asked them to

explain why they thought it was right or wrong. After reminding the previous lesson by the help of the function machine, I distributed a worksheet to each student and gave time to answer the first question which was related to modelling the given operation by using algebra tiles. Then I asked them to write the simplest form of the given operations. The expected answers were *"(4x+3)-(x+2) =4x+3 –x –2=3x+1"and "(6x –2) – (x –2)=6x –2 –x+2=5x",* most of the students gave wrong answer due to minus symbols in front of the parenthesis. The 2nd and 3rd questions in the worksheet were answered by the class. The 2nd question was related to writing the given addition operation which was modelled by algebra tiles. The 3rd question was related to writing the simplest forms of given algebraic operations. After answering these questions, I told the students to form groups of 4 for an activity. BINGO game cards, answer cards, and answer sheets on which the students would write down their answers, were distributed to each group. In this activity, the purpose was matching all questions on the BINGO game cards with the correct answers on the answer cards that were given. The number of answer cards was more than the number of questions on the BINGO game cards. One person from each group wrote their answers in the answer sheet. BINGO game cards and answer cards are given in Figures 3.7 and 3.8.

The group that answered all questions on a single row of the BINGO card would call "First CINKO" to get 10 points. The group who answered 2 rows in total would say "Second CINKO" to get 20 points. The group who answered 3 rows in total would say "Third CINKO" to get 30 points. The group that finished all the matches would say "BINGO", and this group would be the winning group. The instructions of the game were reflected on the board, and the students were asked to read the instructions carefully. Additionally, I walked around the class and helped them when they had a

difficulty and checked the answers of the groups that said “CINKO” or “BINGO”. After the activity, due to the time limitation, the task of answering the questions which the students had difficulty with was given to the voluntary students in the groups.

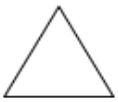
 Yukarıdaki bir kenarı ‘‘a’’ birim olan eşkenar üçgenin çevre uzunluğuna karşılık gelen cebirsel ifade 1	2x-1+5 ifadesinin en sade hali 2	3xy’ye benzer bir terim 3	(5k-7)-(3k-4) ifadesinin en sade hali 4
4x’e benzer bir terim 5	 Yukarıdaki bir kenarı ‘‘x’’ birim olan karenin çevre uzunluğuna karşılık gelen cebirsel ifade 6	4k-7k ifadesinin en sade hali 7	 Yukarıdaki şekilde modellenen cebirsel ifadenin en sade hali 8
(4x-8)+(9x-1) ifadesinin en sade hali 9	$7y^2$’ye benzer bir terim 10	(8y+2)-7y ifadesinin en sade hali 11	8a+6b-10a-12+7b+5 ifadesinin en sade hali 12
(3b-7)-(-11b+3) ifadesinin en sade hali 13	n-5n+7n ifadesinin en sade hali 14	(4a-7)-(8a-3) ifadesinin en sade hali 15	(4c+3)-(2c+1) ifadesinin en sade hali 16

Figure 3.7 BINGO Game Cards

a+a+a	3a	2x-4	2x+4
-xy	x+y	2k-11	2k-3
xy	-2x	4x	x^2
-3k	3k	x+1	5x+3

13x-19	13x +3	$-3y^2$	y
y+2	y-2	-2a+13b-7	2a+13b+7
14b-10	-8b-4	3n	13 n
-4a-4	4a+4	2c+2	2c+4

Figure 3.8 Answer Cards of BINGO

Then, the new worksheet was distributed to each student, and 7-8 minutes were given for the first 3 questions. After giving time, questions answered on the board by the students.

Then, I asked the students to express algebraically the perimeter of the traffic sign in the form of an equilateral triangle with one side as "(a+5)" cm. After given answers, I asked *"Is there a different solution to find the perimeter of this traffic sign?"* The expected answer "3. (a + 5)" was not given by the students, and I mentioned that multiplication means repeated addition. The lesson continued with the 4th question. Before answering the 4th question, I asked how the solution of "*3. (4 + 5)"* could be found and showed the solution of "*3. (4 + 5) = 3 .4 + 3 .5 = 12 + 15 = 27"* on the board. At this point, I stated that the distributive property can be used in multiplication of algebraic expression. I showed that all terms of algebraic expression multiply with a natural number one by one by the *help* of the example of *"a × (b + c) = a × b + a × c".* I asked, *"What should we do in the fourth question?".* Then, the answer of *"3. (3a + 2) = 3. 3a + 3. 2 = 9a + 6"* was shown on the board. The first item of the fifth question was answered, but the rest of the questions in the worksheet were given as a homework to be discussed in the next lesson. At the end of the lesson, I summarized the lesson and asked the multiple-choice question "*What is the simplest form of 5x– (x–3) + 2(4–x)?"* with the choices of *"3x + 5", "3x + 11", "2x +11" and "2x + 1"* to assess the answers by the application of Plickers. Before the assessment, I introduced this application and stated what the students needed to do. Plickers was an application that helped create different QR codes for each student. These QR codes were printed out and distributed to the students. The question was reflected on the board. After giving time for the correct answer, students held up their QR code cards by turning the cards in different orientations to indicate

their answers one side up for A, another side up for B, and so on. An example QR code card of Plickers is in Figure 3.9.

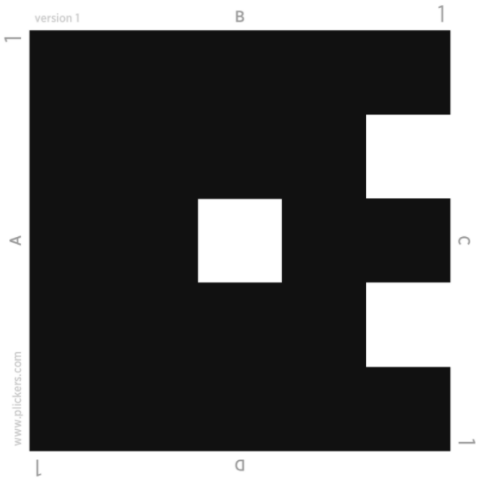


Figure 3.9 QR Code Card of Plickers

The teacher turns on his camera with the Plickers application on his mobile device and points his phone towards the answers. Plickers scans students' responses and lists students who answered on the board.

During the implementation of this lesson, the group which had academically weak students were observed to be much more willing to engage in the BINGO activity. Two groups won BINGO, and stickers were given to members of the winning groups. The inclusive student stated that he enjoyed the lessons.

3.5.5 The Fourth Lesson Plan

At the beginning of the lesson, I told the students that they would play the Algebraic UNO game and asked whether they have played the UNO game

before. Then, I distributed game instructions and gave them a few minutes to read. The instructions of the game were given in Figure 3.10, and UNO cards are given in Figure 3.11.

➢ With UNO playing cards, the class is divided into 4 groups as red, green, yellow and blue.

➢ At the beginning, the variable will be "x". Then, this variable will be used in some algebraic operations which are defined by the UNO cards.

➢ The game continues with all the players in the group choosing one card one at a time from among the shuffled and face-down playing cards.

➢ The meaning of each card with a number is that the variable of *x* or the algebraic expression which was obtained on the previous card will be multiplied by the number on this card (as long as the meaning of the cards does not change).

➢ The meaning of the card with "+2" on it is adding 2 to the last algebraic expression obtained (unless the meaning of the card has changed).

➢ A card with an arrow sign means that the meaning of Uno card will change. This means that the cards that were used for multiplication now become numbers to be added, and the card of "+2" becomes a card to be multiplied. After drawing this card, students should also draw a number card and continue the steps of UNO according to the card they draw.

➢ The card of *"Ø"* means that all subsequent cards would be used for subtraction. After drawing this card, the students should also draw a number card and continue the steps of UNO according to the card they draw.

➢ During the UNO activity, one writer from each group should note the algebraic expression obtained at each stage.

➢ After finishing the cards, each group shares the algebraic expression they obtain finally.

➢ A voluntary student draws a number from among the whole numbers in a box. The drawn number is substituted for *x* in the algebraic expressions obtained finally, and the group that has the highest value at the result of the substitution will be the winner.

Figure 3.10 The Instructions of the Algebraic UNO

Figure 3.11 UNO Cards

After giving time to read the instructions of UNO, I explained the instructions of the UNO activity by giving an example to make sure it was understood. This example was that if I draw the card of "3" first, what I should do in the next steps. I said "*This means I need to multiply x with 3. Now, I obtained "3x". If the next person draws the card of "+2", this means, the obtained algebraic expression will be "3x +2." If the next person draws the card with arrow, this person needs to draw any other card and the meaning of the cards changed now. For example, if the drawn card is "5", she needs to add 5 to the last algebraic expression instead of multiplying by 5. If this person draws the card of "5", the algebraic expression would be "3x+2+5=3x+7". After that, if the card of "Ø" is drawn, the meaning of all cards will be subtraction, and the person who draws this card needs to draw any other card. For example, this person draws the card of "4", the algebraic expression would be "3x+7-*

4=3x+3". The game will continue until finishing all cards. When all cards are finished, each group shares their own algebraic expression at the last step. For example, let's say the algebraic expression which belongs to one of the groups is 6x-2, the other group's expression is 5x+3, and the number to substitute for x is 2. In this situation, the value of the first algebraic expression would be 10, and the value of the second algebraic expressions would be 13. Since 13 is higher than 10, the group which obtained 13 will be the winner."

After giving 20 minutes for the UNO activity, I distributed the activity sheets to each student and gave 5 minutes to them to think about the questions on the activity sheet. I indicated that they could create groups of 5 or 6 to think about these questions. Then, the students shared their opinions and inferences they made looking at the examples in the activity sheet with the class. In this activity sheet, the picture of a scale was given as in Figure 3.12.

Figure 3.12 Scale in the Activity Sheet (taken from MoNE book, 2018)

Additionally, the question in this sheet were *"If 1 marble is added to the left pan of the balance scale, how will the balance status be changed? What should you do if it is unbalanced?", "What do you observe about the balance when you add two marbles to each of the pans of the scale?",* "*How is the balance situation when you take one marble from each of the*

pans of the scale?", "What should you do in order preserve the balance when you take some marbles from one of the pans of the scale?", "If the number of balls on each pan of the scale is doubled, how does the balance change?", and "If you take half of the balls on the scales from both pans, how will the state of balance change?".

Then, making inferences related to these questions was expected from the students. By the help of these questions, some inferences related to conservation of equivalence were made. Then, I distributed the worksheet. The first question was *"Nehir and Salih are riding a seesaw. When Nehir takes a bag with a mass of 6 kg, the seesaw is balanced. If Salih's mass is 28 kg, find the mass of Nehir by using an equation."* The second question expected the students to find the missing values in the given equations. This question is given in Figure 3.13.

a) △ – 23 = 10 ise △ = ?

b) ★ + 25 = 56 ise ★ = ?

c) 45 = a × 5 ise a = ?

d) k : 10 = 8 ise k = ?

e) -15 . p = 120 ise p= ?

Figure 3.13 The Second Question of the Worksheet in the 4th Lesson

The third and fourth questions of the worksheet were given as a homework due to time limitation. Then, the lesson continued with the DOMINO activity. I created groups of 4 and distributed domino game cards. Then, I reflected the instructions of the activity on the board and shared with the students how this activity would be done. In the domino cards which were divided into 2 pieces, each side of the cards had a part of a different equation. The purpose of the DOMINO was to connect the pieces that completed these equations when matched and return to the point where you started. The group which finished correctly was the winner. At the end of the lesson, I summarized the lesson and distributed the exit card. Exit card asked them how they would summarize what they learned in class today to a friend who did not come to the school.

During the implementation of this lesson, the students were observed not to have the habit of reading the instructions of the activities. Due to this, I had to explain the instructions a few times, and this situation caused to time problem in the lesson. They had more difficulty with the instructions of the UNO when compared with the instructions of the DOMINO. Although they did not have much more difficulty related to the instructions of DOMINO, they had difficulty to think about the balance while answering the questions related to equivalence. I observed that they were having difficulty in finding the results of the mathematical operations. Additionally, the inclusive student stated that he enjoyed the lessons.

3.5.6 The Fifth Lesson Plan

At the beginning of the lesson, some of the questions of the DOMINO

activity from the previous lesson was answered. Then, I provided a few verbal statements about the topics discussed so far and asked the students whether the statements were true or false. I asked the students to raise their heads if they think the statement was correct and to bow their heads if they think it was wrong, as in the day-night game.

The statements were as in Figure 3.14.

- ***The constant term of 2a + 3b is 3.***
- ***While adding and subtracting algebraic expressions, constant terms are added to obtain the coefficient of the variable.***
- ***When adding and subtracting algebraic expressions, similar terms are grouped and put in common brackets.***
- ***In multiplication with algebraic expressions, the natural number and the constant term of the algebraic expression are not multiplied.***
- ***If a weight is added to only one side of a balance scale, it will not be unbalanced.***
- ***According to the principle of conservation of equality, if both sides of an equation are multiplied by the same number or if both sides are divided by the same number, the equality is preserved.***

Figure 3.14 Beginning Statements in the 5th Lesson

Then, I briefly summarized the topics that have been focused on during the 5 weeks by the help of these statements. After the summary, I told the

students that they will play the Algebra Path game related to the topics covered so far and explained the rules of the game. While creating this game, I was inspired by the name of an existing board game. The game board is provided in Figure 3.15.

Figure 3.15 Game Board of the Algebra Path

The instruction of the game was given in Figure 3.16.

➢ The class is divided into groups of 5 or 6 people.

➢ On the given game platform, the players move forward with the number that comes on the dice they roll with any object they have determined as a pawn.

- If the pawn comes to the pink cell; players take from pink question cards,
- If the pawn comes to the yellow cell, players take from the yellow question cards,
- If the pawn comes to the blue cell, players take one of the blue question cards,
- If the pawn comes to the green cell, players take one of the green question cards and answer the question on it.

➢ Meanwhile, one volunteer student from each group checks the answers to the questions from the answer key.

➢ Students have 1 minute for each question. The person responsible for checking the answers is also responsible for the time.

➢ If the question cannot be answered in the given time, the student can move his pawn by 1 minus the number on the dice when it is his turn again.

➢ If the pawn lands in the white cell, the student cannot roll and move on the path in the next round.

➢ The aim of the game is to reach the finish first.

Figure 3.16 The Instructions of the Algebra Path

The questions of the Algebra Path were given in Figure 3.17.

Find the simplest form of the given operations.

- (2x + 3) + (5x -2)
- x.(5x -10) + (-2x + 7)
- (2x -1) + (10 + 3x)
- (11x -10) + (12x -20)
- (3×2 + 5) + (-3×2 +4)
- x + y + 5x - 6y
- 4x + 8y -3x + 5y + 6x
- x + y + z + 2x + -3y + 5z
- 6x + 7y + 4x +13

- (3n + 4) – (n -2)
- 3a – 12a -10x2 + 11x 2
- 2a – 7 – (a – 7)
- 21 – x – (-x -21)
- (-8x + 3) + (-2x – 5)
- (4x + 1) – (-x -5) + (2x – 1)
- 4a – (2a + 1)
- (2y + 6) – 4y

- 7(m-8) – 2(m – 2)
- 2(x – 4) + 3x
- (2x – 6) – 4. (3x -4)
- 2/3 (x – 5) – 5/6 (4x -1)
- 2 • (2x/3 – 5)
- Kenar uzunlukları x – 3, x – 3, x – 5 ve 2x + 1 birim olan yamuğun çevresi
- Kenar uzunlukları 4x + 3 ve 3x + 1 birim olan dikdörtgenin çevresi
- -120 = 5n ise n=?
- -6. (-3x + 1)

- Mert'in bugünkü yaşı 5x -1'dir. Mert x + 2 yıl önce emeklemeyi öğrendiğine göre, Mert'in emeklediği yaşı cebirsel olarak ifade ediniz.
- A = x -7 ve B = 2x + 8 olduğuna göre, A+ B toplamının x =3 için değeri
- Arda'nın bugünkü yaşı x + 7'dir. Buna göre, Arda'nın 4x +1 yıl sonraki yaşını cebirsel olarak ifade ediniz.
- Erhan'ın yaşı x + 4'tür. Dedesinin yaşı Erhan'ın yaşının 9 katı ise dedesinin yaşını cebirsel olarak ifade ediniz.
- M= 3x +1, N = 3x ve K = x +2 ise M – N + K ifadesi neye eşittir?
- Bir sınıfta, x + 2 tane öğrenci vardır. Bu öğrencilerin her birinin 3'er tane kurşun kalemi ve 2'şer tane tükenmez kalemi varsa, sınıftaki öğrencilerin toplam kalem sayısını veren cebirsel ifade
- -42 = - 6n ise n =?
- -4 = x + 8 ise x=?
- 4 + x = 5 + 17 ise x = ?

Figure 3.17 The Questions of the Algebra Path

At the end of the lesson, I summarized the topics which were focused on the last 5 weeks, and I thanked the students for their participation. I told them that I will give the posttest of the Algebra Achievement Test and Mathematics Attitude Scale, respectively. During the implementation of this lesson, I observed that the students liked the Algebra Path game, and they engaged in it. Also, compared to the first weeks, I observed that they were better in terms of group work.

3.5.7 Implementation of the Posttests

At the beginning of the lesson, I told the students that they will repeat the two tests they answered in the first week. Then, I reminded them that the students will not be graded in any way, and they should not worry. Then, I gave the posttests of the Algebra Achievement Test and Mathematics Attitude Scale, respectively. After giving 30 minutes for the Algebra Achievement test and 10 minutes for the Mathematics Attitude Scale, I collected the tests and thanked for their attendance.

3.6 Data Analysis

The data collected through the Algebra Achievement Test and Mathematics Attitude Scale were analyzed by quantitative methods. Students' responses were assessed through correctness, and while the wrong or empty answers in the Algebra Achievement Test were coded as "0", the correct answers were coded as "1". In the Mathematics Attitude Scale, quantitative method was used by reverse coding from "5" to "1" for the negative and positive items of the scale. The quantitative analysis of the Algebra Achievement Test and Mathematics Attitude Scale was performed by statistical tests at IBM SPSS Statistics 22. Paired-Samples T Test was used to investigate whether there was a significant difference between pretest and posttest scores if the assumptions were met. Since the

assumption of normality were not met, the non-parametric alternative Wilcoxon Signed Rank Test was conducted. The data collected through interviews were analyzed by qualitative methods. The interviews were first transcribed. While reading the narrative data, the categories were noted as they appear as Mertler (2006) stated. The categories are identified and organized by conducting inductive analysis.

3.7 Validity and Reliability

Fraenkel et al. (2011) identify reliability as "the consistency of the scores obtained for each individual from one administration of instrument to another and from one set of items to another" (p. 154).

According to Joppe (2000, p. 1), "Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are." (as cited Golafshani, 2003). This section will focus on issues related to internal and external validity and reliability of the study.

3.7.1 Internal Validity

This study was a weak experimental study since there was no control group. Since random assignment of the subject to the groups was impossible, an already existing class constituted the experimental group. The experimental group was selected from the same grade level students. In this study, the researcher was the implementer of the lesson plans during the research, so I taught the related objectives and observed the experimental group actively. Due to not only the administration of the tests, but also scoring of them, there might have been a researcher bias. Besides this, collecting the pretest and posttest data by the same

researcher might have helped eliminate the data collector bias. Additionally, the items of the pretests and the posttests were the same. By the help of this, the effect of intervention could be observed by comparing the pretest and posttest scores. Since pretests and posttests were implemented to all the students except the inclusive student, the loss of participation was not a threat in this study.

3.7.2 External Validity

The sample of the study consisted of 19 7th-grade students from one public middle school. Since convenience sampling method was used in this study, generalization of the findings to the population might be limited.

"Ecological generalizability refers to the degree to which the results of a study can be extended to other settings or conditions" (Fraenkel et al., 2011, p. 105). When the ecological generalizability definition was considered, while the study has a limitation to be extended to the other conditions, the study can be generalized to all 7th-grade classes at public middle schools which have similar settings or conditions.

3.7.3 Reliability

According to Creswell (2012), reliability means that scores from an instrument are stable and consistent. In this study, to increase the reliability of the analysis of the Algebra Achievement Test, interrater reliability was used. Interrater reliability involves observations made by two or more individuals. The observers record their scores, then compare scores to see if their scores are similar or different (Creswell, 2012). Therefore, the threat of any bias to scoring could be eliminated. For the interrater reliability, 20% of the data of achievement tests were randomly

selected and the data were scored by a second coder by using the coding manual developed by the researcher. The second coder was a mathematics teacher with 5 years of experience and a master's degree student in mathematics education program. There was one item which the agreement was lower than 80%. This codes for item was discussed between the two coders and revised accordingly. After the discussion, different data were coded by the second coder, and the agreement reached above 80%. Moreover, Cronbach Alpha values were calculated for the tests. In the pretest of the Algebra Achievement Test, Cronbach Alpha was calculated as .872, and as .926 in the posttest of the Algebra Achievement Test. The Cronbach Alpha value was calculated for the pretest of the Mathematics Attitude Scale as .948 and for the posttest of the Mathematics Attitude Scale as .921. According to Pallant (2011), values above .70 are considered acceptable, however, values above .80 are preferable (p. 100). Therefore, the reliability of the tests was found to be satisfied in the study.

3.8 Assumptions and Limitations

3.8.1 Assumptions

In this study, it was assumed that standard conditions were enabled for the students to implement the data collecting tools. Moreover, it was assumed that all participants reflected their own knowledge and opinions in the Algebra Achievement Test and Mathematics Attitude Scale, and they sincerely responded the interview questions.

3.8.2 Limitations

In this study, the most important limitation was convenience sampling. Due to the

convenience sampling, generalization of the results could be limited. Moreover, limited sample size of the study was a limitation for the generalization of the results. The other limitation was that there was not a control group to compare with the experimental group. Since the researcher did not have another appropriate class hour to implement the tests to another seventh-grade class, no control group could be involved in the study. Moreover, in this study, a pilot study could not be implemented due to time limitations. Implementation of a pilot study could enable the researcher or teacher to realize if there are any issues in the study before the main study. With the help of a pilot study, revisions may be done in the process. Furthermore, the duration of the implementation was limited by 10 class hours, and 2 class hours in total were allocated to the pretests and posttests. Eight class hours for the intervention might have been limited, and increasing the length of the intervention might play a role in having a more meaningful difference which in turn could lead to higher total scores of the posttests. Also, the results of the Algebra Achievement Test could be analyzed in terms of the strategies related to algebraic thinking. Strategies could be analyzed deeply to focus on students' conceptual understanding of algebra. Moreover, in order to avoid difficulties in managing game-based learning activities during the intervention, it may be beneficial for students to familiarize themselves with game-based learning activities beforehand. If the length of the intervention is increased, 1 or 2 class hours could be given to introduce the students with game-based learning activities. In these class hours, some warm-up games, such as Mirror-Image, Follow Your Leader, Find Your Partner and Kneel Down (Sezgin, 2015), aim to prepare students to act as a group and enable them to be familiar with game-based learning activities, can be implemented.

3.9 Ethics

Official permissions were received from the Human Research Ethics Committee and MoNE (see Appendices E and F, respectively). Moreover, a parental approval form was sent to the parents for informing them about the study and to get permission. Information was provided about the study, and oral consent of the students was obtained. After the data collection process, personal information of the participants was kept confidential. The participants were coded by assigning numbers instead of names, so the data could be analyzed detachedly.

CHAPTER 4

RESULTS

This chapter presents the descriptive and inferential statistics analysis and findings in detail to respond to the following research questions.

1. What is the effect of using game-based learning activities on seventh-grade students' achievement in algebra?
2. What is the effect of using game-based learning activities on seventh-grade students' attitudes towards mathematics?
3. What are seventh-grade students' opinions about the use of game-based learning activities in mathematics lessons?

4.1 Descriptive Statistics Results of the Algebra Achievement Test

The AAT (Pre-AAT and Post-AAT) included 6 open-ended questions, 5 of them with sub-items. The test, which included 23 items in total, was implemented to the group at a public school in Sarıyer in the Fall semester of the 2019-2020 academic year.

The analysis was conducted for 23 sub-items under 6 main questions. The sub-items were graded as 1 point for each correct answer, and the incorrect answers were graded as 0 points. Therefore, the maximum score that the student could have in the AAT was 23 points and the minimum score was 0 points. The descriptive statistics of the tests are given in Table 4.1. As shown in Table 4.1, the students' mean score in the Pre-AATwas found 4.72 with a standard deviation of 4.44.

Minimum and maximum scores were computed as 0 and 12, respectively. The students' mean score in the Pos-AAT was 7.53 with a standard deviation of 6.14. Minimum and maximum scores were computed as 0 and 17, respectively.

Table 4.1 Descriptive Statistics Results of the Pre-AAT and the Post-AAT

	Pre-AAT	Post-AAT
N	18	19
Mean	4.72	7.53
Median	3.50	7.00
Std. Deviation	4.44	6.14
Minimum	0	0
Maximum	12	17

The items which were given in the Pre- and post-AAT and percentages of correctness will be presented next.

Question 1

The first question is given in Figure 4.1 was related to writing an algebraic expression for a given situation in words and writing a given situation in words for a given algebraic expression as well as calculating an algebraic expression for different values of a variable.

In the first question, there were 5 sub-items. The percentages of the correct, incorrect and no response (NR) are given in Table 4.2.

1) It is known that the number of notebooks in a stationery is denoted by "d". The following statements are given regarding the number of items in this stationery;

a) If the number of books is twice the number of notebooks, write the algebraic expression for the number of books.

b) Write verbally what the algebraic expression "3d" can be as an algebraic expression .

c) If the number of pencils is 3 less than twice the number of notebooks, write the algebraic expression that gives the number of pencils.

d) If the number of erasers is twice the number of pencils, write the algebraic expression for the number of erasers.

e) Write down the number of erasers when the number of notebooks is 4.

Figure 4.1 1st Question in the AAT

Table 4.2 Percentages of Correct, Incorrect and NR Responses for the 1st Question of the AAT

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 1a	27.78%	61.11%	11.11%	52.67%	42.11%	5.26%
Item 1b	5.56%	66.66%	27.78%	0%	21.05%	88.95%
Item 1c	22.22%	72.52%	5.26%	21.05%	73.69%	.26%
Item 1d	5.56%	61.11%	33.33%	5.26%	84.21%	10.53%
Item 1e	5.56%	38.88%	55.56%	10.53%	63.15%	26.32%

When the pretest and posttest scores related to the 1st question were examined, among five sub-items, item 1b was the least correctly answered sub-item in both pretest and posttest. It is understood from here that the students had the most difficulty in writing a given situation in words for a given algebraic expression. In the pretest, most of the students who gave incorrect answers for item 1b interpreted the algebraic letters as the name of the object, and gave answers for what the algebraic expression “3d” can be (where d stands for the number of notebooks) as “3 notebooks” or “3 many notebooks”. Also, some of the students who gave incorrect answer for item 1b in the pretest, gave answers as “3 times notebooks” instead of “3 times the number of notebooks” for item 1b, using objects instead of quantities in their expressions. In the posttest, most of the students who gave incorrect answers for item 1b interpreted the algebraic letters as the name of the object as in the pretest by writing “3 times notebooks”. Also, some of the students who gave incorrect answers were found to ignore the given meaning of variable

“d” as the “number of notebooks” and they gave answers such as “ 3 times the number of something.”

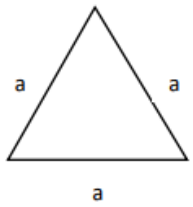
Question 2

The second question given in Figure 4.2 was related to writing the perimeter of the given polygons using algebraic expressions in the forms of both addition and multiplication.

In the second question, there were 4 sub-items. The percentages of the correct, incorrect and no response (NR) for the 2nd question are given in Table 4.3.

2) Write the algebraic expressions corresponding to the perimeters of the polygons given below, first as a sum and then as a product.

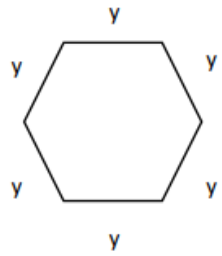
a)



in the form of addition: .....

in the form of multiplication: .....

b)



in the form of addition: .....

in the form of multiplication: .....

Figure 4.2 2nd Question in the AAT

Table 4.3 Percentages of Correct, Incorrect and NR for the 2nd Question of the AAT

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 2a.1	16.67%	72.22%	11.11%	42.11%	57.89%	0%
Item 2a.2	44.44%	44.45%	11.11%	57.89%	42.11%	0%
Item 2b.1	16.67%	72.22%	11.11%	42.11%	52.63%	5.26%
Item 2b.2	38.89%	38.89%	22.22%	52.63%	42.11%	5.26%

In the 2nd question, among 4 sub-items, items 2a.1 and 2b.1 were the least correctly answered sub-items when the pretest and posttest scores were considered. It is understood from here that some students were confused to write the perimeter of the given polygons using algebraic expressions in the form of addition. In both pretest and posttest of items 2a.1 and 2 b.1, most of the students who gave incorrect answers wrote the algebraic expression in the form of multiplication form instead of in the form of addition.

Question 3

The third question given in Figure 4.3 was related to performing addition operation with algebraic expressions.

In the third question, there were 2 sub-items. The percentages of the correct, incorrect and no response (NR) for the3rd question are given in Table 4.4.

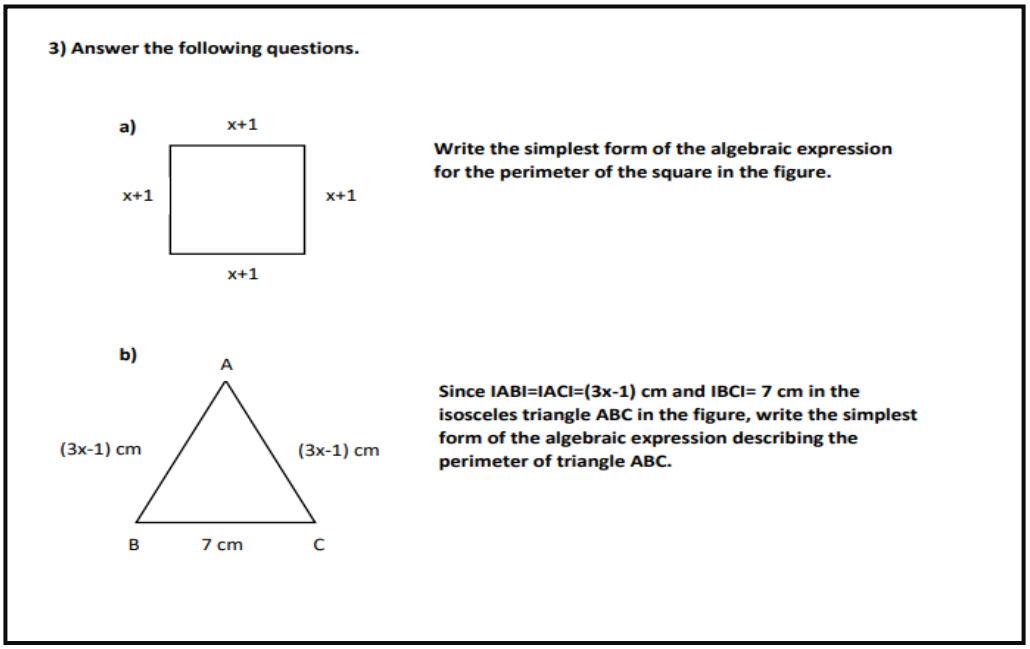


Figure 4.3 3rd Question in the AAT

Table 4.4 Percentages of Correct, Incorrect and NR for the 3rd Question of the AAT.

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 3a	5.56%	61.11%	33.33%	21.05%	73.69%	5.26%
Item 3b	0%	54.44%	55.56%	10.53%	73.68%	15.79%

In the 3rd question, among two sub-items, item 3b was the least correctly answered sub-item when the pretest and posttest scores were considered. It is understood from here that some students confused the addition of different algebraic expressions such as (3x -1) and 7. Moreover, students were found to have difficulty

adding a constant term and an algebraic expression. In the pretest, most of the students who gave incorrect answer for item 3b combined like and unlike terms incorrectly, such as “4x + 7 = 11x”. Also, some of the students who gave incorrect answer for item 3b in the pretest did not write the algebraic expressions in the simplest form as asked in the question. In the posttest, most of the students who gave incorrect answers for item 3b did not write the algebraic expressions in the simplest form as in the pretest.

Question 4

The fourth question given in Figure 4.4 was related to performing operations with algebraic expressions.

In the fourth question, there were 4 sub-items. The percentages of the correct, incorrect and no response for the 4th question are given in Table 4.5.

4) Write the simplest forms of the algebraic expressions given below.

a) $2(x + 3) =$

b) $2x - (6x - 2) =$

c) $x + 2x - y =$

d) $3x + 5 - 4 + 2x =$

Figure 4.4 4th Question in the AAT

Table 4.5 Percentages of Correct, Incorrect and NR Responses for the 4th Question of the AAT

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 4a	0%	66.67%	33.33%	15.79%	68.42%	15.79%
Item 4b	0%	87.78%	22.22%	0%	78.95%	21.05%
Item 4c	11.11%	55.56%	33.33%	52.63%	31.58%	15.79%
Item 4d	5.56%	66.66%	27.78%	36.84%	42.11%	21.05%

In the 4th question, among 4 sub-items, items 4a and 4b were the least correctly answered sub-items in the pretest. Students were found to have difficulty with the distributive property items in the pretest. In the pretest, most of the students who gave incorrect answer for the items did not multiply the outside term by each of the terms in the parenthesis while using the distributive property. For example, for item 4b, these students gave answers as "$2x - (6x - 2) = 2x - 6x - 2$" instead of "$2x - 6x + 2$", and they concluded the answer as " $-4x - 2$." Also, some of the students, who gave incorrect answers for the items added unlike terms, after the distributive property misconception. In the posttest, item 4b was the least correctly answered sub-item. This showed that the students had the most difficulty to multiply the "–" which is the outside term of the parenthesis by each of the terms in the parenthesis. Most of the students who gave incorrect answers for this item gave the answer of "$-4x - 2$" as in the pretest. Also, some of the students who gave incorrect answers for the items added unlike terms after the distributive property as in the pretest and they gave the answers of "$2x$" or "- 6". In addition to these

answers, some of the students who gave incorrect answers just added the unlike terms in the item and gave answer as "- 2*x*" or "-2".

Question 5

The fifth question given in Figure 4.5 was related to understanding the principle of conservation of equality.

> **5) In the solution of the equation of n + 15 = 31, n = 16**
>
> **What is "n" in the solution of the equation of n + 15 – 9 = 31 – 9-? Explain why.**

Figure 4.5 5th Question in the AAT that was adapted from Stephens (2006)

In the fifth question, there was not any sub-item. The percentages of the correct, incorrect and NR for the 5th question are given in Table 4.6.

Table 4.6 Percentages of Correct, Incorrect and NR Responses for the 5th Question of the AAT

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 5	33.33%	16.67%	50%	42.11%	21.05%	36.84%

In the 5th question, when the posttest resuts was compared with the pretest results, the percentage of correct answers were found to increase while there was a

decrease in the percentage of no response, and the percentage of incorrect answers also increased compared to the pretest. In the pretest, most of the students who gave incorrect answers considered the first term after the equal sign as a result of the operation. These students gave the answer as “22” by performing the operations of “16 + 15 = 31” and “31 – 9 = 22”. In the postest most of the students who gave incorrect answers used different strategies that are not discernible.

Question 6

The sixth question given in Figure 4.6 was related to understanding the principle of conservation of equality and the meaning of the equal sign.

6) Find the unknown values in the following equations.

a) $4 + \square = 7 + 5$ $\square = ?$

b) $5 - x = 4$ $x = ?$

c) $-5 + \triangle = -6$ $\triangle = ?$

d) $-6 + x = 7$ $x = ?$

e) $10 - 3 = 11 - \square$ $\square = ?$

f) $-15 = 5x$ $x = ?$

g) $4 \times 15 = a \times 30$ $a = ?$

Figure 4.6 6th Question in the AAT

In the sixth question, there were seven sub-items. The percentage of the correct, incorrect and NR for the 6th question are given in Table 4.7.

Table 4.7 Percentage of Correct, Incorrect and NR Responses for the 6th Question of the AAT

	Pre			**Post**		
	Correct (%)	**Incorrect (%)**	**NR (%)**	**Correct (%)**	**Incorrect (%)**	**NR (%)**
Item 6a	38.89%	33.33%	27.78%	52.63%	36.84%	10.53%
Item 6b	47.06%	11.76%	41.18%	57.89%	21.06%	21.05%
Item 6c	44.44%	22.23%	33.33%	57.89%	21.05%	21.05%
Item 6d	22.22%	38.89%	38.89%	47.37%	31.58%	21.05%
Item 6e	27.78%	27.78%	44.44%	31.58%	47.37%	21.05%
Item 6f	16.67%	22.22%	61.11%	15.79%	36.84%	47.37%
Item 6g	38.89%	22.22%	38.89%	36.84%	47.37%	15.79%

In the 6th question, among 7sub-items , item 6f was the least correctly answered sub-item in the pretest and the posttest.

Except sub-items 6f and 6g, where there was a slight decrease (about 1 to 2%) from the pretest to posttest correctness, the correctness percentages in all other sub-

items were found to increase from the pretest to posttest. The detailed analysis of the percentages of the correct answers to the sub-items of 6th questions in the pretest of AAT showed that the percentage of the correct answers for “6f” and “6g” was higher than the posttest of AAT.

In the pretest and the posttest, most of the students who gave incorrect answers for item 6f and 6g did not give any detail for the solution of the problem, and they gave only answer. Only one student from the students who gave an incorrect answer eliminated the negative while doing algebraic operations in the pretest, and this student gave an answer as “$x = 3$” in 6f, which asked the value of x in the equation, $15 = 5x$. Also, some of the students who gave incorrect answers for item 6g in the pretest and posttest considered the first term after the equal sign as the result of the operation and they gave the answer as “$4 \times 15 = a$” and “$a = 60$” when asked the value of a in the equation, $4 \times 15 = a \times 30$.

To sum up, in the items of “1d” and “4b”, the percentage of correctness did not change in the posttest when it was compared with the pretest. While the percentage of correctness for the items of “1b”, “1c”, “6f” and “6g” was found lower, the percentage of correctness for the items of “1a”, “1e”, “2a.1”, “2a.2”, “2b.1”, “2b.2”, “3a”, “3b”, “4a”, “4c”, “4d”, “5”, “6a”, “6b”, “6c”, “6d” and “6e” increased in the posttest. It is understood from here that writing a given situation in words as an algebraic expression, writing a situation in words for a given algebraic expression and solving equations by using division and multiplication might have still been difficult for the students.

4.2 Inferential Statistics Results of the Algebra Achievement Test

Students' answers for the Algebra Achievement Test were analyzed in terms of correctness. If given answers were wrong or no answer was given, these were coded as "0". If correct answers were given, these kinds of answers were coded as "1".

4.2.1 The Results of the Algebra Achievement Test

In this study, to respond to the first research question, the Paired Samples T-Test were aimed to be used since there was only one group and the data was collected data from them before and after the intervention that focused on using game-based learning activities in algebra. Since the assumption of normality for Paired Samples T-Test was not met, Wilcoxon Signed Rank Test which is a non-parametric alternative to the Paired Samples T-Test was conducted to analyze the results of the Algebra Achievement Test.

4.2.1.1 Assumptions of the Paired Samples T-Test

The basic assumptions for the Paired Samples T-Test are level of measurement, independence of observations and normal distribution.

4.2.1.1.1 Level of Measurement

According to Pallant (2011), while designing a study, trying to use of continuous measures rather than categorical gives a wide range of possible techniques to use when analyzing the data. In this study, dependent variables were measured under two different conditions as pretest and posttest before and after the intervention and were continuous. Therefore, this assumption was satisfied by the measure of the dependent variable in this study.

4.2.1.1.2 Independence of Observations

In this study, each observation or measurement was not influenced by any other observation or measurement. Therefore, the violation of this assumption was prevented.

4.2.1.1.3 Normal Distribution

As Pallant (2011) stated that "for parametric techniques, it is assumed that the populations from which the samples are taken are normally distributed" (p. 206). In this study, firstly, the Shapiro-Wilk Test was conducted since the sample size was less than 50. The results of this test are given in Table 4.8.

Table 4.8 The Results of the Shapiro-Wilk Test for the AAT

	Statistic	Df	Sig.
Pretest Scores	.864	18	.014
Posttest Scores	.901	19	.050

The Shapiro-Wilk Test indicated p values as .014 for pretest and .050 for posttest. Since significance values more than .05 are sought, the assumption of normal distribution was not met.

4.2.1.2 Wilcoxon Signed Rank Test

Among the assumptions of the Paired Samples T-Test, normality was violated when the Shapiro-Wilk Test was conducted. Since normality assumption could not be ensured, the Wilcoxon Signed Rank Test, which is a non-parametric technique, was conducted instead of the Paired Samples T-Test.

4.2.1.3 The Results of the Wilcoxon Signed Rank Test

To investigate whether there was an effect of using game-based learning activities on seventh-grade students' achievement in algebra, the mean difference between pretest and posttest scores were analyzed. The results are in Table 4.9.

Table 4.9 The Results of Wilcoxon Signed Rank Test of the Pre -AAT and the Post -AAT

	Z	Sig
Pretest-Posttest	-3.426	.001

The Wilcoxon Signed Rank Test showed that the intervention that focused on using game-based learning activities elicited a statistically significant increase on seventh-grade students' achievement in algebra *(Z=-3.426, p =0.001* with a large size effect *r=.56).*

4.3 Descriptive Statistics Results for the Mathematical Attitude Scale

The Mathematical Attitude Scale included 20 items. Therefore, the maximum score that the student could have in the MAS was 100 and the minimum score was 20. The descriptive statistics of the MAS are given in Table 4.10. As shown in Table 4.10, the students' mean score in the Pre-MAS was 55.84 with a standard deviation of 20.79. Minimum and maximum scores were computed as 23 and 95, respectively. The students' mean score in the Post-MAS was 63.79 with a standard deviation of 18.63. Minimum and maximum scores were computed as 26 and 94, respectively.

As seen in Table 4.10, the mean score from Pre-MAS to Post-MAS increased. That means seventh-grade students' attitude scores towards mathematics increased after the intervention.

Table 4.10 Descriptive Statistics of the Study of Pre-MAS and Post-MAS

	Pre-MAS	Post-MAS
N	19	19
Mean	55.84	63.79
Std. Error of Mean	4.77	4.27
Median	56.00	63.00
Std. Deviation	20.79	18.63
Variance	432.58	347.06
Skewness	.28	-.32
Kurtosis	-.67	-.45
Range	72	68
Minimum	23	26
Maximum	95	94

4.4 Inferential Statistics Results for the Mathematical Attitude Scale

The Mathematical Attitude Scale were included both positively worded items (1, 4, 5, 8, 11, 13, 14, 17, 18, 20) as well as negatively worded items (2, 3, 6, 7, 9, 10, 12, 15, 16, 19). While coding, positive statements were coded from “5” (totally agree) to “1” (totally disagree), and for negative statements, coding was reversed according to the order of alternatives.

4.4.1 The Results of the Mathematical Attitude Scale

To respond to the second research question which was about the effect of using game-based learning activities on seventh-grade students’ attitudes towards

mathematics, the Paired Sample T-Test was considered. There was only one group of people and data through the Mathematical Attitude Scale (MAS) were collected from them under two different conditions which are before and after the intervention. The assumptions of the Paired Sample T-Test were checked.

4.4.1.1 Assumptions of the Paired Samples T-Test

The basic assumptions for the Paired Sample T-Test are level of measurement, independence of observations and normal distribution.

4.4.1.1.1 Level of Measurement

According to Pallant (2011), while designing a study, trying to use continuous measures rather than categorical gives a wide range of possible techniques to use when analyzing the data. In this study, the dependent variables that were measured under two different conditions as pretest and posttest before and after the intervention of the lesson plans were continuous. Therefore, this assumption was satisfied by the measure of the dependent variable in this study.

4.4.1.1.2 Independence of Observations

In this study, each observation or measurement were not influenced by any other observation or measurement. Therefore, violation of this assumption was prevented.

4.4.1.1.3 Normal Distribution

As Pallant (2011) stated that "for parametric techniques, it is assumed that the populations from which the samples are taken are normally distributed" (p. 206). In this study, firstly, the Shapiro-Wilk Test was conducted since the sample size was less than 50. The results of this test are given in Table 4.10.

Table 4.11 The Results of the Shapiro-Wilk Test for the MAS

	Statistic	df	Sig.
Pretest Scores	.964	19	.654
Posttest Scores	.970	19	.776

As seen from Table 4.11, the p values for both tests (.654 for the pretest and .776 for the posttest) were higher than the alpha value (.05). Therefore, the assumption about the normal distribution was satisfied.

4.4.1.2 The Results of the Paired Samples T-Test

To investigate whether there was an effect of using game-based learning activities on seventh-grade students' attitudes towards mathematics, the mean difference between pretest and posttest scores were checked. The results are seen in Table 4.12.

Table 4.12 The Results of the Paired Samples T-Test of Pre-MAS and Post-MAS

	Paired Differences							
				95 % Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig(2_tailed)
Pair1__Pretest_Postest	−7.9474	15.5294	3.5627	−15.4323	−4624	−2.231	18	.039

The findings showed that there was a statistically significant increase from pretest to posttest scores, $t(18) = -2.231 < .01, p < .05$. Moreover, the eta squared was obtained as .21. This showed that there was a large effect size.

Therefore, according to the results, using game-based learning activities had a significant positive effect on seventh-grade students' attitudes towards mathematics.

4.5 Students' Opinions About the Use of Game-Based Learning Activities

To respond to the third research question, seventh-grade students' opinions about the use of game-based learning activities, the findings regarding the semi-structured interviews will be presented in this section. The interviews were carried out with 10 purposively selected students (5 girls and 5 boys) after the intervention. There were five main questions asked in the interviews to get students' opinions related to game-based learning activities. Findings for each question will be presented next.

The first question of interview protocol was *"Did you use game-based learning activities in the mathematics lessons before? If so, could you briefly describe them?".*

Eight out of 10 students stated that they did not use game-based learning activities in the mathematics lessons before, while 2 of them stated that they used. While the students who stated that they did not use game-based activities did not give any detailed explanation, the explanations of the students who stated that they used game-based learning activities included award-winning (additional points, etc.) competitions. One of these students stated that these competitions were based on answering the question asked in the lesson or being the first in answering the question asked. Additionally, answering the multiple-choice questions by raising hands according to the choices was another example of these students for game-based learning activities. It is understood that the conception of a game-based learning activity for some students did not require the use of concrete materials or any game element. At the same time, from these 2 students' responses, it was understood that the reward was important in the perception of a game-based learning activity.

The second question of interview protocol was *"Were game-based learning activities effective in your understanding of the topic? Why or why not?".* Nine out of 10 students stated that game-based learning activities were effective in their understanding of the topic, while 1 of them stated that game-based learning activities were not effective in his understanding the topic.

Six of those students who stated that game-based activities were effective, stated that learning in a fun way helped them increase their interest and desire for the lesson. For instance, student 5 stated that *"Game is useful for learning. For example, I really liked the Uno." Student 8 said, "I guess it is effective. Because I didn't think that the mathematics lesson would be such a fun lesson and I wanted to*

listen to the lesson more because it was fun." Lastly, student 12 stated,"It has been effective since I wasn't very good at algebraic expressions. It was like solving a mystery on a map and moving slowly with the game."

One of the students who stated that game-based learning activities were effective, focused on winning a reward and earning respect. *Student 3 stated, "It was effective. ...When it comes to winning awards or earning respect, we try harder."*

The last two students who stated that game-based learning activities were effective, described that group work in the games supported their learning. For instance, student 14 stated, *"It has been effective. For example, I could understand by the help of my groupmates and the other groups."*

The student who stated that using game-based learning activities was not effective in understanding the topic was the inclusive student. Student 19 stated,*"It has not been effective because it was boring. The topic was boring, not games."*

The third question of interview protocol was *"Did you have any difficulty during the activities? If yes, what kind of difficulties did you have? Please explain."*. Six out of 10 students stated that they had difficulties, while 4 of them stated that they did not have any difficulties.

One of the students who had diffculty explained the reason due to the groupmates who did not work together with the other groupmates. Student 3 stated,*"I had a difficulty. We had difficulties in the groups. We could not do group work because 2 people decided on their own."*

Three of the students who had difficulties stated that they had difficulty in the mathematics questions. For instance, student 7 stated, *"I had difficulties in some games. For example, I had difficulties in Domino and Algebra Path. Some questions were very easy, but I struggled with difficult questions."*

One of the students who had difficulties stated that she had difficulty due to not reading the instructions. Student 8 stated, *"I had difficulties in one of the games. I couldn't understand a little bit in Domino. Since we did not read the instruction, we tried to understand what you said; but we had a hard time."*

One of the students first stated that he did not have any difficulties. In response, I addressed an additional question to this student based on my observations. The question was: *"According to my observations, you do not read the instructions in group work. Did you have any difficulties regarding this issue?"*. Then, the student answered as *"In one of the activities, we thought we won because we did not read the instructions. However, the highest scorer won, the first to finish did not win."*

Additionally, one of the students who did not have any difficulties stated that it was easier for them when a group member read the instructions aloud. Moreover, one of the other student who said that he did not have any difficulties stated that game-based learning activities were fun. This student was the inclusive student in the group.

The fourth question of interview protocol was *"Did group work affect your learning? How did it affect? Please explain."* Seven out of 10 students stated that group work affected their learning , while 3 of them said the opposite of it. The majority of the students who stated that group work was effective for their learning stated that peer-to-peer communication and cooperation facilitated their learning. For instance, student 5 stated, *"It affected very well. We were talking a lot more, and we could do the activities quickly, much more easily."* Student 7 stated, *"It affected. We helped each other because we were a group. It was so much better."*

Lastly, student 14 stated "Yes, it did. Games get better with group work. For example, my groupmates were helping me with questions if I do not have any idea."

According to one of the students who stated that group work affected his learning, there was a negative effect of group work in addition to the positive effects. Student 3 stated *" It affected my learning but not too much. While the four of us were making the same decision, another person's thinking differently made our work difficult."*

Three students stated that group work did not affect their learning. One of the students who thought that group work did not affect his learning was the inclusive student. He did not express a detailed opinion on the matter. Another student who stated that group work did not affect learning (student 2) described the reason as groupmates' not helping each other. Lastly, student 12 described the reason of the same opinion as having worked on the task individually since he stated that the groupmates did not have an opinion on the mathematics topic. An additional question was asked to this student as *"Can't you learn something from your friends too?"*. The student's answer was *"Actually, I can learn from some of my friends, but I did not get help."*

The fifth question of interview protocol was *"Could you please indicate your comments and suggestions regarding the lessons in which game-based learning activities were used?"* Nine out of 10 students stated that their attitudes towards mathematics and opinions related to mathematics changed and game-based learning activities should take place in mathematics lessons while one of them said the opposite of it.

Six of the students who found using game-based learning activities favorable in mathematics lessons talked about the positive effect of adding some fun to mathematics that is believed to be difficult and boring. For instance, student 2 stated, *"Mathematics is already a difficult lesson, so I think it is necessary to add some fun to it.."* Student 7 said, *"The teacher is also important to me, but I think that mathematics is better with games. I had a lot of fun for 5 weeks when*

compared with the other weeks' mathematics lessons. My interest in mathematics increased and my negative opinions about mathematics decreased. Mathematics could be fun. It would be more fun if mathematics lessons were like this..." Lastly, student 10 stated,*"When I started to middleschool, I was alienated from mathematics, but in these 5 weeks, I started to like it more. I thought I was wrong. I thought it was not such a boring and difficult lesson. For example, I also play at home with the game cards you gave us during the activities…"*

One of the students (student 14) who found using game-based learning activities favorable in mathematics lessons also emphasized that using such a method helped to learn the topics. Also, another student (student 3) stated that when the games were related to the content, they were effective in understanding the topics. Student 3 also emphasized the positive effects of making an effort and managing their decision-making processes during the game-based learning activities stating *"I gained a lot of knowledge in the games and tried to make my own decisions. We tried to rise to the occasion in the BINGO game."*

Three students who found using game-based learning activities favorable in mathematics lessons emphasized the effect of the competitive environment during the activities. Student 12 stated *"For example, in a game such as Monopoly, we can gain land in exchange of the mathematics questions, and we need to solve 15 questions for this."* Additionally, student 7 made a suggestion, *"More competition could take place in the activities. Time limitation should be added to make the activities more exciting. When there is a time limitation, we try to do it faster."*

As opposed to the 9 students who stated that their attitudes towards mathematics and opinions on mathematics changed and mathematics lessons should include game-based learning activities, one student (student 5) thought differently. This student stated that such activities do not always need to take place, and they can happen occasionally.

Consequently, the opinions of the 10 students interviewed about using the game-based learning activities in mathematics lessons mainly were found positive.

For the first question of interview protocol which was *"Did you use game-based learning activities in the mathematics lessons before? If so, could you briefly describe them?",* Eight out of 10 students stated that they did not use game-based learning activities in the mathematics lessons before, while 2 of them stated that they used. From this, it was understood that the students were not accustomed to the use of game-based learning activities and they could interpret some activities that do not fit the definition of game-based learning activities as game-based learning activities. For the second question of interview protocol which was *"Were game-based* l*earning activities effective in your understanding of the topic? Why or why not?",* nine out of 10 students stated that game-based learning activities were effective in their understanding of the topic, while 1 of them stated that game-based learning activities were not effective in his understanding the topic. From the answers given to this question, it could be concluded that the factors such as fun, competition, peers helping each other among the game-based activities affect the understanding of the subject and the learning process positively. For the third question of interview protocol which was *"Did you have any difficulty during the activities? If yes, what kind of difficulties did you have? Please explain.", s*ix out of 10 students stated that they had difficulties, while 4 of them stated that they did not have any difficulties. With the help of the answers given to this question, the students showed that they had difficulties due to the fact that they had not done such activities before, they were not accustomed to the nature of such activities and the group work that they sometimes required. Some of the reasons for difficulty were that they tried to do the activity without reading the activity instructions and they had difficulty in making joint decisions with their group friends. For the fourth question of interview protocol which was *"Did group work affect your learning? How did it affect? Please explain.",* seven out of 10 students stated that group work

affected their learning , while 3 of them said the opposite of it. From the answers given to this question, it was understood that it affects learning positively because of being able to help each other in the group and having more peer-to-peer communication. For the fifth question of interview protocol which was *"Could you please indicate your comments and suggestions regarding the lessons in which game-based learning activities were used?",* nine out of 10 students stated that their attitudes towards mathematics and opinions related to mathematics changed and game-based learning activities should take place in mathematics lessons. Based on the answers given to this question, it was understood that with the activities implemented in this process, the prejudice that mathematics is boring and difficult has been broke down, and the students' attitudes towards mathematics and opinions related to mathematics have changed in a positive way, with the effect of the lessons that have become more fun and the students being able to make their own decisions more easily.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The purpose of the present study was to investigate the effect of using game-based activities in algebra on seventh-grade students' algebra achievement, their attitude towards mathematics, and their opinions about using game-based activities. In this chapter, firstly, the findings of the study will be discussed, then the implications and recommendations for future studies will be shared.

5.1 Discussion

In this part, the effect of using game-based learning activities will be discussed in terms of mathematics, specifically, algebra achievement, attitude towards mathematics, and students' opinions.

5.1.1 The Effect of Using Game-Based Learning Activities on Mathematics and Algebra Achievement

According to the findings of this study, there was a statistically significant mean difference between the PreAAT and PostAAT. While the mean was 4.72 in the pretest, it was found as 7.53 in the posttest. We can conclude that using game-based learning activities might have played a role in this difference. These findings support the other studies that claimed using hands-on activities in seventh-grade

(e.g., Görgün, 2017) and using game-based instructional techniques in secondary algebra (e.g., Ezeugwu et al., 2016) made a significant difference on students' algebra achievement. In the study of Görgün (2017), algebra was taught by using worksheets that included hands-on activities and some materials in the experimental group of seventh-grade students for 28 class hours. The hands-on materials which were used during the implementation included Brahma Tower, some puzzles, and Tarsia activities. After the implementation of the hands-on activities, the achievement score of the experimental group was higher than the achievement score of the control group in this study. Additionally, in the study of Ezeugwu et al. (2016), the games, such as Algebraic Substitution Attack Game, Algebra Snadder Joint Game, and Number Line Game, were used for the experimental group, and algebra achievement test was implemented before and after using these games. Meanwhile, the traditional method was used in the control group, and the mean difference in achievement test scores in the control group was lower than in the experimental group.

In addition to the studies related to the effect of game-based learning on algebra achievement, many studies investigated the effect of game-based learning on mathematics. In White and McCoy's study (2019), the average of students' assessment scores increased after applying game-based learning. This study was implemented in a standard-level fifth-grade class. The implementation period was 5 school days. During the lessons, some activities such as coordinate path in their Emojilicious Coordinate Story, Dice Game, Mission: Zombies, Connect Four, Finger Twister, and City Planner were used. Moreover, many studies focused on the effect of digital or video games on mathematics achievement. According to the meta-analysis conducted, Tokac et al. (2018), found that mathematics video games were slightly more effective in contributing to mathematics achievement compared with traditional instructional methods by considering 24 studies that compared game-based learning and traditional method in mathematics classes. Additionally,

Kebritchi et al. (2010) showed a significant difference in achievement after using mathematics computer games for 9th and 10th-grade students. Consequently, most of the studies that investigated the effects of game-based learning on achievement showed that using digital or non-digital games made a difference in algebra, and in general, mathematics achievement.

In the present study, students' algebra achievement was analyzed by using the AAT before and after the intervention. For 17 of the 23 items of AAT, the percentage of correctness increased in the posttest compared to the pretest. Therefore, this situation led to a significant mean difference between PreAAT and PostAAT, supporting the positive effect of game-based activities. Although there was a significant mean difference, there were some items that had a lower percentage of correctness in the PostAAT.

When those items are considered, the students were found to have difficulty writing algebraic expressions using words and calculating an algebraic expression for different values of variables. As MacGregor (1997, p. 16) stated, "some students had difficulty distinguishing the object (e.g., the person Con) from a quantity or measure (e.g., Con's height)" since "referring to the difference of objects or measures is not important" in daily life. As in the study of Clement (1982), students were found to read the equation as if 6S stands for 6 students instead of 6 times the number of students could also be a misconception for the students who had difficulty writing the given algebraic expressions in words. I spent a short time (1 lesson hour) on the 6th-grade objectives in the first week of the intervention, which might be increased in future studies.

Additionally, for the item related to multiplication by applying the distributive property, the percentage was 0% in pretest and posttest. The students did not multiply the "–" which was the outside term of the parenthesis, by each of the terms in the parenthesis while multiplying terms. This finding was also evident in

the literature in that “Students began to apply the distributive property correctly, but failed to complete the process. For example, -8(x + 2) may be simplified as -8x +16 instead of -8x – 16” (Barcellos, 2005, p. 12). Moreover, in this item, some students added unlike terms while writing the simplest form of the algebraic expression.

For some items, the percentage of correctness decreased in the posttest compared to the pretest. In one of those items, which is“-15 = 5*x*”, most of the students ignored the influence of negative signs on algebra operations. They also had difficulty solving equations by dividing both sides of the equality by a negative number. Especially, in the item of “4 ×15= *a* × 30”, one of the common difficulties for the students was related to the meaning of the equal sign as stated in the study of Knuth et al. (2006). In this item, the students answered as “4 × 15 = 60 and *a* = 60”. In these items, the difficulty may be that the students did not focus enough on these kinds of algebraic operations. Among the game-based learning activities which are used in the lessons, only Domino was related to equality. Due to the limited number of questions about equality in this game-based learning activity, the students could not have enough experience to focus on “the relational” meaning of the equal sign.

Although for the item “Find the perimeter of an isosceles triangle whose isosceles sides measure (3x - 1) cm and the other side is 7 cm,” there was an increase in the percentage of correctness, the reason of the 0% percentage of correctness in the pretest revealed an important misconception related to algebra. The answers of the students who gave the wrong answer to this item included a misconception about adding unlike terms to each other The students gave answers for this item first adding, (3x-1) +(3x -1) =4x, then 4x +7=11x”. The probable reason for the increase in the percentage of the correctness of other items may be game-based activities that provide knowledge enhancement and development of thinking skills. Some

studies also support the view that games or game-based learning activities lead to increasing achievement (e.g., Erdem et al., 2018; Ezeugwu et al., 2016; Michael, 2016; Rondina et al., 2019). Therefore, mathematics lessons, especially algebra, should be supported by game-based learning to develop algebraic achievement and thinking.

5.1.2 The Effect of Using Game-Based Learning Activities on Attitude Towards Mathematics

According to the present study's findings, there was a statistically significant mean difference between the PreMAS and PostMAS. While the mean was 55.84 in the pretest, it was found as 63.79 in the posttest. This finding suggests that using game-based learning activities might have played a role in attitude changes towards mathematics. Previous studies also had found statistically significant differences in students' attitudes when game-based learning activities were used. For instance, according to Afari et al. (2013), there were significant positive correlations between students' perceptions of the learning environment involving mathematics games and students' enjoyment of mathematics lessons in college-level classes. Moreover, in the study which reviewed 30 Internet math games, Erickson (2015) stated that with the help of carefully selected math games, students' motivation might increase in 6th to 8th-grade levels. White and McCoy (2019), applying game-based learning in a fifth-grade math class, stated that almost all students' comments and reactions became more positive every day. Tural's study (2005), which was implemented with third-grade students in the topic of natural numbers, and Siew et al.'s study (2016), which aimed to examine the effect of an android app, Dragon Box 12+, on attitude towards algebra in eight-grade students also supported the findings of the present study related to the effect of using game-based activities on

attitude towards mathematics in that they found significantly more positive attitudes toward mathematics after the intervention in these studies.

5.1.3 Students' Opinions about Using Game-Based Learning Activities in Mathematics Lessons

After the game-based learning activities, ten students were interviewed to get their detailed opinions. From the interview, it was understood that game-based activities had not been used in mathematics lessons before. Answers to the interview revealed that seventh grade learning activities were effective and helpful to understand the topics. Also, according to the students' opinions, winning awards, earning respect, and competition motivated them to try harder. One of the critical structural elements of digital games defined by Prensky (2001, as cited in Ferguson, 2014) was also conflict and competition, as stated by the students in this study.

Some student opinions related to the group work could be obtained through the third and the fourth interview questions. During the game-based learning activities, the students had some difficulties because of groupmates who did not work together well with the other groupmates or because of reading the instructions in the group. Besides the challenges in the group work, there were some benefits as well. As Johnson et al. (2011) stated, one of the game characteristics is collaboration and socialization with others. These characteristics cannot be ignored in game-based learning activities since these might affect learning, as the students' answers showed. Students' answers about communication and supporting each other in group work might have positively affected their learning. According to responses to the fifth interview question, game-based learning activities added

some fun to mathematics that is believed to be difficult and boring, and these activities helped break down prejudices about mathematics. Also, making an effort and managing their decision-making processes during the game-based learning activities influenced students' opinions about lessons positively. The interview results with fifth-grade students in White and McCoy's study (2019, p. 10) support the positive effect of game-based learning. Some of the answers of these students in this interview were "I am getting so much better at math now", "… I didn't know it was possible, but I understand so much more now." and "This week made math feel like there was no pressure because everyone was having fun while they were learning." Therefore, we can conclude that using game-based learning activities in lessons could change students' negative opinions about mathematics. With the help of changing opinions, students can be more active in lessons, and they may feel more belonging to the class.

5.2 Implications and Recommendations

The results of this study have many implications for researchers, mathematics teachers and preservice mathematics teachers, and teacher educators. After using game-based learning activities in the mathematics lessons, the seventh-grade students in this study were found to have made progress in their algebra achievement and attitudes towards mathematics. Also, the students stated the benefits of game-based learning activities, and their opinions about mathematics by using game-based learning activities in mathematics lessons were changed. Nine out of ten students interviewed indicated that they developed positive thoughts towards mathematics and that they wanted game-based activities to be used in mathematics lessons. Thus, this study corroborated the literature regarding the positive effect of game-based learning activities on mathematics achievement,

attitude, and opinions. These results may encourage other researchers to continue investigating the effects of game-based learning activities. Teachers and researchers may continue to integrate game-based learning activities into mathematics lessons in algebra and other learning areas in different grade levels and investigate their effects. Since this study presents lesson plans that consist of game-based learning activities, researchers or mathematics teachers can benefit from these plans while preparing their own resources or plans. In addition to the teachers and researchers, an opportunity could be given to pre-service teachers to prepare game-based learning lesson plans and activities throughout their teacher education programs. Making the importance of using game-based activities more visible, especially for teacher candidates, would enable game-based learning activities to be used effectively in schools in the future. The suggested course of "Teaching Mathematics through Games" by the Council of Higher Education as an elective course could be an excellent opportunity to help preservice teachers to have an idea and be informed about this teaching method and create a much more effective learning environment for their students in mathematics classrooms.

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APPENDICES

A. Algebra Achievement Test

CEBİR BAŞARI TESTİ

Sevgili Öğrenciler,

Bu testin amacı; cebirsel ifadeler konusuna ilişkin bilgilerinizi ölçmektir. Sizden beklenen aşağıda verilen 6 soruyu cevaplandırmanızdır. Cevaplarınız herhangi bir şekilde not ile değerlendirme amacıyla kullanılmayacaktır. Süreniz 35 dakikadır.

Aşağıdaki soruları cevaplarken işlem adımlarınızı gösteriniz.

1) Bir kırtasiyedeki defterlerin sayısının ‘‘d’’ ile gösterildiği biliniyor. Bu kırtasiyedeki eşyaların sayıları ile ilgili aşağıdaki ifadeler veriliyor;

a) Kitapların sayısı, defterlerin sayısının 2 katı ise, kitap sayısını veren cebirsel ifadeyi yazınız.

b) ‘‘3d’’ şeklindeki cebirsel ifadenin neyi verebilecek bir cebirsel ifade olabileceğini sözel olarak yazınız.

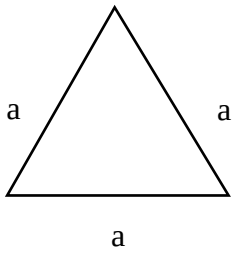
c) Kalemlerin sayısı, defterlerin sayısının 2 katından 3 eksik ise, kalemlerin sayısını veren cebirsel ifadeyi yazınız.

d) Silgilerin sayısı, kalemlerin sayısının 2 katı ise, silgi sayısını veren cebirsel ifadeyi yazınız.

e) Defterlerin sayısı 4 olduğunda silgi sayısının kaç olacağını yazınız.

2) Aşağıda verilen çokgenlerin çevre uzunluklarına karşılık gelen cebirsel ifadeleri önce toplam, sonra çarpım şeklinde yazınız.

a)



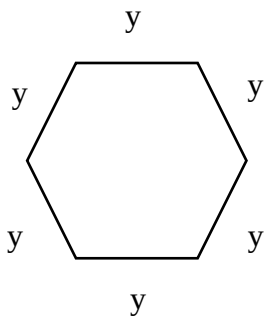
Toplam şeklinde:

…….

Çarpım şeklinde:

…….

b)



Toplam şeklinde:

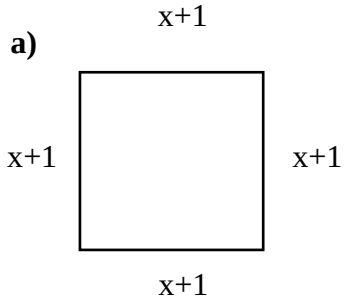
…….

Çarpım şeklinde:

…….

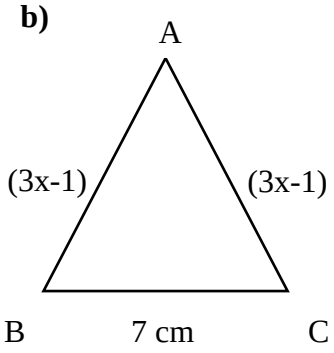
3) Aşağıdaki soruları cevaplayınız.

a)



Şekildeki karenin çevresini belirten cebirsel ifadenin en sade halini yazınız.

b)



Şekildeki ABC ikizkenar üçgeninde

$|AB| = |AC| =$ **(3x-1) cm ve** $|BC| =$ **7 cm olduğuna göre ABC üçgeninin çevresini belirten cebirsel ifadenin en sade halini yazınız.**

4) Aşağıda verilen cebirsel ifadelerin en sade hallerini yazınız.

a) 2(x + 3) =

b) 2x – (6x – 2) =

c) x + 2x – y =

d) 3x + 5 – 4 + 2x

5) n + 15 = 31 eşitliğinin çözümünde n = 8'dir

n + 15 – 9 = 31 – 9 eşitliğinin çözümünde n nedir? Nedenini açıklayınız.

6) Aşağıdaki eşitliklerde bilinmeyen değerleri bulunuz.

a) 4 + □ = 7 + 5 □ = ?

b) 5 – x = 4 x = ?

c) -5 + △ = -6 △ = ?

d) -6 + x = 7 x = ?

e) 10 – 3 = 11 – □ □ = ?

f) -15 = 5x x = ?

g) 4 × 15 = a × 30 a = ?

B. Mathematics Attitude Scale

MATEMATİK DERSİNE YÖNELİK TUTUM ÖLÇEĞİ

Sevgili Öğrenciler,

Bu ölçek sizin matematik dersi ile ilgili düşüncelerinizi öğrenmek için hazırlanmıştır. Cümlelerden hiçbirinin kesin cevabı yoktur. Her cümleyle ilgili görüş, kişiden kişiye değişebilir. Bu sebeple, vereceğiniz cevaplar kendi görüşünüzü yansıtmalıdır. Her cümleyle ilgili görüş belirtirken, öncelikle cümleyi dikkatle okuyunuz. Sonrasında, cümlede belirtilen düşüncelerin, sizin düşüncenize ve duygunuza ne derecede uygun olduğuna karar veriniz. Karar verdiğiniz seçeneği işaretlerken aşağıdaki bilgiye dikkat ediniz.

Tamamen katılıyorsanız; *''Tamamen Uygundur''*

Kısmen katılıyorsanız; *''Uygundur''*

Kararsız iseniz; *''Kararsızım''*

Katılmıyorsanız; *''Uygun Değildir''*

Hiç katılmıyorsanız; *''Hiç Uygun Değidir''*

seçeneğini işaretleyiniz ve seçeneklerden yalnızca birisini işaretlemeye dikkat ediniz.

	Tamamen Uygundur	Uygundur	Kararsızım	Uygun Değildir	Hiç Uygun Değildir
1. Matematik sevdiğim bir derstir.					
2. Matematik dersine girerken büyük sıkıntı duyarım.					
3. Matematik dersi olmasa öğrencilik hayatı daha zevkli olurdu.					

4. Arkadaşlarımla matematik tartışmaktan zevk alırım					
5. Matematiğe ayrılan ders saatlerinin fazla olmasını dilerim.					
6. Matematik dersi çalışırken canım sıkılır.					
7. Matematik dersi benim için angaryadır.					
8. Matematikten hoşlanırım.					
9. Matematik dersinde zaman geçmek bilmez.					
10. Matematik dersi sınavından çekinirim.					
11. Matematik benim için ilgi çekicidir.					
12. Matematik bütün dersler içinde en korktuğum derstir.					
13. Yıllarca matematik okusam bıkmam.					
14. Diğer derslere göre matematiğe daha çok severek çalışırım.					
15. Matematik beni huzursuz eder.					
16. Matematik beni ürkütür.					
17. Matematik dersi eğlenceli bir derstir.					
18. Matematik dersinde neşe duyarım.					
19. Derslerin içinde en sevimsizi matematiktir.					
20. Çalışma zamanımın çoğunu matematiğe ayırmak isterim.					

C. Interview Protocol

UYGULAMA İLE İLGİLİ ÖĞRENCİ GÖRÜŞLERİ

GÖRÜŞME SORULARI

1. Matematik derslerinde daha önce oyun temelli etkinlikler kullandınız mı?

Kullandıysanız, kısaca bahseder misiniz?

2. Oyun temelli etkinlikler konuyu anlamanızda etkili oldu mu? Neden?

3. Etkinlikler sırasında herhangi bir zorlukla karşılaştınız mı?

Yanıtınız evet ise, nasıl bir zorluk yaşadınız? Açıklayınız.

4. Grup çalışmaları öğrenmenizi etkiledi mi?

Nasıl etkiledi? Açıklayınız.

5. Oyun temelli etkinliklerin kullanıldığı derslere ilişkin yorumlarınızı ve önerilerinizi belirtir misiniz?

D. Implementation of the Tests and The Lesson Plans

1.HAFTA - ÖN TEST UYGULAMA

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 50 dakika

Araç-Gereçler: Tutum Ölçeği, Başarı Ölçeği

Öğretim Yöntemleri: Soru-Cevap, Bireysel Çalışma

BAŞLANGIÇ: (5-10 dk)

- Öğretmen, öğrencilere kendisini tanıtır ve öğrencilerin de kendi isimlerini birer isimliğe yazarak derste önlerinde bulundurmalarını rica eder.
- Yapacağı çalışmanın amacından bahseder.
- Öğrencelerin çalışma ile ilgili sorularını(varsa) cevaplar.
- Ek olarak, derslerde ses kayıt cihazı kullanacağını belirtir.
- Öğrencilerin çalışmayla ilgili sözlü onayını alır.
- Yapacağı çalışma öncesi, öğrencilere, iki test uygulayacağını; ancak öğrencilerin bu testler sonucunda herhangi bir şekilde notlandırılmayacaklarını ve bu yüzden endişelenmemelerini belirtir.
- Öncelikle, başarı testini, ardından tutum testini, her bir öğrenci birer tane alacak şekilde dağıtır.
- Öğrencilere, kağıtlara isimlerini yazmalarını hatırlatır.

GELİŞME: (45 dk)

- Öğretmen, dağıtılan başarı testinin cevaplanması için 30 dakika süre verir.
- Bu esnada sınıfta dolaşarak sorusu olan öğrencilerin sorularını cevaplar.
- Verilen sürenin ardından, başarı testlerini toplar ve tutum testlerini dağıtır.
- Tutum testlerinin cevaplanması için 10 dakika süre verir.
- 10 dakika sonra, tutum testlerini toplar.

SON: (1-2 dk)

Öğretmen, testlere katılımlarından dolayı öğrencilere teşekkür eder.

1.HAFTA - DERS PLANI 1

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 30 dakika

Kazanımlar:

M.7.2.1.1. Cebirsel ifadelerle toplama ve çıkarma işlemleri yapar.

Ön Koşul Bilgileri:

- Sözel olarak verilen bir duruma uygun cebirsel ifade ve verilen bir cebirsel ifadeye uygun
  bir durum yazar.
- Cebirsel ifadelerin değerini değişkenin alacağı farklı doğal sayı değerleri için hesaplar.

Araç-Gereçler: Tabu kartları,kum saati, çıkış kartı

Öğretim Yöntemleri: Oyun Temelli Öğrenme

BAŞLANGIÇ: (10 dk)

- Öğretmen, derste, cebirsel ifadelerle toplama ve çıkarma işlemlerini öğreneceklerini; ancak öncesinde, 6. sınıfta öğrendikleri bazı kavramları hatırlamak için kısa bir matematik tabusu oynayacaklarını belirtir ve Tabu oyununu daha önceden bilip bilmediklerini sorar.
- Öğretmen oyun hakkında yönerge verir. Aynı zamanda, yönergeyi tahtaya yansıtır.

Gönüllü öğrenciler tahtaya çağırılarak Tabu kartlarında yer alan kelimeleri, yasaklı kelimeleri kullanmadan anlatmaya çalışırlar.
Her kelime için kum saati kullanılarak süre tutulur. Süre tutma ve yasaklı kelimeleri kontrol etme görevi gönüllü öğrencilere verilebilir. Bu sırada, dinleyici olan öğrencilerin kelime hakkındaki tahminleri alınır.

- Her kelimeden sonra, kelimenin yasaklı kelimelerinin neler olabileceği üzerine konuşulur.

GELİŞME: (15 dk)

- Öğretmen, öğrencilerin geçen yıldan hatırladıkları; cebirsel ifade, katsayı, sabit terim ve değişken gibi kavramların tanımlarına Tabu oyunundaki kelimeleri de hatırlatarak değinir.
  Cebirsel İfade: *En az bir bilinmeyen ve işlem içeren ifadelere cebirsel ifadeler denir.*
  Değişken: *Cebirsel ifadelerde kullanılan ve sayıları temsil eden harflere değişken veya bilinmeyen denir.*
  Katsayı: *Bir cebirsel ifadede bir sayı ile bir veya birden fazla değişkenin çarpımına* ***terim*** *denirken çarpım durumunda bulunan sayıya ise katsayı denir.*
  Sabit Terim: *İçinde değişken bulunmayan terime sabit terim denir. Sabit terim de bir katsayıdır.*
  3x-4y+11 ifadesindeki değişken, katsayı, sabit terim ve katsayılar toplamı üzerine konuşulur.

SON: (1-2 dk)

- Öğretmen, öğrencilerle birlikte öğrenilen konuyu özetler.
- Arkasından, öğrencilerin herhangi bir sorularının olup olmadığını sorar.

DEĞERLENDİRME: (3 dk)

- Konuyla ilgili çıkış kağıdını dağıtarak öğrencilerin karttaki soruyu verilen sürede cevaplamalarını ister.

ÇIKIŞ KARTI

DERS/KONU: Matematik /Cebirsel İfadeler **TARİH:**

ADI SOYADI/NO: **SINIF: 7-**

- **Aşağıda verilen her bir cebirsel ifade için tabloyu doldurunuz.**

Cebirsel İfade	Terim Sayısı	Değişken(ler)	Terim(ler)	Sabit Terim(ler)	Katsayı(lar)
4a + b					
2xy-8y+2					

EK 1

MATEMATİK Sayı İşlem Ders Zor/Sıkıcı Öğretmen Adı	**SAYI** Matematik Rakam Hesap Doğal Sayı Rasyonel Sayı
CEBİRSEL İFADE Bilinmeyen X,Y Değişken Terim İşlem	**DEĞİŞKEN** Bilinmeyen Harf Cebirsel İfade Çarpım X,Y
KATSAYI Bilinmeyen Sayı Cebirsel İfade Çarpım Harf	**SABİT TERİM** Bilinmeyen Sayı Katsayı Sıfır Harfsiz

2. HAFTA - DERS PLANI 2

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 80 dakika

Kazanımlar:

M.7.2.1.1. Cebirsel ifadelerle toplama ve çıkarma işlemleri yapar.

Ön Koşul Bilgileri:

- Sözel olarak verilen bir duruma uygun cebirsel ifade ve verilen bir cebirsel ifadeye uygun bir durum yazar.
- Cebirsel ifadelerin değerini değişkenin alacağı farklı doğal sayı değerleri için hesaplar.

Araç-Gereçler: Cebir karoları, Çalışma Kağıtları, Etkinlik Kağıdı, Flaş Kartlar, Çıkış Kartı

Öğretim Yöntemleri: Oyun Temelli Öğrenme

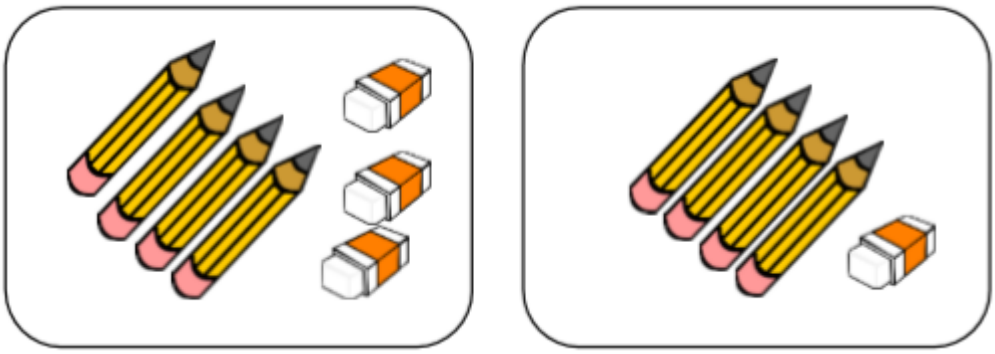
BAŞLANGIÇ:(7-8 dk)

- Öğrenciler yerlerine oturmadan önce, giriş etkinliği olarak bir oturma etkinliği yapar.
- Öğrencileri sıraya geçmeleri için yönlendirir ve her birine üzerinde soru yazan kağıtlar dağıtır.

- Öğrencilerin, ellerindeki kağıtlarda yazan soruların cevaplarının olduğu sıralara oturmalarını ister ve öğrenciler ders boyu yeni sıralarında otururlar.

GELİŞME:(60-65 dk)

- Öğretmen, önceki derste bahsedilen kavramları içeren çalışma kağıdını her öğrenci birer tane alacak şekilde dağıtır.
- Çalışma kağıdındaki iki soru sınıfça cevaplanır.
- Öğretmen, öğrencilerin bu noktaya kadar herhangi bir sorularının olup olmadığını sorar ve tahtaya yansıttığı görsel üzerinden şu soruları yöneltir;



Modellenen kalem kutularda toplam;

- *Kaç tane kurşun kalem vardır?*
- *Kaç tane silgi vardır?*

Kalem kutulardaki;

- *Kurşun kalemlerle silgileri toplayabilir misiniz?*
- *Kurşun kalemlerden silgileri çıkarabilir misiniz? Nedenini açıklayınız.*

- Öğretmen, toplama ve çıkarma işlemini yaparken birbiriyle aynı cins olan(benzer) şeyleri toplayabildiğimizi ve bu nedenle, kalemlerle silgileri toplayıp çıkaramadığımızı açıklar.

- Öğretmen, elindeki cebir karolarını öğrencilere gösterir ve bir cebirsel ifadenin bunlarla nasıl modellenebileceği sorusunu yöneltir.

- Öğrencilerin cevaplarını dinledikten sonra, x'i ve 1'i temsil eden cebir karolarını öğrencilere göstererek 2x+3 ifadesini cebir karolarıyla gösterir.
- Sonrasında, öğrencilere cebir karoları ve etkinlik yönergelerini dağıtarak yönergede verilen etkinliği gerçekleştirmeleri için 7-8 dakika süre verir.
- Verilen sürenin ardından, etkinlikte yer alan sorular üzerine konuşulur ve cebirsel ifadeleri toplarken benzer terimlerin toplanması gerektiği vurgulanır.
- Her bir öğrenci birer tane alacak şekilde yeni bir çalışma kağıdı dağıtarak öğrencilerin çalışma kağıdının ilk sorusundaki modellemeleri yapmalarını söyler. Bu esnada, yan yana oturan öğrencileri birbirlerine yardım etmeleri ve birbirlerinin cevaplarını kontrol etmeleri için yönlendirir.
- Öğrencilere 5 dakika süre verir.
- 5 dakika sonra, yapılan modellemeler üzerine konuşulur.
- Cebir karoları ile yapılan toplama sonucu elde edilen çıkarımları sorar. Beklenen cevaplar şöyledir;(bu cevaplar verilmezse öğrencileri sorularla yönlendirir.)

➢ *Cebirsel ifadelerde toplama işlemi yapılırken;*

1) *Benzer terimler bir araya getirilir(gruplandırılır).*
2) *Bir araya getirilen terimler ortak çarpan parantezine alınarak işlem yapılır.*

➢ *Cebirsel ifadelerde toplama işlemi yapılırken benzer terimlerin katsayıları da sabit terim olarak yazılır.*

(a, b, c ve d tam sayı olmak üzere)

$(ax+b)+(cx+d)=(a+c)x+(b+d)$

$2x+3x-2=5x-2$

$x-2+2x+1=3x-2$

- Öğrencilerin bunu çalışma kağıtlarındaki ilgili yere not etmeleri için süre verir.

- Buradan hareketle, çalışma kağıdındaki 2. ve 3. sorular sınıfça cevaplanır.

2. Soru Beklenen Cevaplar:

a) 5k

b) 3s

c) 5k+3s

d) 5k+3s+2s=5k+5s

3. Soru Beklenen Cevaplar:

- 2a ile 5a, 4b ile -3b
- 9x ile 13x, -y ile -5y
- 3a ile 8a, y ile -24y
- 11 a ile 2a, -7b ile -3b, 5c ile 6c

- Ardından, öğrencilere 3a-5a+12a ifadesinin en sade halinin ne olabileceğini sorar.

Beklenen Cevap: a. (3-5+12)=10a veya a.(3+12)-5.a=15a-5a=10a vb. cevaplar

- Öğrencilerden gelen yanıtların ardından, verilen cebirsel ifadenin en sade halini bulurken benzer terimlerin katsayılarının toplanması gerektiğini tahtada gösterir ve ardından, 2a + 3 – a - 4 cebirsel ifadesinin en sade halini sorar.

Beklenen Cevap: a. (2-1)+(3-4)=a-1

- Öğretmen, öğrencilerin arkasındaki ve yanındaki arkadaşlarıyla 4 kişilik gruplar oluşturmalarını ister ve flaş kartları dağıtır.
- Öğrencilere kartlardaki soruların cevaplarını verilen kağıtlara yazmalarını söyler.
- Kartlardaki soruları cevaplamayı önce ve doğru şekilde tamamlayan grubun kazanan grup olacağını belirtir.(Hepsini doğru yapan grup olmaması halinde, kazanan en çok doğruya sahip olan grup olur.)
- Öğretmen, öğrencilere süre vererek etkinliği başlatır ve bu sırada, sınıfta dolaşarak öğrencilere rehberlik eder.

- Tüm grupların etkinliği tamamlamasının ardından, kartlardaki soruların doğru yanıtları üzerine konuşulur.
- Bu sırada, doğru yanıtlar tahtaya yansıtılır.

SON: (1-2 dk)

- Öğretmen, öğrencilerle birlikte öğrenilen konuyu özetler.
- Arkasından, öğrencilerin herhangi bir sorularının olup olmadığını sorar.

DEĞERLENDİRME: (3 dk)

- Konuyla ilgili çıkış kağıdını dağıtarak öğrencilerin karttaki soruyu verilen sürede cevaplamalarını ister.

ÇIKIŞ KARTI

DERS/KONU: Matematik /Cebirsel İfadeler **TARİH:**

ADI SOYADI/NO: **SINIF: 7-**

Aşağıda verilen soruları cevaplayınız.

- **2x ve 3y ifadeleri toplanabilir mi? Neden?**

- **4x - 5y + 2x + 8y + 7 ifadesinin en sade halini yazınız.**

EK 1

OTURMA ETKİNLİĞİ SORU KARTLARI

2xy-8y+6 ifadesinin sabit terimi	2xy-8y+6 ifadesinin katsayıları	2xy-8y+6 ifadesinin değişkenleri	2xy-8y+6 ifadesinin katsayılar toplamı
a+3w+8z-2c-30 ifadesinin sabit terimi	a+3w+8z-2c-30 ifadesinin katsayıları	a+3w+8z-2c-30 ifadesinin değişkenleri	a+3w+8z-2c-30 ifadesinin katsayılar toplamı
4f ifadesinin sabit terimi	4f ifadesinin katsayıları	4f ifadesinde f=3 olursa, ifadenin değeri	4f ifadesinin terim sayısı
13d+7e+8 ifadesinin sabit terimi	13d+7e+8 ifadesinin katsayıları	13d+7e+8 ifadesinin terim sayısı	13d+7e+8 ifadesinin katsayılar toplamı
k+25l+2m ifadesinde l'nin katsayısı	k+25l+2m ifadesinde katsayılar toplamı	k+25l+2m ifadesinin değişkenleri	3n-5 ifadesinde n=5 olursa, ifadenin değeri

OTURMA ETKİNLİĞİ CEVAP KARTLARI

6	2, -8, 6	xy ve y	0
-30	1, 3, 8, -2, -30	a, w, z ve c	-20
0	4	12	1
8	13, 7, 8	3	12
25	28	k, l ve m	10

EK 2

ÇALIŞMA KAĞIDI

DERS/KONU: Matematik /Cebirsel İfadeler **TARİH:**

ADI SOYADI/NO: **SINIF: 7-**

Aşağıda verilen soruları cevaplayınız.

1) Aşağıda verilen her bir cebirsel ifade için tabloyu doldurunuz.

Cebirsel İfade	Değişken(ler)	Terim(ler)	Sabit Terim(ler)	Katsayı(lar)	Katsayı(lar)Toplamı
3k					
-6xy+1					
2a+5b-8					

2) Aşağıdaki soruları cevaplayınız.

a) ‘‘Bir akvaryumdaki balıkların sayısının 3 katının 7 fazlası’’ ifadesine uygun bir cebirsel ifade yazınız.

b) Balık sayısının 15 olması durumunda, yazdığınız cebirsel ifadenin değerini hesaplayınız.

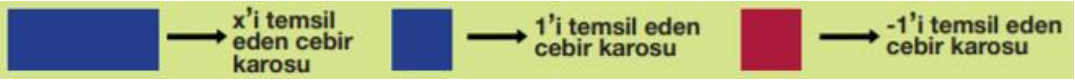
EK 3

ETKİNLİK KAĞIDI

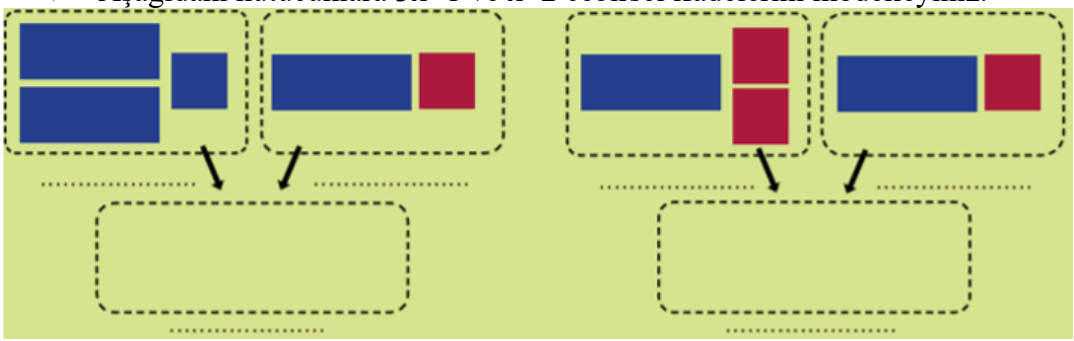
Araç-Gereçler: Cebir karoları

Yönerge:

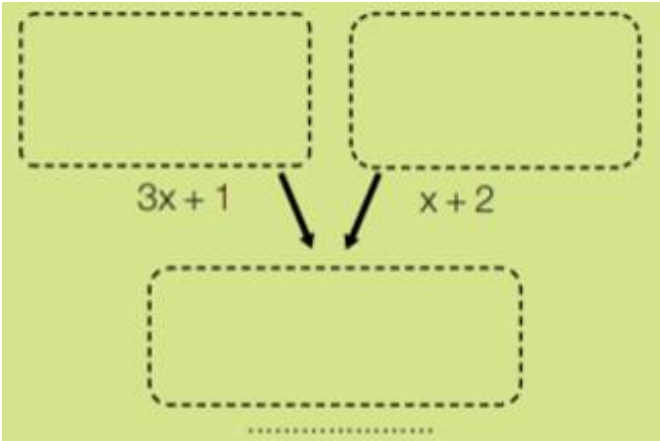
- 4 kişilik gruplar oluşturunuz.
- Gruplar olarak -1, +1 ve x'i temsil eden cebir karolarını alınız.



- Aşağıda cebir karolarıyla modellenen cebirsel ifadeleri belirleyip altlarındaki boşluklara yazınız.
- Belirlediğiniz cebirsel ifadeleri birleştirerek modelleyiniz ve bu birleşimle oluşan modellemeye uygun cebirsel ifadeyi yazınız.
- Aşağıdaki kutucuklara 3x+1 ve x+2 cebirsel ifadelerini modelleyiniz.



- Modellediğiniz cebirsel ifadeleri bir araya getiriniz.
- Bir araya getirdiğiniz cebir karolarına ait cebirsel ifadeyi yazınız.



- Verilen cebirsel ifadeleri birleştirirken dikkat ettiğiniz iki noktayı aşağıdaki boşluklara yazınız.
  - *x'ler bira araya getirilirken …….. toplanır.*
  - *Sabit terimler bir araya getirilirken …….. toplanır.*

(taken from MoNE, 2018)

EK 4

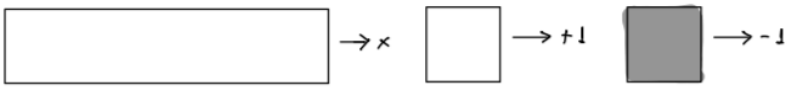
ÇALIŞMA KAĞIDI

DERS/KONU: Matematik /Cebirsel İfadeler **TARİH:**

ADI SOYADI/NO: **SINIF: 7-**

Aşağıdaki soruları cevaplayınız.

1) **Aşağıda verilen işlemleri cebir karoları kullanarak modelleyiniz.**



a) 2x+3+3x-2

b) x-2+2x+1

c) Cebir karolarıyla toplama yaparken nelere dikkat ettiniz? Yaptığınız çıkarımı yazınız.

2) Bir kırtasiyeye giden Burcu beş kalem ve üç silgi alıyor. Bir kalemin fiyatı ‘’k’’ ve bir silginin fiyatı ‘’s’’ lira olduğuna göre;

a) Burcu’nun kalemler için ödeyeceği toplam ücreti belirten cebirsel ifadeyi yazınız.

b) Burcu’nun silgiler için ödeyeceği toplam ücreti belirten cebirsel ifadeyi yazınız.

c) Burcu’nun kalemler ve silgiler için ödeyeceği toplam ücreti belirten cebirsel ifadeyi yazınız.

d) Burcu sonradan iki silgi daha aldığında ödeyeceği toplam ücreti belirten cebirsel ifadeyi belirtiniz.

3) Aşağıdaki tabloda boş bırakılan yerleri uygun şekilde doldurunuz.

CEBİRSEL İFADE	BENZER TERİMLER
$2a + 5a + 4b - 3b$	
$9x + 13x - y - 5y$	
$3a + y - 24y + 8a$	
$11a - 7b + 5c + 2a - 3b + 6c$	

EK 5

FLAŞ KARTLAR

5x - 7x + 3y - y ifadesinin en sade halini yazınız. #1	**4a + 11b - 9b - 8a ifadesinin en sade halini yazınız.** #2
12k - 14k + 7 ifadesinin en sade halini yazınız. #3	**17a + 7b - 45a – 12 - 9b - 4 ifadesinin en sade halini yazınız.** #4
$\left(\frac{x}{2}-9\right)+\left(\frac{5x}{2}-4\right)$ **ifadesinin en sade halini yazınız.** #5	**$2x^2 + 5xy - x^2 + 2xy + 5$ ifadesinin en sade halini yazınız.** #6

3.HAFTA- DERS PLANI 3

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Al anı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 80 dakika

Kazanımlar:

M.7.2.1.1. Cebirsel ifadelerle toplama ve çıkarma işlemleri yapar.

M.7.2.1.2. Bir doğal sayı ile bir cebirsel ifadeyi çarpar.

Ön Koşul Bilgileri:

M.6.2.1.1. Sözel olarak verilen bir duruma uygun cebirsel ifade ve verilen bir cebirsel ifadeye uygun bir durum yazar.

M.2.1.2. Cebirsel ifadelerin değerini değişkenin alacağı farklı doğal sayı değerleri için hesaplar**.**

Araç-Gereçler: Cebir karoları, Çalışma kağıtları, Bingo oyun ve cevap kartları, Plickers

Öğretim Yöntemleri: Oyun Temelli Öğrenim

BAŞLANGIÇ:(7-8 dk.)

- Öğretmen, tahtaya bir fonksiyon makinesi görseli yansıtır. Bu fonksiyon makinesinin verilen cebirsel ifadeleri başka cebirsel ifadelere dönüştürdüğünü ve makinenin boş düğmelerini, soldaki her bir ifadenin sağdakine dönüşmesini sağlayacak şekilde cebirsel ifade veya işlem sembolü ile doldurmalarını söyler.

x+4		2x+5	3x+9
2x-4	+		5x-7
6x-3y-2x	+		4x+2y
13x+6		10x+4	3x+2

- Gönüllü öğrenciler tahtaya gelerek soruları cevaplarken, öğretmen, yerlerindeki öğrencilerin arkadaşlarının verdiği cevabın doğru olduğunu düşünüyorlarsa, gece-gündüz oyununda olduğu gibi başlarını yukarı kaldırmalarını, yanlış olduğunu düşünüyorlarsa başlarını öne eğmelerini ister. Neden doğru neden yanlış olduğunu düşündüklerini açıklamalarını ister.

GELİŞME: (60-65 dk.)

- Fonksiyon makinesi üzerinden bir önceki dersle ilgili yapılan hatırlatmanın ardından, öğretmen, öğrencilere yeni bir çalışma kağıdı dağıtarak ilk soruya göz atmaları için 1-2 dakika süre verir.
- Sürenin ardından, sorunun ilk şıkkını sınıfça cevaplamak için öğrencileri yönlendirir.
- Sorunun b şıkkı için birkaç dakika süre verir ve ardından öğrencilerden cevaplamalarını ister.
- Bu soruda elde edilen cebirsel ifadelerin en sade hallerinin ne olabileceği sorusunu yöneltir.

Beklenen Cevap:

- $(4x+3)-(x+2) = 4x+3-x-2=3x+1$
- $(6x-2)-(x-2)=6x-2-x+2=5x$

- Öğretmen, yönelttiği soru ile ilgili tahminleri aldıktan sonra, *parantezin önündeki ‘‘-’’ işaretinin parantezin içindeki terimlerin üzerine dağılarak işaretlerini değiştirdiğini* vurgular.
- Çalışma kağıdındaki 2. ve 3. sorular sınıfça cevaplanır.
- Öğretmen, öğrencilerin yapılacak etkinlik için 4 kişilik gruplar oluşturmalarını ister.
- BİNGO oyun kartlarını, sorularla eşlenecek olan cevap kartlarını ve öğrencilerin cevapları not edecekleri cevap kağıtlarını her gruba 1 tane gelecek şekilde dağıtır.
- Oyun kartlarındaki soruların tümünü verilen cevap kartlarındaki doğru cevaplarla eşleştirmelerini söyler.
- Cevap kartı sayısının soru kağıdından fazla olduğunu belirtir.
- BİNGO kartının tek bir satırındaki soruların tümünü cevaplandıran grubun ‘‘1. Çinko’’ demesi gerektiğini ve böylece 10 puan kazanacağını, toplam 2 satırı cevaplandıran grubun ‘‘2. Çinko’’ demesi gerektiğini ve böylece 20 puan kazanacağını, toplam 3 satırı cevaplandıran grubun ‘‘3. Çinko’’ demesi gerektiğini ve böylece 30 puan kazanacağını belirtir.
- Tüm eşleştirmeleri bitiren grubun ise BİNGO demesi gerektiğini ve kazanan grup olacağını belirtir.
- Öğretmen, oyun esnasında, yönergeyi tahtaya yansıtır ve sınıfta dolaşarak öğrencilere rehberlik eder.
- Oyun sonrasında, zorlanılan soruların cevapları üzerine konuşulur.

Ardından, öğretmen, öğrencilere yeni bir çalışma kağıdı dağıtır ve çalışma kağıdındaki ilk 3 soru için 7-8 dakika süre verir.

- Bu sırada, öğretmen sınıfta dolaşarak öğrencilere yardımcı olur.
- Verilen sürenin ardından, modellemeler sınıfça tahtada yapılır.

- Öğretmen, öğrencilerin, tahtaya yansıttığı ve bir kenarı (a+5) cm olan eşkenar üçgen şeklindeki trafik levhasının çevresini cebirsel olarak ifade etmelerini ister.

- Verilen cevapların ardından, ‘‘Bu levhanın çevresini bulmak için farklı çözüm yolu var mıdır?’’ diye sorar.

  Beklenen Cevap: $3\cdot(a+5)$ ifadesi 3 tane (a+5) şeklinde okunarak çarpmanın tekrarlı toplama anlamına değinilmiş olunur.

- Cevaplamanın ardından, çalışma kağıdındaki 4. Soruyla devam edilir.

- Öğretmen, öğrencileri, soruyu sınıfça cevaplamak için yönlendirir. Bu sırada, $3\cdot(4+5)$ işleminin nasıl yapıldığı sorusunu yöneltir.

  $3\cdot(4+5)=3\cdot4+3\cdot5=12+15=27$

  Öğretmen, cebirsel ifadelerde *çarpma işlemi yaparken çarpma işleminin toplama işlemi üzerine dağılma özelliğinden yararlanıldığını* belirtir ve *doğal sayı ile cebirsel ifadenin tüm terimlerinin ayrı ayrı çarpıldığını* ekler.

$$a\times(b+c)=a\times b+a\times c$$

‘‘O halde burada nasıl bir işlem yapılmalı?’’der.

Beklenen Cevap:

3.(3a+2) = 3.3a + 3.2 = 9a +6 (Dikdörtgen alanı üzerinden, modelleme ile dağılma özelliği daha anlamlı hale getirilebilir.

- Öğretmen, öğrencileri, çalışma kağıdından ilerlemeleri için yönlendirir ve bir sonraki soru için 5 dk. süre verir.
- 5 dk. sonra, sorular gönüllü öğrenciler tarafından cevaplanır.

SON: (1-2 dk.)

- Öğretmen, öğrencileri, çalışma kağıdından ilerlemeleri için yönlendirir ve bir sonraki soru için 5 dk. süre verir.
- 5 dk. sonra, sorular gönüllü öğrenciler tarafından cevaplanır.

DEĞERLENDİRME: (3 dk)

- Öğretmen, dersin sonunda Plickers uygulaması yardımıyla derste öğrenilenlerle ilgili öğrencilere aşağıdaki soruyu yöneltir.

5x - (x-3) + 2(4 – x) ifadesinin en sade hali hangisidir?

a) 3x+5

b) 3x+11

c) 2x+11

d) 2x+1

Öğretmen, Plickers uygulaması yardımı ile her öğrenci için ayrı bir QR kod oluşturur.
Bu QR kodlar yazıcıdan çıktı alınarak öğrencilere dağıtılır. Sorular tahtaya yansıtılır, öğrenciye zaman verilir ve doğru cevabı QR kodun ilgili kısmını üste getirecek şekilde kaldırması istenir. Öğretmen, kendi mobil cihazından Plickers uygulaması ile kamerasını açarak cevaplara doğru telefonunu yöneltir. Plickers öğrencilerin yanıtlarını tarar ve tahtaya cevap veren öğrenciler listeler.

- Soru için öğrencilere 3 dk. süre verilir ve verilen süre sonunda Plickers kartları ve uygulama yardımıyla hangi öğrencilerin soruya ne yanıt verdiğini gözlemler.

EK 1

ÇALIŞMA KAĞIDI

DERS/KONU: Matematik /Cebirsel İfadeler	**TARİH:**
ADI SOYADI/NO:	**SINIF: 7-**

Aşağıdaki soruları cevaplayınız.

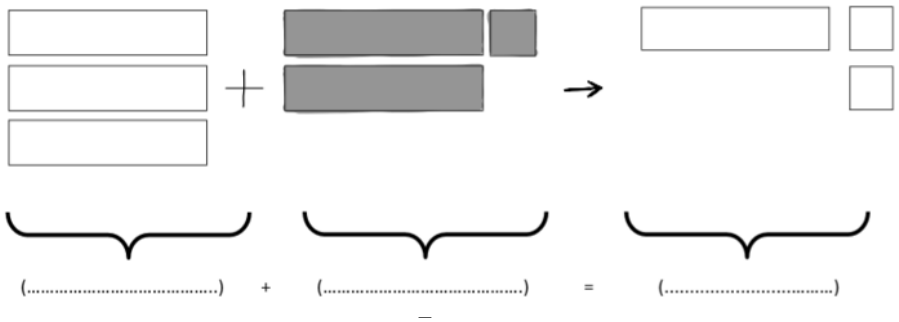
1) Aşağıda verilen işlemleri cebir karoları kullanarak modelleyiniz.

a) (4x+3)-(x+2)

b) (6x-2)-(x-2)

c) Yukarıda verilen cebirsel ifadelerin en sade helleri ne olabilir?

2) Aşağıda modellenen cebirsel ifadeyi yazınız.



3) Aşağıda verilen ifadelerin en sade hallerini yazınız.

a) -7a - (-4a + 5) =

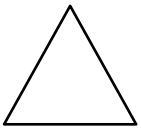
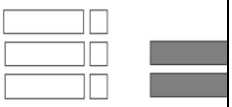
b) (-7x + 7) - (4x + 3) =

c) (5k - 7) - (8k – 3) =

d) $\left(\frac{y}{3}-7\right)-\left(\frac{5y}{3}-5\right)=$

EK 2

BİNGO

 Yukarıdaki bir kenarı ‘‘a’’ birim olan eşkenar üçgenin çevre uzunluğuna karşılık gelen cebirsel ifade 1	2x-1+5 ifadesinin en sade hali 2	3xy’ye benzer bir terim 3	(5k-7)-(3k-4) ifadesinin en sade hali 4
4x’e benzer bir terim 5	 Yukarıdaki bir kenarı ‘‘x’’ birim olan karenin çevre uzunluğuna karşılık gelen cebirsel ifade 6	4k-7k ifadesinin en sade hali 7	 Yukarıdaki şekilde modellenen cebirsel ifadenin en sade hali
(4x-8)+(9x-1) ifadesinin en sade hali 9	7 y^2’ye benzer bir terim 10	(8y+2)-7y ifadesinin en sade hali 11	8a+6b-10a-12+7b+5 ifadesinin en sade hali 12
(3b-7)-(-11b+3) ifadesinin en sade hali 13	n-5n+7n ifadesinin en sade hali 14	(4a-7)-(8a-3) ifadesinin en sade hali 15	(4c+3)-(2c+1) ifadesinin en sade hali 16

CEVAP KARTLARI

a+a+a	3a	2x-4	2x+4
-xy	x+y	2k-11	2k-3
xy	-2x	4x	x^2
-3k	3k	x+1	5x+3

13x-19	13x +3	$-3y^2$	y
y+2	y-2	-2a+13b-7	2a+13b+7

14b-10	-8b-4	3n	13 n
-4a-4	4a+4	2c+2	2c+4

CEVAP KAĞIDI

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

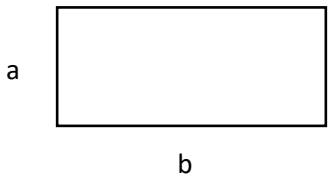
EK 3

ÇALIŞMA KAĞIDI

DERS/KONU: Matematik /Cebirsel İfadeler	**TARİH**
ADI SOYADI/NO:	**SINIF: 7-**

Aşağıdaki soruları cevaplayınız.

1)



Yukarıdaki dikdörtgenin çevre uzunluğunu veren cebirsel ifadeyi yazınız.

2)

3x cebirsel ifadesini cebir karolarıyla modelleyiniz.

3)

4·(x+2) cebirsel ifadesini cebir karolarıyla modelleyiniz.

4) (3a + 2) + (3a + 2) + (3a + 2)işleminin sonucunu bulunuz.

5) Aşağıdaki cebirsel ifadelerin en sade hallerini yazınız.

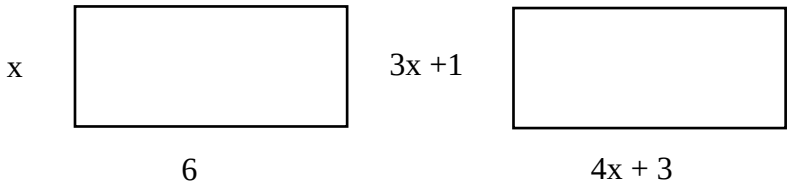
a) 4. (x+7)=

b) 5(3x-7)=

c) $\frac{1}{3}(x+3) =$

d) $\frac{2}{3}\left(\frac{2x}{5} - \frac{5}{3}\right) =$

6) Verilen dikdörtgenlerin çevre uzunluklarını veren cebirsel ifadeleri bulunuz.



4.HAFTA - DERS PLANI 4

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 80 dakika

Kazanımlar:

M.7.2.1.1. Cebirsel ifadelerle toplama ve çıkarma işlemleri yapar.

M.7.2.1.2. Bir doğal sayı ile bir cebirsel ifadeyi çarpar.

M.7.2.2.1. Eşitliğin korunumu ilkesini anlar.

Ön Koşul Bilgileri:

M.6.2.1.1. Sözel olarak verilen bir duruma uygun cebirsel ifade ve verilen bir cebirsel ifadeye uygun bir durum yazar.

M.6.2.1.2. Cebirsel ifadelerin değerini değişkenin alacağı farklı doğal sayı değerleri için hesaplar**.**

Araç-Gereçler: Uno oyun kartları, Domino oyun kartları, çalışma kağıdı, etkinlik kağıdı

Öğretim Yöntemleri: Oyun Temelli Öğrenim

BAŞLANGIÇ: (20 dk)

- Öğretmen, öğrencilere bugün Cebirsel UNO oyunu oynayacaklarını söyler ve daha önce UNO oyunu oynayıp oynamadıklarını sorar.
- Oyunu oynarken de yardımcı olması adına oyun yönergelerini dağıtır.
- Yönergeyi okumaları için 2 dakika süre verir

Oyunun kuralları şöyledir;

- *UNO oyun kartlarıyla sınıf kırmızı, yeşil, sarı ve mavi olmak üzere 4 gruba ayrılır.*

- *Başlangıç olarak alınacak olan değişken x olmak şartıyla, sonrasında, x değişkenini UNO kartları yardımıyla bir işleme sokacaksınız.*
- *Oyun, gruptaki tüm oyuncuların, karıştırılmış ve kapalı bir şekilde duran oyun kartları arasından, sırasıyla birer kart çekmeleriyle ilerler.*
- *Üzerinde rakam olan her kart x'in veya bir önceki kartla elde edilmiş son cebirsel ifadenin, bu kart üzerindeki rakamla çarpılacağı anlamına gelir. (Kartların anlamı değişmediği sürece)*
- *Üzerinde +2 yazan kart, elde edilen en son cebirsel ifadeye 2 ekleneceği anlamına gelir. (Kartın anlamı değişmediği sürece)*
- *Üzerinde ok işareti olan kart ise, kartların anlam değiştireceği anlamına gelir. Yani öncesinde çarpım anlamına gelen kartların artık eklenecek rakamlar haline geldiği, eklenen +2'nin ise çarpılacak bir kart haline geldiği anlamına gelir. Bu kartı çeken sonrasında bir rakam kartı da çekmeli ve çektiği karta göre işlemine devam etmelidir.*
- *θ işaretli kart ise, sonrasında gelecek tüm kartların çıkarma anlamına geleceğini anlatır. Bu kartı çeken sonrasında bir rakam kartı da çekmeli ve çektiği karta göre işlemine devam etmelidir.*
- *Oyun sırasında her gruptan birer yazıcı her aşamada elde edilen cebirsel ifadeyi not eder.*
- *Kartlar bittikten sonra her grup elde ettiği cebirsel ifadeyi paylaşır. Bir kutu içerisini atılmış olan tam sayılar arasından, gönüllü bir öğrenci tarafından sayı çekilir. Çekilen sayı, elde edilen cebirsel ifadelerde x yerine koyulur ve elde ettiği değer en büyük olan grup kazanan olur.*

- *Ardından, öğretmen yönerge maddelerini açıklar ve şöyle bir örnek verir;*
- *Örneğin; önce 3 kartını çektim. Bu x'i 3 ile çarpacağım anlamına gelir. Artık elimdeki cebirsel ifade 3x'tir. Benden sonraki kişi, +2 çekti. Bu, artık, elimdeki ifadenin 3x+2 olduğu anlamına gelir. Sonraki kişi eğer ok işaretine rastlarsa bir kart daha çeker ve bu kez kartlar anlam değiştirir. Diyelim ki çıkan kart 5oldu, artık, 5 ile çarpmak yerine 5 ile toplarım. Ya da +2 çıktığında, artık, 2 ile toplamak yerine çarparım. Biz 5 çıktığını düşünerek devam edersek; ifademimiz 3x+2+5=3x+7 olur. Bundan sonra, 0 işareti gelirse sonraki tüm kartların çıkarma işlemi anlamına geleceğini söyler. Bu kartı çeken bir kart daha çeker. Örneğin 4 geldiyse; ifade 3x+7-4=3x+3 olur. Oyun tüm kartlar bitene kadar devam eder. Kartlar bitince, her grup elde ettiği cebirsel ifadeyi söyler. Örneğin biz en son durumda 6x – 2 elde ederken bir başka grup 5x + 3 elde etti. X yerine koyulacak sayı da 2 olarak çekildi. Bu durumda; 6.2-2=12-2=10 ve 5.2+3=13 değerlerinden dolayı, diğer grubun elde ettiği sonuç daha fazla çıkmış olur.*

<u>GELİŞME: (55 dk)</u>

- Öğretmen, her bir öğrenci birer tane alacak şekilde etkinlik kağıtlarını dağıtır.
- Etkinlik kağıdı üzerindeki sorular üzerine düşünmeleri için öğrencilere 5 dakika süre verir.
- Verilen sürenin ardından, etkinlik kağıdı üzerindeki sorular hakkında, sınıfça fikir yürütülür.

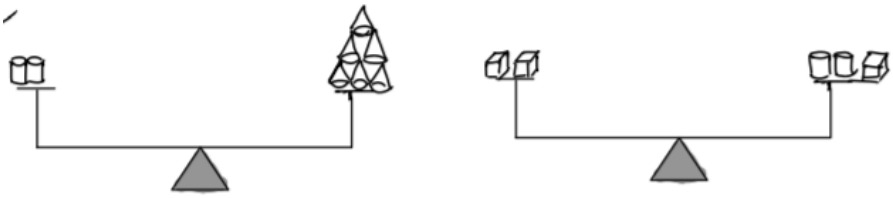
- Öğretmen, öğrencilerin, buradan hareketle hangi çıkarımlarda bulundukları sorusunu yöneltir.

  Beklenen Cevaplar:

- ➢ Eğer dengede bir terazi varsa ve bir tarafına bir şey ilave edilirse, o tarafa doğru eğilecektir. Eğer terazinin her iki tarafından da aynı **ağırlıktaki** nesneyi çıkarırsak hala dengede kalacaktır.
- ➢ Yani, bir eşitliğin; her iki tarafına aynı sayı eklenirse veya her iki tarafından aynı sayı çıkarılırsa eşitlik bozulmaz. Buna **''eşitliğin korunumu''** denir.
- ➢ Eşitliğin korunumu ilkesine göre, bir eşitliğin her iki tarafı aynı sayı ile çarpılırsa veya her iki tarafı aynı sayıya bölünürse eşitlik bozulmaz.
- Eşitliğin korunumu ile ilgili yapılan çıkarımlardan sonra öğretmen, sunum üzerinden aşağıdaki soruları öğrencilere yöneltir.

ÖRNEK 1:

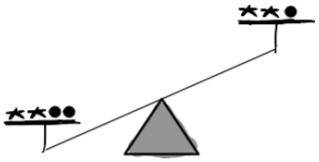
a) Aşağıdaki denge konumunda olan eşit kollu terazideki nesnelerin kütleleri hakkında neler söyleyebilirsiniz?



b) Aşağıdaki terazinin denge durumunda olması için "?" yerine kaç tane koni yerleştirilmelidir?

ÖRNEK 2:

olduğuna göre, yandaki teraziyi nasıl denge durumuna getirebiliriz?



- Soruların sınıfça cevaplanmasının ardından, öğretmen bir eşitliğin her iki tarafında yer alan matematik cümlelerinin (işlem veya cebirsel ifade) değerlerinin eşit olduğunu vurgular.
- Öğretmen, öğrencilere bir çalışma kağıdı dağıtır ve çalışma kağıdındaki ilk soru üzerine düşünmeleri için öğrencilere 2 dakika süre verir.
- Verilen sürenin ardından, soru sınıfça akıl yürüterek cevaplanır.

  Beklenen Cevap:

  N + 6 = 28

  N + 6 -6 = 28 – 6

  N = 28 – 6

  N= 22 kg
- Cevaplamadan sonra, çalışma kağıdındaki 2. soruya geçilir.
- Öğretmen, öğrencilere soru hakkında düşünmeleri için 5 dakika süre verir.
- Soru cevaplandıktan sonra, 3. ve 4. sorular sınıfça düşünülerek cevaplanır.
- Öğretmen, sınıfı 4'er kişilik gruplara ayırır ve domino oyun kartlarını dağıtır.
- Yönergeyi tahtaya yansıtır ve öğrencilere oyunun nasıl oynandığını şu şekilde özetler;
  - *2 parçaya ayrılmış domino kartlarında, kartların her iki tarafında farklı birer eşitliğe ait parçalar verilmiştir. Bu eşitlikleri tamamlayan parçaları uç uca getirerek tüm eşitlikleri tamamlayın ve başladığınız noktaya dönün.*
  - *Domino kartlarını önce ve doğru şekilde tamamlayan grup kazanan grup olacaktır.*

SON: (1-2 dk)

- Öğretmen, öğrencilerle birlikte öğrenilen konuyu özetler.
- Arkasından, öğrencilerin herhangi bir sorularının olup olmadığını sorar.

DEĞERLENDİRME: (3 dk)

- Konuyla ilgili çıkış kağıdını dağıtarak öğrencilerin karttaki soruyu verilen sürede cevaplamalarını ister.

ÇIKIŞ KARTI	
DERS/KONU: Matematik /Cebirsel İfadeler	**TARİH:**
ADI SOYADI/NO:	**SINIF: 7-**
Diyelim ki bugün bir arkadaşınız okula gelmedi ve size derste neler öğrendiğinizi soruyor. Derste öğrendiklerinizi arkadaşınıza nasıl özetlersiniz? Belirtiniz.	

EK 1

UNO OYUNU YÖNERGESİ

Oyunun kuralları şöyledir;

- *UNO oyun kartlarıyla sınıf kırmızı, yeşil, sarı ve mavi olmak üzere 4 gruba ayrılır.*
- *Başlangıç olarak alınacak olan değişken x olmak şartıyla, sonrasında, x değişkenini UNO kartları yardımıyla bir işleme sokacaksınız.*
- *Oyun, gruptaki tüm oyuncuların, karıştırılmış ve kapalı bir şekilde duran oyun kartları arasından, sırasıyla birer kart çekmeleriyle ilerler.*
- *Üzerinde rakam olan her kart x'in veya bir önceki kartla elde edilmiş son cebirsel ifadenin, bu kart üzerindeki rakamla çarpılacağı anlamına gelir. (Kartların anlamı değişmediği sürece)*
- *Üzerinde +2 yazan kart, elde edilen en son cebirsel ifadeye 2 ekleneceği anlamına gelir. (Kartın anlamı değişmediği sürece)*
- *Üzerinde ok işareti olan kart ise, kartların anlam değiştireceği anlamına gelir. Yani öncesinde çarpım anlamına gelen kartların artık eklenecek rakamlar haline geldiği, eklenen +2'nin ise çarpılacak bir kart haline geldiği anlamına gelir. Bu kartı çeken sonrasında bir rakam kartı da çekmeli ve çektiği karta göre işlemine devam etmelidir.*
- *θ işaretli kart ise, sonrasında gelecek tüm kartların çıkarma anlamına geleceğini anlatır. Bu kartı çeken sonrasında bir rakam kartı da çekmeli ve çektiği karta göre işlemine devam etmelidir.*
- *Oyun sırasında her gruptan birer yazıcı her aşamada elde edilen cebirsel ifadeyi not eder.*
- *Kartlar bittikten sonra her grup elde ettiği cebirsel ifadeyi paylaşır.*
- *Bir kutu içerisini atılmış olan tam sayılar arasından, gönüllü bir öğrenci tarafından sayı çekilir. Çekilen sayı, elde edilen cebirsel ifadelerde x yerine koyulur ve elde ettiği değer en büyük olan grup kazanan olur.*

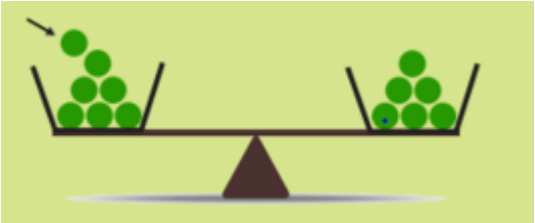
Örneğin; *önce 3 kartını çektim. Bu x'i 3 ile çarpacağım anlamına gelir. Artık elimdeki cebirsel ifade 3x'tir. Benden sonraki kişi, +2 çekti. Bu, artık, elimdeki ifadenin 3x+2 olduğu anlamına gelir. Sonraki kişi eğer ok işaretine rastlarsa bir kart daha çeker ve bu kez kartlar anlam değiştirir. Diyelim ki çıkan kart 5oldu, artık, 5 ile çarpmak yerine 5 ile toplarım. Ya da +2 çıktığında, artık, 2 ile toplamak yerine çarparım. Biz 5 çıktığını düşünerek devam edersek; ifademimiz 3x+2+5=3x+7 olur. Bundan sonra, 0 işareti gelirse sonraki tüm kartların çıkarma işlemi anlamına geleceğini söyler. Bu kartı çeken bir kart daha çeker. Örneğin 4 geldiyse; ifade 3x+7-4=3x+3 olur. Oyun tüm kartlar bitene kadar devam eder. Kartlar bitince, her grup elde ettiği cebirsel ifadeyi söyler. Örneğin biz en son durumda 6x – 2 elde ederken bir başka grup 5x + 3 elde etti. X yerine koyulacak sayı da 2 olarak çekildi. Bu durumda; 6.2-2=12-2=10 ve 5.2+3=13 değerlerinden dolayı, diğer grubun elde ettiği sonuç daha fazla çıkmış olur.*

EK 2

ETKİNLİK KAĞIDI

- 5-6 kişilik tartışma grupları oluşturarak aşağıdaki sorular üzerine yorum yapınız.
- Elinizde bir terazi olduğunu düşününüz ve terazinin her iki kefesine altışar bilye koyunuz.
- Terazinin denge durumu hakkında yorum yapınız.

- Dengedeki teraziler için aşağıdaki sorgulamaları yapınız. Dengedeki terazinin sol kefesine 1 bilye eklenirse denge durumu bozulur mu? Bozulursa ne yapmalısınız?



- Terazinin dengedeki kefelerinin her ikisine de ikişer adet bilye eklediğinizde dengeye dair ne gözlemlersiniz?

- Terazinin dengedeki kefelerinden birer adet bilye aldığınızda denge durumu nasıl olur?

(Taken from MoNE book, 2018)

- Terazinin dengedeki kefelerinin birisinden bir miktar bilye aldığınızda dengenin bozulmaması için ne yapmalısınız. Bu durumla ilgili yaptığınız matematiksel çıkarımı belirtiniz.

- Terazinin her kefesindeki bilye sayısını 2 katına çıkarırsanız denge durumu nasıl değişir? Bu durumla ilgili yaptığınız matematiksel çıkarımı belirtiniz.

- Terazinin kefelerindeki bilyelerin yarısını her iki kefeden alırsanız denge durumu nasıl değişir? Bu durumla ilgili yaptığınız matematiksel çıkarımı belirtiniz.

EK 3

ÇALIŞMA KAĞIDI

DERS/KONU: Matematik /Cebirsel İfadeler	**TARİH:** / /
ADI SOYADI/NO:	**SINIF: 7-**

Aşağıdaki soruları cevaplayınız.

1)

Nehir ve Salih bir tahterevalliye karşılıklı olarak biniyorlar. Nehir yanına kütlesi 6 kg olan bir çanta aldığında, tahterevalli dengeleniyor. Salih'in kütlesi 28 kg olduğuna göre, Nehir'in kütlesinin kaç kg olduğunu eşitlik kullanarak bulunuz.

2) Aşağıdaki eşitliklerde verilmeyen değerler yerine hangi sayıların gelmesi gerektiğini bulunuz. Nedenini tartışınız.

a) △– 23 = 10 ise △ = ?

b) ★+ 25 = 56 ise ★= ?

c) 45 = a × 5 ise a = ?

d) k : 10 = 8 ise k = ?

e) -15 . p = 120 ise p= ?

3) Aşağıda verilen ifadelerin doğru veya yanlış olduğuna karar veriniz.

……. 674 – 389 = 664 - 379

……. 37 + 54 = 38 + 53

……. 5 × 84 = 10 × 42

…..… 64 : 14 = 32 : 28

4) Aşağıdaki eşitliklerde verilmeyen değerler yerine hangi sayıların gelmesi gerektiğini bulunuz. Nedenini tartışınız.

a) 73 + 56 = 71 + $\square$

b) 126 – 37 = $\square$ – 40

c) 20 × 48 = $\square$ × 24

d) 68 + 58 = 57 + 69 + $\square$

EK 4

DOMİNO KARTLARI

x =12	**30 + 7**
25 + 12	**40 – 17**
36 - 13	**44 – 14**
41 - 11	**2 + 11**
11 . 38	**9 + 4**
66 : 3	**22 . 19**

12 - 5	**132 : 6**
50 . 7	**9 – 2**
35 . 10	**30 + 29**
18 + 41	**-9x = 45**
x = -5	**8 + 6 = 5 + x**
x = 9	**-4 + x = 8**

5.HAFTA - DERS PLANI 5

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 40 dakika

Kazanımlar:

M.7.2.1.1. Cebirsel ifadelerle toplama ve çıkarma işlemleri yapar.
M.7.2.1.2. Bir doğal sayı ile bir cebirsel ifadeyi çarpar.
M.7.2.2.1. Eşitliğin korunumu ilkesini anlar.

Ön Koşul Bilgileri:

- Sözel olarak verilen bir duruma uygun cebirsel ifade ve verilen bir cebirsel ifadeye uygun bir durum yazar.
- Cebirsel ifadelerin değerini değişkenin alacağı farklı doğal sayı değerleri için hesaplar.

Araç-Gereçler: Cebir Yolu Oyunu
Öğretim Yöntemleri: Oyun Temelli Öğrenme

BAŞLANGIÇ: (5-10 dk)

- Öğretmen şu ana kadar üzerinde durulan konularla ilgili birkaç sözel ifade belirtir ve belirttiği ifadelerin doğru mu yanlış mı olduğunu öğrencilere sorar.
  - *2a + 3b ifadesinin sabit terimi 3'tür.*
  - *Cebirsel ifadelerde toplama ve çıkarma işlemi yapılırken sabit terimler toplanarak değişkenin katsayısı elde edilir.*
  - *Cebirsel ifadelerde toplama ve çıkarma işlemi yapılırken benzer terimler gruplandırılarak ortak paranteze alınır.*

- *Cebirsel ifadelerde çarpma işlemi yaparken doğal sayı ile cebirsel ifadenin sabit terimi çarpılmaz.*
- *Dengedeki bir terazinin yalnızca bir tarafına ağırlık eklenirse denge bozulmaz.*
- *Eşitliğin korunumu ilkesine göre, bir eşitliğin her iki tarafı aynı sayı ile çarpılırsa veya her iki tarafı aynı sayıya bölünürse eşitlik bozulmaz.*

- Öğrencilerden söylenen ifadenin doğru olduğunu düşünüyorlarsa gece-gündüz oyununda olduğu gibi başlarını yukarı kaldırmalarını, yanlış olduğunu düşünüyorlarsa başlarını öne eğmelerini ister.
- Ardından, söylediği ifadelerin doğruları üzerinden, o ana kadar üzerinde durulan konuları kısaca özetler.

<u>GELİŞME: (30 dk)</u>

- Öğrencilere, şu ana kadar üzerinde durulan konularla ilgili bir Cebir Yolu oyunu oynayacaklarını söyler ve oyunun kurallarını anlatır.

  Oyunun kuralları şöyledir;
  - *Sınıf 5 ya da 6 kişilik gruplara ayrılır.*
  - *Verilen oyun platformu üzerinde oyuncular piyon olarak belirledikleri herhangi bir nesne ile attıkları zarın üzerine gelen sayı kadar ilerler.*

    Eğer piyonları;

    Pembe hücreye gelirse; pembe soru kartlarından,

    Sarı hücreye gelirse sarı soru karlarından,

    Mavi hücreye gelirse mavi soru kartlarından,

    Yeşil hücreye gelirse, yeşil soru kartlarından

    bir tane alıp üzerindeki soruyu yanıtlarlar.
  - *Bu esnada, her gruptan bir gönüllü öğrenci cevap anahtarından soruların cevaplarını kontrol eder.*
  - *Öğrencilerin her soru için 1 dakika süreleri vardır. Cevapların kontrolünden sorumlu kişi süreden de sorumludur.*
  - *Verilen sürede soru cevaplanamazsa, öğrenci, sıra yeniden kendisine geldiğinde piyonunu zar üzerine gelen sayının 1 eksiği kadar ilerletebilir.*

- *Piyon beyaz hücreye gelirse, öğrenci bir sonraki turda zar atıp ilerleyemez.*
- *Oyunda amaç; bitişe önce ulaşmaktır.*

<u>SON: (2-3 dk)</u>

- Öğretmen, 5 haftada öğrenilen konuların neler olduğunu özetler.
- Öğrencilere herhangi bir soruları olup olmadığını sorar.
- Katılımlarından dolayı, öğrencilere teşekkür eder ve bir sonraki derste öğrencilere başarı ve tutum testi uygulanacağını belirtir.

EK 1

CEBİR YOLU OYUNU SORU KARTLARI

Pembe Kartlardaki Sorular:

- $(2x + 3) + (5x -2)$ ifadesinin en sade hali
- $x(5x -10) + (-2x + 7)$ ifadesinin en sade hali
- $(2x -1) + (10 + 3x)$ ifadesinin en sade hali
- $(11x -10) + (12x -20)$ ifadesinin en sade hali
- $(3 x^2 + 5) + (-3x^2 +4)$ ifadesinin en sade hali
- $x + y + 5x - 6y$ ifadesinin en sade hali
- $4x + 8y -3x + 5y + 6x$ ifadesinin en sade hali
- $x + y + z + 2x + -3y + 5z$ ifadesinin en sade hali
- $6x + 7y + 4x +13$ ifadesinin en sade hali

Sarı Kartlardaki Sorular:

- $(3n + 4) – (n -2)$ ifadesinin en sade hali
- $3a – 12a$ ifadesinin en sade hali
- $-10x^2 + 11x^2$ ifadesinin en sade hali
- $2a – 7 – (a – 7)$ ifadesinin en sade hali
- $21 – x – (-x -21)$ ifadesinin en sade hali
- $(-8x + 3) + (-2x – 5)$ ifadesinin en sade hali
- $(4x + 1) – (-x -5) + (2x – 1)$ ifadesinin en sade hali
- $4a – (2a + 1)$ ifadesinin en sade hali
- $(2y + 6) – 4y$ ifadesinin en sade hali

Mavi Kartlardaki Sorular:

- 7(m-8) – 2(m – 2) ifadesinin en sade hali
- 2(x – 4) + 3x ifadesinin en sade hali
- (2x – 6) – 4. (3x -4) ifadesinin en sade hali
- 2/3 (x – 5) – 5/6 (4x -1) ifadesinin en sade hali
- 2. (2x/3 – 5) ifadesinin en sade hali
- Kenar uzunlukları x - 3, x - 3, x - 5 ve 2x + 1 birim olan yamuğun çevresi
- Kenar uzunlukarı 4x + 3 ve 3x + 1 birim olan dikdörtgenin çevresi
- -120 = 5n ise n=?
- -6. (-3x + 1) ifadesinin en sade hali

Yeşil Kartlardaki Sorular:

- Mert'in bugünkü yaşı 5x -1'dir. Mert x + 2 yıl önce emeklemeyi öğrendiğine göre, Mert'in emeklediği yaşı cebirsel olarak ifade ediniz.
- A = x -7 ve B = 2x + 8 olduğuna göre, A+ B toplamının x =3 için değeri
- Arda'nın bugünkü yaşı x + 7'dir. Buna göre, Arda'nın 4x +1 yıl sonraki yaşını cebirsel olarak ifade ediniz.
- Erhan'ın yaşı x + 4'tür. Dedesinin yaşı Erhan'ın yaşının 9 katı ise dedesinin yaşını cebirsel olarak ifade ediniz.
- M= 3x +1, N = 3x ve K = x +2 ise M – N + K ifadesi neye eşittir?
- Bir sınıfta, x + 2 tane öğrenci vardır. Bu öğrencilerin her birinin 3'er tane kurşun kalemi ve 2'şer tane tükenmez kalemi varsa, sınıftaki öğrencilerin toplam kalem sayısını veren cebirsel ifade
- -42 = - 6n ise n =?
- -4 = x + 8 ise x=?
- 4 + x = 5 + 17 ise x = ?

- (2x + 3) + (5x -2)
- x.(5x -10) + (-2x + 7)
- (2x -1) + (10 + 3x)
- (11x -10) + (12x -20)
- (3×2 + 5) + (-3×2 +4)
- x + y + 5x - 6y
- 4x + 8y -3x + 5y + 6x
- x + y + z + 2x + -3y + 5z
- 6x + 7y + 4x +13

- (3n + 4) – (n -2)
- 3a – 12a
- -10x2 + 11x 2
- 2a – 7 – (a – 7)
- 21 – x – (-x -21)
- (-8x + 3) + (-2x – 5)
- (4x + 1) – (-x -5) + (2x – 1)
- 4a – (2a + 1)
- (2y + 6) – 4y

- 7(m-8) – 2(m – 2)
- 2(x – 4) + 3x
- (2x – 6) – 4. (3x -4)
- 2/3 (x – 5) – 5/6 (4x -1)
- 2. (2x/3 – 5)
- Kenar uzunlukları x - 3, x - 3, x - 5 ve 2x + 1 birim olan yamuğun çevresi
- Kenar uzunlukarı 4x + 3 ve 3x + 1 birim olan dikdörtgenin çevresi
- -120 = 5n ise n=?
- -6. (-3x + 1)

- Mert'in bugünkü yaşı 5x -1'dir. Mert x + 2 yıl önce emeklemeyi öğrendiğine göre, Mert'in emeklediği yaşı cebirsel olarak ifade ediniz.
- A = x -7 ve B = 2x + 8 olduğuna göre, A+ B toplamının x =3 için değeri
- Arda'nın bugünkü yaşı x + 7'dir. Buna göre, Arda'nın 4x +1 yıl sonraki yaşını cebirsel olarak ifade ediniz.
- Erhan'ın yaşı x + 4'tür. Dedesinin yaşı Erhan'ın yaşının 9 katı ise dedesinin yaşını cebirsel olarak ifade ediniz.
- M= 3x +1, N = 3x ve K = x +2 ise M – N + K ifadesi neye eşittir?
- Bir sınıfta, x + 2 tane öğrenci vardır. Bu öğrencilerin her birinin 3'er tane kurşun kalemi ve 2'şer tane tükenmez kalemi varsa, sınıftaki öğrencilerin toplam kalem sayısını veren cebirsel ifade
- -42 = - 6n ise n =?
- -4 = x + 8 ise x=?
- 4 + x = 5 + 17 ise x = ?

5.HAFTA - SONTEST UYGULAMA

Ad-Soyad: Zeynep Işılay BAŞKAHYA

Öğrenme Alanı: M.7.2 Cebir

Alt Öğrenme Alanı: M.7.2.1 Cebirsel İfadeler

Sınıf Seviyesi: 7. Sınıf

Süresi: 45 dakika

BAŞLANGIÇ: (2-3 dk)

- Öğretmen, yapacağı çalışma öncesi, öğrencilere uygulamanın ilk haftasında da cevapladıkları iki testi tekrar uygulayacağını söyler ve öğrencilerin bu testler sonucunda herhangi bir şekilde notlandırılmayacaklarını ve bu yüzden endişelenmemeleri gerektiğini yeniden hatırlatır.
  Öncelikle, başarı testini, ardından tutum testini, her bir öğrenci birer tane alacak şekilde dağıtır.
- Öğrencilere, kağıtlara isimlerini yazmalarını hatırlatır.

GELİŞME: (40 dk)

- Öğretmen, dağıtılan başarı testinin cevaplanması için 30 dakika süre verir.
- Bu esnada sınıfta dolaşarak sorusu olan öğrencilerin sorularını cevaplar.
- Verilen sürenin ardından, başarı testlerini toplar ve tutum testlerini dağıtır.
- Tutum testlerinin cevaplanması için 10 dakika süre verir.
- 10 dakika sonra, tutum testlerini toplar.

SON: (1-2 dk)

- Öğretmen, testlere ve 5 hafta boyunca yapılan derslere katılımlarından ve gösterdikleri çabadan dolayı öğrencilere teşekkür eder.

E. Ethical Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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02 Ocak 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Işıl İşler BAYKAL

Danışmanlığını yaptığınız **Zeynep Işılay BAŞKAHYA'nın "Matematik Eğitiminde Oyun Temelli Etkinlik Kullanımının Ortaokul Öğrencilerinin Matematik Başarısı ve Matematik Hakkındaki Görüşleri Üzerine Etkisi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **506 ODTU 2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız

Doç.Dr. Mine MISIRLISOY
Başkan

Prof. Dr. Tolga CAN
Üye

Doç.Dr. Pınar KAYGAN
Üye

Dr. Öğr. Üyesi Ali Emre TURGUT
Üye

Dr. Öğr. Üyesi Şerife SEVINÇ
Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ
Üye

Dr. Öğr. Üyesi Sureyya Özcan KABASAKAL
Üye

F. Permission Obtained From Ministry of Education

T.C.
İSTANBUL VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : E-59090411-44-11484350
Konu : Anket Araştırma İzni

27.08.2020

ORTA DOĞU TEKNİK ÜNİVERSİTESİ REKTÖRLÜĞÜNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : a) 13.02.2020 tarihli ve 183 sayılı yazınız.
b) Valilik Makamının 27.08.2020 tarihli ve 11423524 sayılı oluru.

Üniversiteniz Yüksek Lisans Öğrencisi Zeynep Işılay BAŞKAHYA'nın **"Matematik Eğitiminde Oyun Temelli Etkinlik Kullanımının Ortaokul Öğrencilerinin Matematik Başarısı ve Matematik Hakkındaki Görüşleri Üzerine Etkisi"** konulu tez araştırma çalışması hakkındaki ilgi (a) yazınız ilgi (b) valilik onayı ile uygun görülmüştür.

Bilgilerinizi ve araştırmacının söz konusu talebi; bilimsel amaç dışında kullanmaması, **uygulama sırasında bir örneği müdürlüğümüzde muhafaza edilen mühürlü ve imzalı veri toplama araçlarının kurumlarımıza araştırmacı tarafından ulaştırılarak uygulanılması,** katılımcıların gönüllülük esasına göre seçilmesi, araştırma sonuç raporunun kamuoyuyla paylaşılmaması koşuluyla, gerekli duyurunun araştırmacı tarafından yapılması, okul idarecilerinin denetim, gözetim ve sorumluluğunda, eğitim-öğretimi aksatmayacak şekilde ilgi (b) Valilik Onayı doğrultusunda uygulanması ve işlem bittikten sonra 2 (iki) hafta içinde sonuçtan Müdürlüğümüz Strateji Geliştirme Bölümüne rapor halinde bilgi verilmesini arz ederim.

Murat GÖZÜDOK
İl Milli Eğitim Müdürü a.
Şube Müdürü

Ek:
1- Valilik Onayı
2- Ölçekler

Adres: İstanbul Milli Eğitim Müdürlüğü - Strateji Geliştirme Şb.Md.
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Tel: 0 (212) 384 36 32
Faks: 0 (___) ___ __ __

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G. Parent Approval Form

Veli Onay Formu

Sayın Veliler,

Bu çalışma Orta Doğu Teknik Üniversitesi yüksek lisans öğrencisi Zeynep Işılay Başkahya tarafından Dr. Işıl İşler Baykal danışmanlığında yürütülmektedir.

Bu çalışmanın amacı nedir?: Çalışmanın amacı; matematik eğitiminde oyun tabanlı etkinlik kullanımının ortaokul öğrencilerinin matematik başarısına ve öğrencilerin matematik hakkındaki görüşlerine etkisini incelemektir.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?: Bu amaç doğrultusunda, çocuğunuzdan 5 hafta sürecek olan derslere katılmasını, 5 haftanın başında ve sonunda verilecek olan tutum ve başarı testlerini cevaplamasını isteyeceğiz. Ayrıca dersler esnasındaki cevapları ses kaydı ve yazılı notlar biçiminde toplayacağız. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü olarak katılımıyla ilgili rızası mutlaka alınacaktır.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?: Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla (yayın, konferans sunumu, vb.) kullanılacak, çocuğunuzun ya da sizin isim ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?: Katılım sırasında sorulan sorulardan ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya sorular tamamlanmadan ve derhal son verilecektir.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz: Çalışmaya katılımınızın sonrasında, bu çalışmayla ilgili sorularınız olması halinde sorularınız cevaplandırılacaktır. Çalışma hakkında daha fazla bilgi almak için Orta Doğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi Zeynep Işılay Başkahya ile (e-posta: zbaskahya@gmail.com veya telefon: 0543 899 5528) veya danışmanı Dr. Işıl İşler Baykal (e-posta: iisler@metu.edu.tr veya telefon: 0536 224 5417) ile iletişim kurabilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Yukarıdaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum
(Lütfen alttaki iki seçenekten birini işaretleyiniz.)

Evet onaylıyorum___ ***Hayır, onaylamıyorum___***

Annenin adı-soyadı: _____ Bugünün Tarihi:_____

Çocuğun adı soyadı ve doğum tarihi:_____

(Formu doldurup imzaladıktan sonra araştırmacıya ulaştırınız)