EXAMINING THE PREDICTIVE ROLES OF ALGEBRA LEARNING FIELD ATTITUDE AND MATHEMATICAL LITERACY SELF-EFFICACY ON ALGEBRAIC THINKING OF 8TH GRADE STUDENTS

by

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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 purpose of this study is that examining the predictor roles of 8th grade students' algebra learning field attitude and mathematical literacy self-efficacy on their algebraic thinking. The study was conducted with the participation of 212 students selected by convenience sampling method in a public secondary school in İstanbul. The correlation research was used in this study. Algebraic Thinking Test, Algebra Learning Field Attitude Scale and Mathematical Literacy Self-Efficacy Scale were used as data collection tools. Descriptive Statistics, Correlation and Multiple Regression analyzes were used to analyze the obtained data. According to the results of the analysis, the number of students at Level 0 and 1 was more than the number of students at other levels. The results of the regression analysis ascertained that algebra learning field attitude of students was not significant predictor of their algebraic thinking and mathematic literacy self-efficacy of students was significant predictor of their algebraic thinking. In other words, students' mathematical literacy self-efficacy had an impact on their high or low algebraic thinking levels.

Keywords: Algebraic Thinking, Algebra Learning Field Attitude, Mathematical Literacy Self-Efficacy

ÖZET

Bu araştırmanın amacı, 8.sınıf öğrencilerinin cebir öğrenme alanı tutumu ve matematik okuryazarlığı öz-yeterliklerinin cebirsel düşünmeleri üzerindeki yordayıcı rollerini incelemektir. Araştırma İstanbul'da bir devlet okulunda uygun örnekleme yöntemi ile seçilmiş olan 212 öğrencinin katılımıyla gerçekleştirilmiştir. Bu çalışmada korelasyon araştırması kullanılmıştır. Veri toplama aracı olarak Cebirsel Düşünme Testi, Cebir Öğrenme Alanı Tutum Ölçeği ve Matematik Okuryazarlık Öz-Yeterlik Ölçeği kullanılmıştır. Elde edilen verileri analiz etmek için Betimsel İstatistik, Korelasyon ve Çoklu Regresyon analizleri kullanılmıştır. Analiz sonuçlarına göre seviye 0 ve 1 deki öğrenci sayısı diğer seviyelere göre daha fazlaydı. Regresyon analizi sonucunda öğrencilerin cebir öğrenme alanı tutumunun cebirsel düşünmelerinin anlamlı bir yordayıcısı olmadığı ve öğrencilerin matematik okuryazarlığı öz yeterliklerinin cebirsel düşünmelerinin anlamlı bir yordayıcısı olduğu tespit edilmiştir. Yani öğrencilerin cebirsel düşünmelerinin yüksek veya düşük düzeyde olmasında onların matematik okuryazarlığı öz yeterliğinin etkisi olmuştur.

Anahtar Kelimeler: Cebirsel Düşünme, Cebir Öğrenme Alanı Tutum, Matematik Okuryazarlığı Özyeterlik

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LIST OF ABBREVIATIONS

MEB: Milli Eğitim Bakanlığı (Ministry of National Education)

PISA: Programme for International Student Assessment

TIMSS: Trends in International Mathematics and Science Study

OECD: Organization for Economic Co-operation and Development

ALFA: Algebra Learning Field Attitude

MLSE: Mathematical Literacy Self-Efficacy

ATL: Algebraic Thinking Level

1. INTRODUCTION

1.1. Problem Statement

Considering the routine works and the events, mathematics exists in almost every area of life and is at the core of human thought and logic. The importance of mathematics does not arise only when it is used in everyday life situations such as spending money, using time, cooking, ordering food, it is important in every part of life. Mathematics also has been a key to scientific and technological developments with its contribution to human thinking skills. For example, information about our planet is “in June, the Northern Hemisphere tilts toward the sun, the sun’s rays hit it greater part of the day than in winter. This means it gets more hours of daylight. In December, the Northern Hemisphere tilts away from the sun, with fewer hours of daylight" (National Geographic, n.d.). The mathematical result obtained from the investigation of this information is that “in the Northern Hemisphere, winter generally begins on December 21 or 22 and summer begins on June 20 or 21"(National Geographic, n.d.). In short, mathematics allows people to better understand or interpret information about daily life.

Researchers refer to two types of knowledge in mathematics teaching: Conceptual knowledge and procedural knowledge (Van de Walle, Karp & Bay-Williams, 2013). In conceptual knowledge, “meaning” is important. This meaning is the person's disclosure of new information using their existing information. New information is integrated with existing information and new information is internalized by the person. In procedural knowledge, there are algorithmic procedures that are used to solve mathematical questions. These algorithmic procedures allow people to perform routine mathematical operations without tiring their minds, and thus concentration is provided on more important mathematical relationships. The abundance and easy recall of procedural knowledge depends on how procedural knowledge is supported and articulated with conceptual knowledge. In understanding mathematical knowledge, it is important to integrate conceptual and procedural knowledge (Olkun & Toluk-Uçar, 2014).

Mathematical knowledge has a wide usage area, and mathematical thinking is essential to use mathematical knowledge. Mathematical thinking involves many ways of thinking, and algebraic thinking is one of them. Because algebraic thinking is about investigating the mathematical relationships between numbers, objects, and geometric shapes, and recognizing patterns, it forms the basis of mathematical thinking (Windsor, 2010).

Algebra starts in kindergarten with the practices of recognizing and reproducing simple sequential patterns such as sequences created with geometric shapes. New information is added to these simple patterns at each grade level, and this addition continues throughout high school. Algebra is complex for middle school students because algebra is broader than what was learned in previous years, and at middle school level students study algebra using abstract and symbolic ways.

In algebraic thinking, there are different ways of thinking and understanding symbols. Kaput (2008, as cited in Van de Walle et al., 2013), who studies on algebra, mentioned three branches that support generalization and symbolization.

1. Examination of structures in the number system, that is algebra as generalized arithmetic

2. Examination of patterns, relations, and functions

3. Mathematical modeling process involving meaningful use of symbols

Algebra is not only a separate branch of the mathematics curriculum but is also placed in all fields of mathematics. Therefore, teaching algebra has an important place in school mathematics. At the same time, attitudes also affect the behavior of individuals (Olufemi, 2012). The positive attitude towards algebra in the first grades makes them willing to learn algebra in advanced grades and brings success. In addition, algebra has a wide range of uses in academic life. A positive attitude carried into academic life can lead to more enthusiastic studies.

Algebra appears in many forms in daily life such as tables, patterns, graphs and formulas, and algebra is a tool for defining, understanding, and solving these forms , as well as establishing relationships between these forms, and analyzing these relationships (Kaput, 1999). Understanding algebra and success in algebra are a key for an individual to produce a skilled workforce in the future. Further, being successful in learning algebra requires understanding the meanings of mathematical symbols and basic mathematical concepts (Star, Foegen, Larson, McCallum, Porath, Zbiek, Caronongan, Furgeson, Keating & Lyskawa, 2015).

Understanding and using mathematical notations, and representations matter in the field of mathematics education. The ability to present a concept in various ways by using representations demonstrates a deep understanding of that concept (Yavuz-Mumcu, 2018). With the view that experiencing multiple mathematical representations supports understanding of mathematical concepts, Gagatsis and Elia (2004) examined the effect of multiple representations on mathematical problem solving at different grade levels. As a result of the examination, it was revealed that the use of different representations and problem-solving abilities were related. That is, the ability to construct different forms of representation is a way of mathematical conceptualization. On the other hand, the transformations that can be made between the constructed representations are related to mathematical connections (Yavuz-Mumcu, 2018).

When students embark on productive struggle and make mathematical connections, they develop conceptual understanding (Hiebert & Grouws, 2007). Mathematical connection is the ability of students to associate mathematical concepts with concepts in mathematics and other fields, and with daily life (Menanti, Sinaga & Haratuddin, 2018). The cases of making mathematical connections or using mathematical representation should be evaluated by considering the developmental level, based on information that the use of representation becomes more autonomous as the grade level increases (Gagatsis & Elia, 2004).

Skills such as mathematical connection, mathematical reasoning, interpretation of representation contribute to understanding of algebra. Understanding algebra provides important opportunities for the development of mathematical thinking, reasoning, and problem-solving skills. The concept of literacy is prominent in the acquisition of these skills because the concept of literacy holds knowledges and skills such as making sense of what is happening around, expressing these senses by using different symbols, combining these senses with different meanings, and creating new meanings (Özgen & Kutluca, 2013).

Mathematical literacy includes many abilities such as defining, explaining, formulating, and using these abilities. These abilities comply with the principles and standards required for school mathematics. The focus in mathematical literacy is how the problem is solved, interpreted, analyzed and how it is communicated (OECD, 2013). Students' self-efficacy towards mathematical literacy also allow them to solve, interpret, analyze, and communicate, because self-efficacy is related to individuals' beliefs that will allow them to take action emotionally, cognitively and behaviorally (Wood & Bandura, 1989).

According to all information, mathematical literacy has an important position not only in algebra, which is one of the learning fields of mathematics, but also in all fields of mathematics. This is because mathematical literacy is the ability to utilize mathematical knowledge in the difficulties faced in school, academic and daily life, and in solving these difficulties, to the extent possible (Steen, Turner &Burkhardt, 2007, as cited in Baypınar & Tarım, 2019).

In summary, attitude can affect students' orientation and behavior as well as affect their attitudes towards algebra. Algebra includes understanding and interpreting the algebraic concept, table, pattern, and graph. It takes algebraic thinking to do these. Algebraic thinking also includes process such as understanding algebraic concepts, forming and solving equations by understanding these concepts, reading and creating a graph, exploring and creating a pattern. Understanding, associating, creating, and interpreting used in algebraic thinking is also related to mathematic literacy levels of students. Also, students' self-efficacy towards mathematical literacy can help them to understand, associate, create and interpret, because self-efficacy is related to individuals' cognitive and behavioral action.

1.2. Purpose and Question of Research

The purpose being addressed in this research is that determining 8th grade students' algebraic thinking, algebra learning field attitudes and mathematical literacy self-efficacy, and examining the predictor roles of algebra learning field attitude and mathematical literacy self-efficacy on their algebraic thinking. The question addressed for this purpose is “What is the predictive roles of algebra learning field attitude and mathematical literacy self-efficacy on algebraic thinking of 8th grade students?”

Sub-problem 1: What are the algebraic thinking test score levels of the 8th grade students?

Sub-problem 2: What are the algebra learning field attitude scale score levels of the 8th grade students?

Sub-problem 3: What are the mathematical literacy self-efficacy scale score levels of the 8th grade students?

Sub-problem 4: Is there any relationship between students’ algebra learning field attitude scale scores, mathematical literacy self-efficacy scores and algebraic thinking test scores?

Sub-problem 5: Are students’ algebra learning field attitude and mathematical literacy self-efficacy scores the predictors of their algebraic thinking?

1.3. Importance of Research

In national and international mathematics education programs, algebra education is generally given at the secondary school level, except for limited inferences with some examples in primary school level. The reason for the emphasis on algebra at the secondary school level is that there are generalization abstractions in the structure of algebra. The contents of algebra progress by expanding according to the grade level, and they are given in a spiral manner depending on the grade level. Algebra taught in secondary school is of great importance because the content of algebra learned in secondary school becomes the basis for advanced mathematics subjects (Karaca & Yalçınkaya, 2018).

Since algebra is related to many subjects of mathematics, developing algebraic thinking and related skills has become compulsory. In order to ensure the development of algebraic thinking, it is necessary to increase knowledge and skills in the field of algebra (Kaya & Keşan, 2017). There are variables and relationships in algebraic thinking. Also, some skills are used in expressing variables and relationships mathematically such as using representations, making conversions between these representations, and reasoning that helps to do these (Usta & Gökkurt-Özdemir, 2018). In other words, supporting the development of algebraic skills contributes to the development of many skills besides algebraic skills.

For the development of algebraic skills, algebraic thinking should be supported in the curriculum within the scope of objectives in this field. With this support, there should also be affective domains that can change over time, and one of them is the attitude. The attitude not only reveals the behavior or the emotion, but it also reveals the tendency in the behavior, the emotion, and the thought as a whole (Kağıtçıbaşı, 2005, as cited in Karaca & Yalçınkaya, 2018). With this wholeness, students' attitude towards algebra is not limited to success, but also comprises their thoughts on algebra, their reasoning ability in this field, and their skills such as problem solving. Since algebra includes basic skills in mathematics, behaviors towards these skills may be affected by the attitude formed towards algebra (Karaca & Yalçınkaya, 2018). In addition, the knowledge that the attitude can change over time leads to the conclusion that the change in students' attitude during the education process should be examined (MEB, 2018).

Algebra brings mathematical literacy in its train, in line with special goals of educational approach. Algebra and literacy have a building block role in acquiring basic skills and knowledge in business or daily life (Erbaş, Çetinkaya & Ersoy, 2009).

The concept of mathematics literacy, which is important for all learning fields of mathematics, has been one of the main focal points of PISA (Programme for International Student Assessment) applications (Baypınar & Tarım, 2019). Training mathematics literate individuals also is one of the important goals of education. The Program for International Student Assessment models individuals as problem solvers within the scope of mathematical literacy. With this thought, it engages students in some processes involving some mathematical skills such as formulation that involves applying and using mathematics; using mathematics with the help of mathematical reasoning, procedures, and tools; and mathematical interpretation by considering mathematical solutions and results. These processes can make individuals aware of the role of mathematics in the world, and these also help them make well-founded judgments and decisions by using the function and importance of mathematics (OECD, 2013). PISA also includes questions that require algebraic thinking. That is, the students' mathematical literacy levels are effective when they are dealing with algebra questions. Training mathematics literate individuals can also enable students to deal algebra questions by understanding and interpreting them.

Mathematical literacy and skills have a key position in education, and the progress of affective competency is also important along with these skills. One of the affective competencies associated with behavior is self-efficacy. Self-efficacy differs from individual to individual and from subject to subject, besides, one's self-efficacy for a subject can also change over time. In addition, the individual's self-efficacy for any subject can also affect different areas. Those with strong self-efficacy set challenging goals for themselves and they try to reach their goals by spending more time and effort in case of failure. When faced with difficult tasks, they believe they must be overcome, while those with weak self-efficacy prefer to give up. Individuals’ choices result in increased achievement and performance in strong self-efficacy, while result in decreased motivation and performance in weak. In case individuals evaluate their own performance incorrectly, or are not encouraged to perform a performance, clear information about the beliefs of individuals cannot be obtained, and periodic control is required. In order to obtain accurate results, consistent scales should be used in the evaluation of belief and performance regarding any self-efficacy or affective concept (Pajares, 2003).

In addition to cognitive skills, mathematics curricula also emphasize the development of skills that make mathematics meaningful, such as affective, psychomotor, using representation, and make connections. MEB (2018) under the title of "Issues to be Considered in the Implementation of Mathematics Course Curriculum", It is mentioned that developing positive attitude towards mathematics has an effect on mathematics achievement; connection should be made between mathematics and other courses when appropriate; algebra is an important sub-dimension of mathematical thinking; algebra learning field objectives should be connected with other learning fields objectives of mathematics when appropriate. In addition, the curriculum includes specific goals such as developing mathematical literacy skills and developing a positive attitude towards mathematics with experience. In the 2023 education vision published by MEB, it has been remarked that trainings of awareness and skill will be organized regarding multiple literacy (such as digital, financial, health, ecology, and social media etc.) which are among the 21st century skills, and it has been also remarked that students' qualification levels will be considered.

To sum up, algebraic thinking is used in almost all fields of mathematics to understand and process mathematical concepts, and it contains many mathematical skills. Students' attitudes towards algebraic thinking can affect their involvement and their success in this field. Understanding, interpreting, associating and then expressing in different ways of algebraic representation or problem is related to the literacy level of the individual. Self-efficacy of students toward mathematic literacy is also effective in the stages of understanding, interpreting, associating, and presenting. In this study, student attitude and mathematical literacy self-efficacy, which can affect algebraic thinking affectively were examined.

1.4. Assumptions

It is assumed that students will provide honest and accurate information during the filling the algebra learning field attitude scale, mathematical literacy self-efficacy scale and algebraic thinking test.

1.5. Limitations

The data were obtained from the 8th grade students at school that was selected from Istanbul by convenience sampling. Therefore, the results cannot be generalized to the population.

1.6. Operational Definitions

Algebraic Thinking: It is the level that determined as a result of the answers given by the students to the algebraic thinking test.

Mathematical Literacy Self-Efficacy: It is the score that students got from the mathematical literacy self-efficacy scale that involves 30 items.

Algebra Learning Field Attitude: It is the score that students got from the algebraic learning field attitude scale that includes 28 items.

2. LITERATURE REVIEW

In this chapter, studies on the concepts of algebra, algebraic thinking, mathematical literacy, attitude, and self-efficacy are included.

2.1. Algebra

In algebra, it is emphasized on numbers and operations in the early grades and, in the middle and high school classrooms algebra becomes a major focus (Van de Walle et. al, 2013). Many definitions of algebra, which has a wide-ranging place in teaching, have been made. Taylor Cox (2003, as cited in Acar, 2019) defined algebra as a more generalized form of arithmetic that contains variables and unknowns to solve the problem. Van de Walle et al. (2013) argued that there is a strong connection between algebra and numbers, and that this connection helps students to notice patterns in addition and subtraction as well as multiplication and then generalize these patterns to rules. They called these operations “doing algebra”. In the world order, predicting, analyzing, and concluding are used to make sense of the world, and these require algebra. The mastering the concept of algebra helps to understand the situations occurring in the environment. In algebra, there are situations that involve not only letters and numbers, but also tables, graphs, number relations and properties, and using them. That is, it provides a language to help explain a state by digitizing and to describe changes in a digitized state. In the light of this information, Lacampage (1995) defined algebra as a language of mathematics.

Algebra deals with symbolic expressions beyond the numbers in analyzing relationships in equations, functions, and relations. The mental actions that support these analyzes should be included in algebra courses because these courses include many mathematical actions and concepts that will reveal algebraic thinking. Never forget that the main purpose of algebra is not solving, analyzing, or determining. It is a tool to do these, and it is the way of thinking (Lew, 2004)

Students may experience some problems in algebra learning. Students' difficulties in expressing the symbolic representation of the algebraic verbal representation can be given as an example. Dede & Argün (2003) stated that one of the reasons for students' having difficulty is the structure of algebra, which includes the language and content of algebra. The second reason is the students' mental development and readiness levels. When students fail to move on to the structural dimension of algebra, they are deprived of prior knowledge of algebra such as the concept of equality and variables. Another reason is the deficiencies in algebra teaching. This is because students are not given the opportunity to use the concepts although they have them.

Concepts have also great importance in teaching algebra. For example, the concept of variables is the most basic concept of mathematics that continues throughout the students' education life. Algebra and algebraic thinking are built on the concept of variables. Therefore, where there is algebra and algebraic thinking, there must be the concept of a variable (Akgün, 2019). Concepts are needed to gain knowledge and skills in algebra**.** That increasing knowledge and skills in the field of algebra also enables the development of algebraic thinking skills (Kaya & Keşan, 2017). Many studies show that students have misconceptions about algebra and have difficulty understanding some algebra concepts. Since concepts in mathematics are interconnected, break that may occur while learning concepts cause difficulties in learning future concepts (Yıldırım, 2016)

2.1.1. Teaching and Learning Process of Algebra

There are many concepts in algebra. Any learned concept is adapted to algebra by associating it with a field or content created in the mind. This adaptation is carried out by coding the perceived visuals. In order to understand the algebraic notation, the given expression should be visualized by dividing it into multiple objects (Common Core State Standards Initiative, 2010, as cited in Ottomar & Landy, 2017) and these objects should be categorized according to their mathematical functions. If students use their perceptions to transform expressions, they can identify the structure of the algebraic notation better.

Algebra and algebraic notations, which include important mathematical concepts, are used in many mathematical operations. In the teaching of mathematical concepts, students should be provided with a basis for these concepts at the beginning, and new concepts should be added on this basis. It is suggested that if students are given opportunities to discover and produce their own ideas about mathematical concepts in new environments before the contents are presented, they can create a conceptual basis that facilitates learning (Ottomar & Landy, 2017).

In the meantime, it is possible that after the objects and symbols are completely internalized, students can better apply the rules and formalities specified in the curriculum. For internalization, students need perceptual experiences. Perceptual experiences can be provided with concrete teaching, and students can integrate the concepts that they have obtained through concrete teaching, with the new information they will learn. This integration can help students understand the concepts in the transition from concrete to abstract (Goldstone & Son, 2005; McNeil & Fyfe, 2012, as cited in Ottomar & Landy, 2017). The gradual transition from concrete representations to abstract representations has predicted better achievement and retention than purely abstract or concrete teaching in the fields of science according to Goldstone & Son (2005) and mathematics according to McNeil & Fyfe (2012) (as cited in Ottomar & Landy, 2017).

Every student learns mathematical concepts and information differently. Considering students with different learning styles, instruction should be supported by different methods. In addition, the use of materials not only supports students with different learning styles, but also makes teaching effective**.** Providing students with dynamic and concrete materials that they can explore and then transform them into a more abstract representation using algorithms and symbols, can enable students to identify and focus on basic mathematical structures and properties. Dynamic and concrete materials contribute to students' recognition of algebraic structures and understanding of algebraic transformations by embodying mathematical concepts as moving physical objects (Ottomar & Landy, 2017)

As symbols are transformed, there is constant movement and commutativity. This commutativity is accomplished by physically moving a symbol, such as combining common symbols, factoring them. The student initiates some movement actions and continues by applying algebraic principles. Also, some dynamic applications facilitate learning by allowing to model and move algebraic structures. These applications, which provide quick feedback on errors, can help students be active in algebra learning as well as help them learn by exploring. In this way, it makes conceptual learning effective.

According to Ottomar & Landy's (2017) study, the information presented to students in the form of patterns with little clear perceptual support negatively affects student's conceptual learning. Students prefer to memorize the information presented in the form of patterns rather than learning by understanding. In addition, the expectations from students in exams can also lead students to learn without understanding. The focus of exams in algebra learning is generally on what students know, regardless of students' perceptions. This situation drives students to memorize the rules with counterintuitive notations. In order to obtain substantial learning in algebra courses, algebraic goals and contents as well as activities that will support students' affective domains and motor skills should be taken into account. Supporting students in every learning domain can give them the opportunity to learn with understanding and develop their own learning strategies. That developing students' own strategies in learning algebra, depends on the investigation of possible strategies that are essential in algebra teaching.

In algebra, there are many components and their representations. Students expand these representations with their thoughts by intertwining their pre-existing cognitive and affective processes. At the learning stage, the representations that students form sometimes seem trivial, but such small differences that seem trivial have a significant impact on learning outcomes. Thanks to these differences, it can be understood how students symbolize the knowledge that they comprehend. Ottomar & Landy (2017) have mentioned in their studying that these differences may have gradual effects on learning. To avoid these gradual effects, it is necessary to consider the representations of the students during the learning phase, and if the information that the student comprehends is incorrect, remedial studies are carried out before new information is given.

2.2. Algebraic Thinking

Algebraic thinking covers all mathematics and is essential to make mathematics useful in daily life. Algebraic thinking comprises generated generalizations from experiences, formalizing generated generalizations by using symbol, and discovering the concepts of pattern and functions (Van de Walle et al., 2013).

When the literature is examined, it is possible to see different definitions and studies for algebraic thinking:

In algebraic thinking, students engage in regular roles that are generalized with mathematical relationships and operations. Then, they establish assumptions, discussions, and expressions through these generalizations. In this respect, algebraic thinking skill is one of the high-level mathematical thinking skills (Acar, 2019).

According to Lawrence & Hennessy (2002, as cited in Kaya & Keşan, 2017), algebraic thinking provides the translation of encountered events and learned information into mathematical language, and this helps interpret daily life. With this role, algebraic thinking also contributes to the development of abstract thinking ability required in courses.

Kieran & Chalouh (1993, as cited in Yıldırım, 2016) put assimilating the meaning of symbols and mathematical reasoning at the center of algebraic thinking. According to them, algebraic thinking is the realization of mathematical reasoning in the mind by constructing the meanings of symbols and operations.

Kaya and Keşan (2017) examined the definitions in the literature in their study. As a result of examination, in term of Kaya and Keşan, algebraic thinking refers to establish relationships between algebraic situations by attributing meanings to symbols, revealing idea through multiple representations and different representations, description concrete-semi-concrete and abstract concepts in algebraic relations, and reaching a conclusion through reasoning as reflection of mental activities.

As a result of the literature review, it is understood that algebra has a wider meaning than it expresses, although it is related to algebra (Akkan, 2016, as cited in Oflaz, 2017). Algebraic thinking, which is a special form of mathematical thinking, is among the basic mathematical skills and includes many mathematical skills. In this respect, algebraic thinking skills should be acquired at an early age. For this, it is necessary to use appropriate tools, materials, and methods. Algebra learning, which starts in the early period, can enable middle school and high school algebra learning, which are more abstract, to become more understandable.

2.2.1 Algebraic Thinking and Students

In the study on the development of algebraic thinking by Apsari, Putri, Sariyasa, Abels & Prayitno (2019), stated that students would feel the importance of algebra more in advanced study areas such as their higher education and career. If there is a deficiency in the basis of algebra learning, processes such as problem solving, mathematical proof and analysis can be challenging (Ferryansyah, Widyawati & Rahayu, 2018, as cited in Apsari et al. 2019). This deficiency also creates an obstacle to students' algebraic thinking. Another obstacle in algebraic thinking is the transition from concrete to abstract learning. Since students make a concrete introduction at the beginning of algebra learning, most of them fall into a gap when they move on to abstract learning. This gap which can affect learning and algebraic thinking should be filled before proceeding to advanced classes. When some students encounter a problem in advanced classes, they have difficulty understanding the problem. Because of this difficulty, they cannot move to the stage of modeling, analyzing, and proving a problem, or can make mistakes. In order to avoid students encountering obstacles that may affect students' algebraic thinking in advanced algebra courses, it is necessary to gain the skills of association, working with patterns and generalization, and problem solving in the early algebra classes (Apsari et al., 2019).

According to Eroğlu & Tanışlı (2017), the mind should engage in mental algebra activities in rich relational contexts to develop algebraic thinking. Students can form mental habits through algebraic activities. They dabble in many skills while mental habits are formed. Positive effects of these skills can be observed in not only academic fields but also everyday activities.

The development of algebraic habits includes some components. One of them is the process of doing and undoing. This process is the habit of doing forward and backward analysis. It includes the actions of reading, interpreting and understanding, establishing relationships, and creating representations when faced with a mathematical task. Further, backward analysis does not only cover the process from the completed task to the starting point, but it can also occur while the process is in progress. Building rules, which is one of the other algebraic habit components, involves searching patterns in a problem or a mathematical task, diagnosing, generalizing, and creating rules to represent all operations. Some mathematical operations include algebraic expressions instead of numbers. Students try to abstract these operations by using their thinking skills. This is a habit, and it is called abstraction from computation. Learned information is used in abstraction. The factorization process can be given as an example. While learning the factorization of a quadratic equation, the multiplication process is modeled with area using algebra tiles. In later equations, the process is abstracted without using modeling. As in this learning process, using the ability of generalization and association makes abstraction meaningful (Eroğlu & Tanışlı, 2017).

Eroğlu & Tanışlı, who dealt with algebra habits, conducted research with 7th grade students using numbers. Activities related to the sum of the given numbers were practiced to the students. In the first practice, the students preferred verbal and numerical representations and they were inadequate in searching patterns in numbers. The fact that the students did not use visual representations such as making tables and lists, was stated as a reason for this inadequacy. In the next teaching practice, students were supported to use algebraic expressions and tables. When a total of three teaching practices were examined, it was noticed that the generalizations and ways of thinking that students gained through the practices helped them to integrate easily when they encountered different question types. That is to say, the development of the student's own algebraic habits creates a great foundation for the complex algebra that will be encountered in the future. These habits can be acquired after a long time. In this long process, it is not enough to have rich activities in the classroom environment that include features such as functional thinking, questioning, using multiple representations , but also it should be strong in teacher-student and student-student interaction (Eroğlu & Tanışlı, 2017).

Fyfe, Matthews, Amsel, McEldoon & McNeil (2018) emphasized the meaning of the equal sign in their study on algebra. According to them, knowing that the values on both sides of the equality are the same, is an associational understanding. The understanding of equality includes defining correctly both sides of the equation by recognizing the association inside the equation; creating a strategy while making equalization; and knowing that the quantity on one side of the equation has many equivalents and interchangeable representations. The content of understanding equality is essential in understanding algebraic equations and as well as also in algebraic thinking.

Fyfe et al. (2018) mentioned that children between the ages of 7 and 11 have difficulties in symbolically understanding the equivalence in mathematics, in studies conducted in the United States for many years. It has been said that this situation stems from a cognitive gap between arithmetic and algebra. This gap arises from the incomprehension of the understanding of equality deeply in arithmetic. Students who do not fully adopt the understanding of equality can think of a computational process to fill the given blank, like in arithmetic when they encounter the equation.

Students build their equivalence knowledge in mathematics by constructing them. Rittle-Johnson, Matthews, Taylor & McEldoon (2011) presented this knowledge construction using the level. After a comprehensive review of the literature on students' mathematical equivalence knowledge, they formed 4 levels. At level 1, students perceive the equal sign as a response signal, and they apply the operation-equal sign -response structure. The operation is located on the left side of the equation, and the response is on the right. At level 2, students know that the operations can also be on the right side of the equation, and they also know that there may be structures that do not require operation in the equation. At level 3, they establish relationships between operations on both sides of the equation. At level 4, before operation on the equation they recognize transformations that keep the equation equality, and then they review and compare them.

Some studies which examine the situations affecting algebraic thinking and necessary concepts in algebraic thinking, were mentioned above. In brief, it is stated that individuals who have a deficiency in basic algebra have difficulties when they encounter situations that require algebraic thinking such as analyzing and problem solving in advanced algebra courses and their careers. To overcome this deficiency, it has been mentioned that skills that will improve algebraic thinking should be gained in the early algebra courses. It has also been observed that algebraic mental activities play an important role in the acquisition of these skills. Apart from these skills, some lack of concepts can cause obstacles in understanding algebra and developing algebraic thinking. One of these concepts is the meaning of the expression equality. Knowing the meaning of the equality expression and how to use it, is an important element in understanding algebraic equations and developing algebraic thinking.

2.3. Attitude

Attitude is the reaction of individuals to subjects in the society they live in (Doob, 1947). According to İnceoğlu (2010), attitude is the possible behavior pattern that an individual is expected to exhibit in the face of a situation. The individual's personality traits, social and cultural environment, knowledge, and life experiences are related to possible behavior. A person's attitude towards the idea or situation affects their interpretation of that idea or situation.

Attitudes, beliefs, values, and many things are in the affective field together with emotions. Attitudes that define orientations towards emotions in interaction, can be understandable or changeable over time (Debellis & Goldin, 2006). In this aspect, the attitude takes place in supporting or changing the affective orientation of the students in education and training.

Observations in people's behavior form the concept of attitude, and they have a tendency to affect the person throughout life. Besides, since the attitude is about the things that are made sense of, it has a structure resistant to change (Olufemi, 2012). According to Wood and Wood (1980), attitude consists of three components. The first is the cognitive component, the knowledge of thoughts and beliefs about something like good-bad, right-wrong. The second is the emotional component. It is a feeling created towards something, and it is changeable. The last component is behavior, it focuses on how to behave towards something, and variables such as belief, predisposition can affect behavior (as cited in Olufemi, 2012).

There are many things that have an impact on the formation of attitudes. The main ones are parents, peers, and the media. Operant conditioning in reward-punishment situations, classical conditioning in associating a situation as good or bad, cognitive evaluations in creating logical arguments about a subject, as well as observational learning and persuasion are some situations that have effects on attitude formation (Olufemi, 2012).

Olufemi (2012) mentioned some types of attitudes by taking Jung's definition of attitude:

- Extraversion and introversion attitude; extroverts channel their energies outward, while introverts devote their energies to thoughtful activities.
- The conscious and unconscious attitude; the attitude that is developed intentionally with awareness is considered conscious, while the attitude that develops out of control without is unconscious.
- Implicit and explicit attitudes; there is awareness in explicit attitudes, they are made consciously, they can be directly measured, and they can change over time. Implicit attitudes occur unconsciously, require indirect measurement, and are resistant to change.
- Rational and irrational attitudes; rational is about fitting reasonable emotion and action to an objective value, and it enables individuals to understand that these values are valid. The irrational is not contrary to reason, it signifies beyond reason, and includes perception and intuition.
- Individual and social attitudes are formed towards the object, person, or event as a result of experiences. While the created attitude is accepted in one society, it may not be accepted in another.

Attitude is the psychological feature that defines positive and negative tendencies towards the attitude subject (Toroman & Demir, 2016). The attitude considered in this research is the algebra learning field attitude. This means the attitude formed towards algebra, which is a learning field.

Positive attitudes towards the subject of a learning field have the effect of increasing academic success and performance. Positive attitudes contribute not only to course success and performance but also to career choice. It is important to evaluate students' attitudes, as they may be relevant to students' choice of profession. The attitudes of friends and teachers, whom students consider important to them, can also shape the student's attitude towards both school and a learning field (Lipnevich, Gjicali & Krumm, 2016). Also, emotions such as curiosity, supportive and affectionate approach created at school both increase students' performance in the course and contribute to their development of positive academic attitudes (Akey, 2006).

Getting good grades in a learning field brings commitment to that field. Decreased performance and grades in later times indicate that the attitude has changed (Zhuhadar, Daday, Marklin, Kessler & Helbig, 2019). That is, the success depends on a positive attitude towards learning. Students' desire for learning creates a positive attitude towards their learning. In addition, the culture of the school and extracurricular activities are effective in motivating students and in improving attitudes of students (Valeriu, 2015).

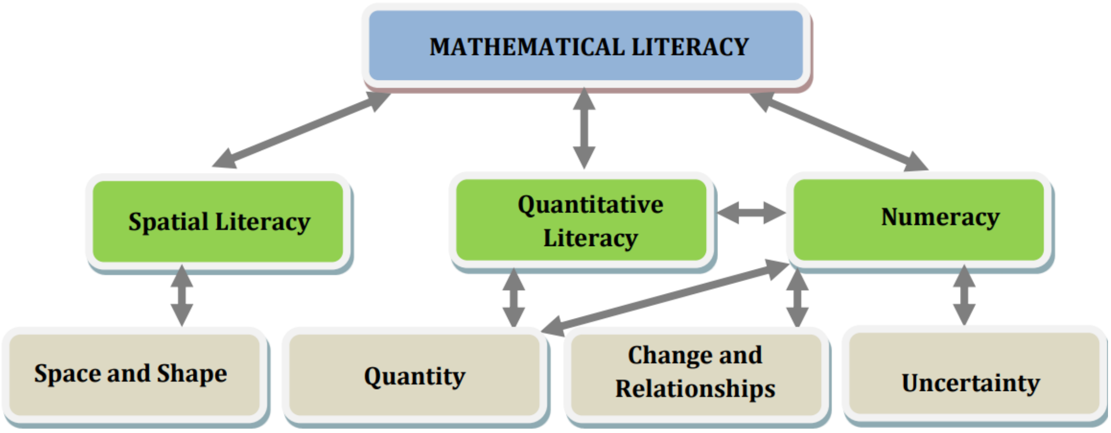
Since the attitude can be affected by everything in the environment, uncertain attitude can be displayed towards the things happening in the environment. Negative factors in the environment take more time from mental time and overshadow the positive attitude. In this way, the attitude is affected negatively, so it may be necessary to be careful with the negative factors. No matter how careful you are, it is not easy to prevent this situation because everything positive or negative is drawn into the mind, albeit unwillingly. The important thing in this regard is to regain the attitude without being stuck with the negativity (McKnight & Chapman, 2010). In the education and training process, the attitude created towards the classroom, the teachers, the courses, and other students will affect the whole process of the student and the teacher. Developing a positive attitude in the education and training process will provide positive feedback both in courses and in daily life.

2.4. Mathematical Literacy

In order to understand the mathematical problem, it is needed to understand the meaning of the words and symbols in the problem and what they represent. At meeting this need, the ability of using mathematical language and reading comprehension are at the forefront. An individual who has the ability of using mathematical language and reading comprehension can also be successful in reading, understanding, and transmitting mathematical information. In order to achieve this success, literacy should be placed at the center of the courses. Students use some representations to conclude the change that can occur in a mathematical relationship. Mathematical literacy is effective in expressing these representations verbally, by creating graphics, using symbols, media, and technology. These representations reflect students' ideas and the way they defend and transmit their ideas. That is related to their mathematical literacy level (Matteson, 2006) .

De Lange (2003) considers mathematical literacy as a dominant literacy over other literacy. In his study, he provides the components of the concept as in Figure 1 for a better understanding of mathematical literacy.

Figure 1 *Components of Mathematical Literacy*



Note. This Figure is from Baypınar & Tarım (2019)

De Lange (2003) has divided the mathematics literacy into three components:

- Spatial literacy (spatial) is concerned with establishing relative positions of objects with their perceived properties, that is the way the individual perceives the world.
- Numeracy is about predicting real-world situations by doing mental processing and evaluating these situations using numbers.
- Quantitative literacy is about understanding certainty, uncertainty, change and the reason for that change in a given situation.

De Lange also presented four mathematical concepts related to these three components:

- Quantity includes numerically representing and making sense of the properties of objects. Also, there is doing mental arithmetic.
- Shape and space include exploring by browsing through the shapes and structures around such as word, writing, music, and architecture, and understanding their relative positions, their different representations,

similarities, and differences. The process of understanding the formation of shadows can be given as an example.

- Change and relationship involve associating observed events with various representations such as symbolic, geometric, algebraic. Organisms that change as they grow, seasonal cycles, and stock market swings can be given as an example for observed events.
- Uncertainty includes collecting and analyzing data, making probability and inference in mathematical events, mathematical concepts, and activities. Instead of certainty, there is making statistics and probability.

These four concepts can be related to one or more of the spatial, numerical, and quantitative literacy components.

In the rapidly developing information age, raising qualified and high-achieving individuals in every sense is among the educational goals of the states (Akyüz & Pala, 2010). These individuals are needed for either developed states to maintain their leadership or to become a developed state (Baypınar & Tarım, 2019). Required qualifications from individuals increase the necessity of being literate individuals. Mathematical literacy is necessary for students to adapt to innovations in the changing world, and it is a concept brought to the literature by PISA, which has been implemented by the OECD since 2000. PISA has many definitions that deal with this concept in different fields. Literacy involves understanding how to use and how to reflect on written texts so that an individual can achieve their goals, develop their knowledge and potential, and participate in society. There are also definitions of this concept in different studies; it is expressed as individual capacity that includes various processes, facts, skills, and basic applications of mathematical tasks at cultural and social levels in daily life (Gülten, 2013)

Mathematical literacy is problem solving and reasoning by using, formulating, and interpreting mathematics. Problem solving and reasoning in this definition is not just knowing mathematical concepts and using them in problems that involve low levels of knowledge and skills. Aforementioned problem solving in literacy enables individuals to make judgments and make decisions in real-world problems, by knowing the role of mathematics in the world and using mathematical knowledge effectively (OECD, 2018).

There are skills that people need to have, in order to qualify as mathematically literate. In general, individuals who can use their mathematics and science skills in real life, who can interpret information by using mathematical and scientific principles and reach conclusions with these interpretations, and who can make logical decisions, are described as mathematically literate (Harms, 2003). Harms (2003) mentions that in order to be literate, it is necessary to have a certain mathematical language, and for this language taking an algebra course and improving geometric reasoning skills are helpful.

Being mathematically literate also includes knowing mathematics. Knowing mathematics covers what individuals can do in case of dealing with a subject. By presenting problems that can be solved in different ways, it can be observed how students use mathematics while dealing with the problem. While creating these problems, it is necessary to consider not only the mathematics subject, but also the competencies of the students. Competencies that include the skills needed in personal, social, academic, and business life, are also among the skills required to raise mathematically literate individuals. Literacy, which is at the center of PISA, includes competences such as using symbols, representations and modeling, making reasoning and argumentation, and communication. Although mathematically literate individuals do not have all the competences fully, they can progress towards improving their shortcomings.

2.5. Self-Efficacy

The concept of self-efficacy is one of the concepts in social cognitive theory, and Bandura was the first to mention this concept. In this theory, self-regulation mechanisms are present. People's belief of their own personal efficacy is one of these mechanisms. Self-efficacy is related to individuals' beliefs that will allow them to take action emotionally, cognitively and behaviorally (Wood & Bandura, 1989). Beliefs are formed by perceived self-efficacy. Bandura (1986) defined perceived self-efficacy as judgments on the ability to perform a specified performance (Shuck, 1989). Perceived self-efficacy is a determinant of expectations that influence behavior choice; however, expectation alone is not enough to explain the behavior. The analysis of expectations and performance is required (Bandura, 1977). The individuals' sense of efficacy can also affect their expectations and performance. Changes in individuals' sense of efficacy depend on their experiences. For example, success through experience strengthens belief in self-efficacy, while failure casts doubt on belief in self-efficacy. İndividuals gain experience by overcoming obstacles, these experiences can provide them with resilience in their efficacies. However, consistently easy success does not ensure resilience because failure after continued success tends to discourage individuals (Wood & Bandura, 1989).

According to Siegle & McCoach (2007), individuals use four resources that depend on self-efficacy in the tasks they encounter. These four sources are as follows

I. individual's past performances

II. indirect performance gained by observing others' experiences

III. verbal persuasion

IV. physiological states

It was stated that teachers who want to raise self-confident students should use the first three resources effectively. There are some examples for the mentioned effective use, asking students to record on the calendar what they learned new, as well as what they did well; encouraging students to try harder by attributing failure to a lack of effort; complimenting students on their own skills by allowing them to see their own progress; making students believe that they can do materials, by stating that peers of students were able to this material.

Each individual's belief in their own abilities differs in a new task. This belief is about efficacy and this sense of efficacy is related to previous experiences. Individuals form clues about what they have accomplished in a task. Using these clues, they evaluate themselves before starting a new task . In this way, the individuals become self-aware, and they can set their own goals for future tasks. There is a positive relationship between individuals who can set their own goals and their self-efficacy (Schunk, 1989).

As an example of this, the clues that students create consciously during the learning phase show what they have learned and what they exhibit. Using these clues, they can evaluate their own self-efficacy, and can change them. Another example of this, social behaviors that occur when interacting with anything in line with the set goals, are related to self-efficacy. In short, the effect of self-efficacy is seen in explaining both cognitive and social skills, and self-efficacy is also one of the predictors of performances and achievements in situations requiring motor skills such as using materials, exercising, doing sports and movements needed for routine tasks.

Mentioned cognitive, social, and motor skills are closely related to education as they are open to learning at school (Schunk, 1989).

Besides skills, the choices that students make consciously or unconsciously are also a part of education. In these choices, there are impacts of some variables such as feeling efficient. When individuals believe that they can adequately perform the tasks required by their academic field or career, they are more likely to choose that academic field or career (Schunk, 1989). As a result, since individuals tend to choose fields that they believe they can achieve and feel confident in, self-efficacy is a predictor in the choice of fields open to self-development such as academic and career. In this respect, self-efficacy is one of the important determinants that positively or negatively affect students' academic achievement.

2.6. Studies Related to Algebra and Literacy

The fact that students are constantly dealing with routine questions may prevent them from moving to more advanced levels. When faced with a non-routine question that has a story, they fall behind in supporting their own ideas by using the mathematical language correctly. This is a deficiency for students. Azizah, Cholily & Cahyono (2019) who observed this deficiency in the students, associated it with literacy. Because literacy is so comprehensive, they have emphasized algebraic literacy and they studied the factors that can affect algebraic literacy. According to them, factors such as students' view and their self-confidence towards algebra, the density and quality of the method used in algebra teaching and the use of educational tools in the classroom, can affect students' algebraic literacy. Because the complex structure can be simplified by concretizing the abstract subjects with the help of the educational tool which makes the lesson more understandable, they focused on the educational tool in their research. As a tool, the comics were handled in their research because they contain the text-visual relation and continuity, and they are also interesting and engaging for students. In implementation, the comics environment based on algebraic literacy was created to improve algebraic literacy. The students both read and portrayed it. At the end of their research, the majority of the students completed the full learning. According to the research of Azizah et al., using comics as an educational tool is effective in algebra courses.

There are many situations in which algebra and literacy become meaningful together in everyday life. The cost of the consumed things can be given as an example of these situations. A certain cost of the things consumed in daily life is determined. In determining this cost, formulas containing linear equations with more than one variable are used. With the help of these formulas, the cost can be found by knowing the amount consumed or the amount consumed can be found by knowing the determined cost. In the equation in this example, the amount consumed can be defined as the input and the cost as the output. Whereas giving an unknown and asking for another unknown is related to algebra, the understanding and interpreting the input, output and the whole of the equation is related to literacy. Mbonambi & Bansilal (2014) examined how students use their mathematical literacy on linear equation questions with two unknowns. It has been observed that most of the students lack the algebraic skill that can make transformations in the equation to find the input when the output is given in the equation. Literate students with insufficient algebraic skills have used different ways such as guessing and testing strategies, using arithmetic procedures, and swapping two variables in the equation. According to the results of the study of Mbonambi & Bansilal (2014), mathematically literate students should be given the opportunity to improve their algebraic skills by allowing them to adapt and use algebraic formulas to different situations, by going beyond simple arithmetic calculations in formulas.

Rusmining, Purwanto & Sumargiyani (2019) examined students' mathematical literacy skills through the topic of linear algebra at different studies. Based on different studies, they concluded that students were active in generating ideas, but they were insufficient to do the mathematical operation part correctly. In their own research , they examined mathematical literacy using a qualitative approach through linear algebra materials. Most students in research had difficulty understanding the problem and formation strategies while solving the problem, and they were lacking in interpreting the problem well. According to the results of their research, including problems that will enable students to discuss and reason, is necessary in students' learning environment in order to carry their literacy skills to higher levels.

In some studies, the results of the common exams that students participated in, were examined with the emphasis on mathematics literacy. It has been presented that some students have difficulty in associating the concept of variables and in simplifying algebraic forms. Based on these results, Angriani, Herman & Nurlaelah (2020) conducted research on students' algebraic literacy skills. Many student errors were encountered in non-routine structured questions that require more thinking and various operations. In student interviews, it was revealed that students with low generalization skills made mistakes in translating the given situations in the problem into mathematical language and transforming them into algebraic form. Moreover, it was observed that students with low algebraic literacy were unable to find arithmetic and algebraic relationships, and interpret the problem, while students with high algebraic literacy have high inference skills. Students with high algebraic literacy tried to find solutions by trying to use different methods, and even if there were errors in their results, they progressed towards reducing their mistakes by realizing them. According to the results of research of Angriani et al. (2020) , it is understood that mathematical literacy comes to the fore when making decisions with constructive and qualified thoughts.

McGee (2019) worked on the application of mathematics literacy to 8th grade algebra students. In this research, vocabulary was highlighted because establishing links using vocabulary while reading the article in a problem, helps generate ideas about the problem and solve it. Vocabulary is also a component of literacy as it enables writing, thinking, explaining, communicating, and connecting them with each other. The application of research which includes mathematical literacy components such as reading, writing, speaking, and listening, encouraged students to use metacognition in the transition from concrete to abstract, communicate and collaborate. After the application of mathematics literacy, an increase was also observed in the algebra success of the students in McGee's research.

In some studies, dealing with algebra and mathematical literacy together, the richness of the classroom environment such as classroom activities, the tools, materials, and strategies used in class, presented the problem or subject, and the communication between students and students came into prominence. In addition, studies have shown that mathematical literacy practices supported in primary school continue to have a positive effect when students pass to secondary school. When both algebra, literacy and the studies conducted together with them are examined, enriching the classroom environment, and managing the classroom well is at the center of the studies.

2.7. Studies Related to Algebra and Self-Efficacy

Affective support of individuals to their potential in any subject takes hold of success. Among this affective support, self-efficacy is one of the supports that affect success. Self-efficacy has a motivating role for the individual to make effort and progress towards success. İndividuals who have high self-efficacy prefer to progress patiently and without giving up while achieving their goals in the organized and planned manner . Low self-efficacy makes the individual anxious, and may hinder individual from achieving success (Çelik, 2019)

Setting goals in learning has often been a priority. Self-efficacy is an important factor in setting a goal and achieving that goal. Individuals with low self-efficacy believe that the choices they make are on the exterior of their personal control, while individuals with high self-efficacy believe that they are in control (Bandura, 2001, as cited in Cheema, 2018). This belief can also have a negative effect on mathematics learning. If students do not receive sufficient and corrective support for the mistakes made in their mathematics course, they may choose to personalize these mistakes or equate it with another inadequacy (National Association of Mathematics Advisers , 2015, as cited in Cheema, 2018). This situation causes students to create a barrier to their own learning.

Self-efficacy may vary according to the desired goal. In order to measure the effectiveness of self-efficacy for a field, it is necessary to use a subject specific to that field or subject that has an impact on the field (Cheema, 2018). Some fields that students have difficulty in learning may be related to their self-efficacy. Some studies on algebra, which is one of these fields, have been examined.

According to Şengül, Kaba and Aydın (2016) , understanding and using symbols in algebra, as well as in interpreting and processing of algebraic equations are based on conceptual knowledge. In their research, they examined the level of self-efficacy by taking students' concept learning in algebraic expressions. As a result of their research, it was concluded that the high level of self-efficacy contributed positively to conceptual learning. In order for self-efficacy to be effective in the success of a particular field, positive thoughts such as "I believe this field is useful, worth the effort" and learning environments that will enable the formation of positive thoughts are needed.

Topçu (2011) shows that the computer-enriched environment used in teaching facilitates the learning of algebra. Allowing students to use software applications in algebra situations such as making changes in expressions by preserving the equivalence in the equation, converting geometric and numerical sequences into equations and modeling, provides benefits for students' learning. With the view that students' self-efficacy is effective in achieving success, Topçu examined the students' self-efficacy by using spreadsheet activities, which is a software application in algebra courses. In his research, it was found that the applied spreadsheet group had higher self-efficacy compared to the group that was not applied. Also, there was an increase in the self-efficacy of the students who performed intermediate in mathematics after the application. It has been considered that the reason for this increase may be derived from students' reliance on the algebra facilitating tool that assists them while solving the questions.

Fast, Lewis, Bryant, Bocan, Cardullo, Retting & Hammond (2010) mention the importance of the learning environment in both algebra and other different fields in terms of self-efficacy. Students' perception of their classroom environment also affects their self-efficacy. Providing emotional and academic support by the teacher to the student, strengthens the teacher-student communication in the classroom. Students who perceive this communication tend to make more effort to learn. This tendency can positively affect self-efficacy and make students likely to be successful. Additionally, students value their learning when they focus on being able to achieve through their own efforts rather than getting good grades. This value given to learning makes the person express themselves and see themselves as sufficient in the learning environment. In the study conducted by Fast et al. (2010), students' mathematics self-efficacy and mathematics performance in the classroom were examined. As a result of their study, they stated that students' self-efficacy would be a meaningful tool in increasing their mathematics test scores. Therewith, it was stated that learning environments should be renewed to increase self-efficacy.

2.8. Studies Related to Algebra and Attitude

Attitude is the tendency of individuals towards themselves, the object, and event. This tendency is based on how individuals associate their experiences, knowledge, emotions, and motives (İnceoğlu, 2010). Many definitions have been made for attitude in different fields, the main common feature of attitudes according to İnceoğlu is that they contain a certain amount of organized mindsets.

In teaching, some subjects may be perceived as incomprehensible, one of these subjects is algebra. There may be many reasons for this incomprehensible. Lee (1996, as cited in Dede & Argün, 2003) likened the reason to cultural shock. The incomprehensibility that occurs during the transition process between branches of mathematics is expressed as shock. The lower grades of mathematics begin with arithmetic. While arithmetic is an old culture for students, as the grade progresses, they experience a cultural shock when they encounter the new culture, algebra.

The wide range of concepts of algebra may be a reason for this shock. For example, in Dede, Yalın & Argün (2002) studies, students confused the concept of variables with some mathematical properties they had learned before. Students accepted some of the operations in arithmetic as variables. In other words, it was stated that students had difficulties in making sense of the concept of variables and in establishing connections with other branches of mathematics. This difficulty may lead students to reduce interest and develop negative attitudes. In addition, this situation may cause them to stay away from that course.

Rather than the individual's feeling of inadequacy due to conceptual intensity or any other reason, the individual's attitude towards the course can be effective in stance against that course. Hannula (2002) evaluated the attitude towards mathematics by dealing with emotions, expectations, and values. While doing this, he prioritized the emotional and cognitive framework that could form the students' attitudes. This framework is made up of four different items.

I. Emotions experienced by the student during math-related activities
II. Emotions that the student naturally associates with concept mathematics
III. Evaluation of states that the student expects to follow as a result of doing math
IV. The value of math-related goals in the overall structure of students

As a result of the research, it has been stated that emotion, value, and expectation, which are handled in four different frameworks, can be used to define the attitude and the change in attitude. In addition, it has been observed that changes can occur in an individual's attitude in a short time.

The attitudes of students can also be affected by the classroom environment they are in. Hayward (2017) created a class with a social constructivist approach to collect information about students' algebraic attitudes and took notes by observing the experiences of the students in the class he created. In his research, he used the framework that Hannula (2002) discussed in four different items to evaluate the attitudes of the students. While the students were dealing with algebra in his created class, students' actions and feelings were evaluated by taking their past experiences with algebra into account. He asked them questions during the activities to see what shaped their attitudes towards algebra. In this way, he examined the reasons why students' difficulties in mathematics, and how they explained and showed them. The care and positive communication he gave to students in the classroom made the students feel safe and welcome in the classroom. This tolerant feeling allowed students to try algebra without fear. According to the results of this research, it was observed that there was a positive increase in the fixed attitudes of the students towards mathematics. It should be noted that the feelings created in the classroom environment are influential in the action phase.

No matter how negative attitudes are formed, these attitudes can change in the learning process. According to Yılmaz (2011) who defines attitude as an individual's predisposition towards any subject in the environment, positive interaction in cognitive, affective, and behavioral fields reveals positive attitude. The positive effects of motivation created at school on learning have been expressed in most studies. Colomeischi and Colomeischi (2015) mentioned in their research that emotional intelligence is also effective in the attitude towards learning mathematics. For more motivation to learn mathematics, it is necessary to organize the school culture in a way that will positively affect the emotional life quality of students. At the same time, in order to overcome the negative attitude, practical and interesting exercises can be used in mathematics courses by combining them with subjects close to daily life (Eurydice, 2011)

3. METHOD

In this chapter, the model of the research, the participants, the data collection tools, the collection process of the data obtained in the research, and the statistical methods used in the solution of this research are mentioned.

3.1. Research Model

The purpose of this study is to investigate the predictive role of algebra learning field attitude and mathematical literacy self-efficacy on 8th grade students’ algebraic thinking. For this purpose, students' algebra learning field attitudes and mathematical literacy self-efficacy will be examined together with their algebraic thinking.

In this study, the correlational research that is one of the quantitative research methods was chosen in order to both investigate the strength of the relationships between students’ algebra learning field attitude, mathematical literacy self-efficacy and algebraic thinking, and to predict the value of a variable with the other variable by analyzing the relationships among these variables.

In correlational research, researchers seek to determine whether a relationship exists between two or more quantitative variables without trying to influence variables (Frankel, Wallen & Hyun, 2012).

3.2. Participants

This research was conducted in the fall semester of the 2021-2022 academic year with the participation of 212 students studying in the 8th grade at Mehmet Akif Ersoy public secondary school, located in Istanbul Arnavutköy district.

The students were selected according to the convenience sampling method, which is one of the non-random sampling methods. In this method, the sample is formed starting from the most accessible participants until reaching a group of the required size. It is also defined as obtaining data from a sample that researchers can easily reached (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2018).

3.3. Data Collection Tools

The data collection tools used in this study to determine the algebraic thinking, algebra learning field attitudes and mathematical literacy self-efficacy of 8th grade students were explained in detail.

3.3.1. Algebraic Thinking Test

The algebraic thinking test (Appendix A) was used in this study to determine the algebraic thinking levels of students. This test was prepared by Altun (2005). While preparing this test, he benefited from the algebra test developed by Hart et al. (1998) and he also considered four consecutive levels determined by Hart et al. They determined these levels, according to the findings of a project conducted by "Concepts in Secondary Mathematics and Science" (CSMS) in England to reveal the students' level of understanding algebraic expressions.

These levels are as follows

Level 1: This is the stage in finding the value of a letter as a result of arithmetic operations, concluding a problem with letters as objects names ,or concluding an operation without valuing the letters.

Level 2: It is the same as the first level in terms of abstraction and it is the stage where the questions are more complex. Students who can reach the second level will be able to solve more complex questions at this level, as they are used to algebraic expressions.

Level 3: It is the stage where letters are perceived and can be used as an unknown. Since the letters represent an unknown, a student who understands them as an object name cannot reach the correct result at this stage.

Level 4: It is the same as the third level in terms of abstraction, but the questions are more complex. Complex expressions are attributed meanings, and the operations are concluded. Letters perceived as unknowns are used in operations by knowing that a letter can represent more than one number (Altun, 2005).

There are 20 questions in the test. Some of the questions consist of sub-items, therefore there are 28 items in total in the test. The 1st, 2nd and 3rd questions of this test are at Level 1; the questions 4, 5 and 6 are at Level 2; the questions 7, 8, 9, 10, 11 and 12 are at Level 3 and the remaining questions are at Level 4.

In determining the distribution of students' algebraic thinking levels, first approximately two-thirds of the questions at the relevant level must be answered correctly. Then, considering that algebraic thinking levels have an ordered structure, the student is required to be successful in previous levels in order to pass the next level. In addition, the algebraic thinking level of students who cannot answer a sufficient number of questions correctly at the 1st level is accepted as Level 0 (Yaprak-Ceyhan, 2012). In Table 1, the items in the algebraic thinking test and the correct numbers to be answered at the relevant level are given.

Table 1

Items of Algebraic Thinking Test and the Correct Numbers to be Answered at the Relevant Level

Level	Item	Item Number	Required Correct Numbers
Level 1	1i, 1ii, 2i, 2ii, 2iii, 3	6	4 and more
Level 2	4i, 4ii, 4iii, 5i, 5ii, 5iii, 6	7	5 and more
Level 3	7, 8, 9, 10, 11, 12	6	4 and more
Level 4	13, 14, 15, 16, 17, 18, 19i, 19ii, 20	9	6 and more
Total		**28**	

Cronbach alpha was used for reliability analysis. As a result of this analysis, the reliability coefficient was .93, this value shows that it is reliable (George & Mallery, 2018). Factor analysis was used for validity analysis. As a result of factor analysis, the Kaiser Meyer Olkin value was .91, it is a marvelous value (George &Mallery, 2018). Bartlett's test of sphericity value was χ^2 (378) = 2812.17 , $p < .001$. These values indicate that the test is acceptable for factor analysis (George & Mallery, 2018). The test consisted of six factors with eigenvalues greater than one. These factors explained 61% of the total variance. According to the factor analysis results, the test was valid (Field, 2009). Independent sample t-test was used to determine whether the scale distinguishes 27% upper-level students and 27% lower-level students. As a result of the t- test, it was seen that there was a significant difference between the students at the lower and upper levels, $t(73) = 27.19$, $p < .001$. This result shows that an algebraic thinking test can distinguish between students with a high level of algebraic thinking and students with low levels of algebraic thinking

3.3.2. Algebra Learning Field Attitude Scale

Secondary school algebra learning field attitude scale (Appendix B) was developed by Karaca & Yalçınkaya (2018). Algebra is a learning field. This scale measures the attitude towards algebra, which is a learning field.

The scale includes 4 factors and 28 items, some of them are negative. These factors are interest dimension, behavioral dimension, emotion dimension, and anxiety dimension. Interest dimension items reflect students' positive or negative interests in algebra. The items in the behavior dimension reflect the tendency of students towards algebra questions. Emotion dimension reflects the effect of algebra on students and students' affective approach to algebra. The anxiety dimension has a content that will determine students' anxiety towards algebra.

The scale has a 5-point Likert type rating. Positive items are evaluated as 5 points= Totally Agree ─ 1 point= Never Agree, while negative items are assessed as 5 points = Never Agree ─ 1point = Totally Agree. The scores of the scale vary between 28 and 140.

The Cronbach alpha value of the scale was found to be .90. Cronbach alpha values were found at the desired level in the reliability analysis made for the sub-dimensions of scale. Cronbach alpha values obtained show that the reliability of the scale is high. As a result of the validity analysis, it was determined that 26^{th}, 27th, and 28^{th} items in the scale did not have a distinguishing feature. However, with the expert opinion, it was decided that it would be more appropriate to keep the items in the scale. In addition, according to the result of factor analysis, these items contribute to the reliability of the scale as they ensure the homogeneity of the scale.

Within the scope of the confirmatory factor analysis, the chi-square/degree of freedom value was found to be 1.83, which indicates that the model has a perfect fit (Karaca & Yalçınkaya, 2018).

The Cronbach alpha value of the scale was high (.88), and it shows that the dimensions of this scale support each other. In this study, the four dimensions of the scale were considered as a whole.

3.3.3. Mathematical Literacy Self-Efficacy Scale

Mathematical literacy self-efficacy Scale (Appendix C) for middle school was developed by Baypınar & Tarım (2019).

The scale includes 4 factors and 30 items, 6 of them are negative. These factors respectively are determined as the Mathematical Skill Dimension, Personal Experience Dimension, Social Context Dimension and Scientific Modeling Dimension. Whereas the mathematical skills dimension includes items that measure the individual's perception of self-efficacy towards mathematical skills, the personal experience dimension includes items that measure the personal self-efficacy perceptions obtained through experiences when applying the mathematical skills. Likewise, in the social context dimension, there are items that measure the perceptions of self-efficacy acquired from performing mathematical operations in everyday life, while in the scientific modeling dimension there are items that measure the self-efficacy perception obtained from building and interpreting scientific models. The scale has a 5-point Likert type rating. Positive items are evaluated as 5 points= Totally Agree ─ 1 point= Never Agree, while negative items are assessed as 5 points = Never Agree ─ 1point = Totally Agree. The scores of the scale vary between 30 and

150. The high score of the student indicates that the self-efficacy perception is high. All the same, a low score indicates a low perception of self-efficacy.

In the development of the measurement tool, five steps stated by DeVellis (2016) were followed. These steps are the generating item pool, ensuring the content validity, ensuring the construct validity, the reliability calculations, and the finalizing of the scale (as cited in Baypınar & Tarım, 2019). The contents of these steps are summarized as follows

- **Generating Item Pool**
  - Literature survey
  - 60 item pool
- **Content Validity and Application**
  - Review by 3 subject matter expert and 3 Turkish Linguistic experts
  - Conducting pilot application with regard the comprehensibility
- **Construct Validity**
  - Exploratory Factor Analysis
  - Confirmatory Factor Analysis
- **Reliability Calculations**
  - Cronbach's alpha reliability coefficient
  - Comparison of upper and lower 27% group mean scores
- **Final Version of the Scale**
  - The scale with 4 factors and 30 items

As a result of confirmatory factor analysis, the structural fit of the scale is significant. The chi-square/degree of freedom value is 2.23, and the goodness of fit indices show an acceptable level of fit.

The Cronbach alpha internal consistency coefficient was calculated as .93 and the scale was seen to be highly reliable. When the coefficients calculated for the sub-dimensions of the scale are taken into consideration, it was observed that the 1st and 3rd factors were highly reliable, and the 2nd and 4th factors were quite reliable. Item total correlation values range between .35 and .69. The scale satisfies the criterion for the correlation coefficient to be greater than .25 and not being negative. Additionally, a significant difference at the level of .01 was determined between the lower 27% group and the upper 27% group scores as a result of the independent samples t-test to test the discrimination power. This result shows that the scale measures the intended characteristics, and it can distinguish between individuals' self-efficacy (Baypınar & Tarım, 2019).

The Cronbach alpha value of the scale was high (.90), and it shows that the dimensions of this scale support each other. In this study, the four dimensions of the scale were considered as a whole.

3.4. Data Collection Procedures

This research was conducted in the fall semester of the 2021-2022 academic year with the participation of 212 students studying in the 8th grade at Mehmet Akif Ersoy public secondary school, located in Istanbul Arnavutköy district. First, research permission was obtained from the Ministry of National Education. Information about this study was given by meeting with the teachers at the school. The students were determined according to the convenience sampling method and the students were informed about this study. The duration and the application days of data collection tools was determined without delaying curriculum lessons by meeting with mathematics teachers. A total of 2 course hours were used, 1 course hour for algebra learning field attitude and mathematical literacy self-efficacy scales, and 1 course hour for algebraic thinking test. On a determined day, data collection tools were applied face to face in accordance with Covid-19 measures. Then, a researcher interpreted collected data by using statistical analysis.

3.5. Data Analyses

All gathered data were transferred to the computer environment and analyzed by using SPSS.

At the beginning of statistical analysis, the normal distribution of the data in this study was checked. The skewness and kurtosis values give information about the normality of the data. The skewness and kurtosis values show a normal distribution between +1 and -1 (Büyüköztürk, 2017) and also +2 and -2 (George & Mallery, 2018). The normal distribution of the data in this study are shown in Table 2.

Table 2

The Skewness and Kurtosis Values of the Data in This Study

Obtained Data	**Skewness**	**Kurtosis**
Algebraic thinking test scores	.76	-.40
Algebra learning field attitudes scores	-.20	-.05
Mathematical literacy self-efficacy scores	-.01	-.03

Since the kurtosis and skewness values of the data were in the acceptable range, algebraic thinking test scores, algebra learning field attitudes scores and mathematical literacy self-efficacy scores showed the normal distribution.

In this study, **descriptive statistical analysis** was used to determine the arithmetic mean and standard deviation of students' algebra learning field attitudes and mathematical literacy self-efficacy scores.

Correlation analysis was used to determine the relationship between students' algebraic thinking levels , algebra learning field attitudes and mathematical literacy self-efficacy scores.

Correlation analysis is used when examining the relationship between two or more variables in the direction of the change of variables. If the obtained coefficient is positive, it indicates an increase in both variables or a decrease in both variables. If the coefficient is negative, it means that one of the variables increases while the other decreases. Information about the correlation coefficient value is given in Table 3. (Büyüköztürk et al., 2017).

Table 3

The Information About the Correlation Coefficient Value

Correlation Coefficient r	**Correlation**
0	No correlation
.01-.29	Weak correlation
.30 - .70	Moderate correlation
.71 - .99	Strong correlation
1	Very strong correlation

Regression analysis is used to examine the relationship between two or more variables. The relationships between two variables are called simple regression analysis, and the relationships between more than two variables are called multiple regression analysis. In regression analysis, variables are divided into two: Dependent variable and independent variable or variables. The value of the dependent variable is estimated with the help of independent variables. It shows how much the independent variable or variables affect the dependent variable value (Karabulut & Şeker, 2018). In this research, the dependent variable is students' algebraic thinking levels and independent variables are students' algebra learning field attitudes and mathematical literacy self-efficacy scores. Because of two independent variables and one dependent variable (three variables), **multiple regression analysis** was used for this study.

4. RESULTS

This chapter contains the results of the sub-problems of this study. The results were found by statistical analysis of the data obtained from this study.

4.1. Findings Related to the Sub-Problem 1

The first sub-problem of this study is "What are the algebraic thinking test score levels of the 8th grade students?" Algebraic thinking test scores measure students' algebraic thinking levels, so it is expressed as algebraic thinking levels. Findings related to algebraic thinking levels of students are shown in Table 4.

Table 4

The Distribution of Algebraic Thinking Levels of Students

ATL	**Level 0**		**Level 1**		**Level 2**		**Level 3**		**Level 4**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Grade 8 students	78	36.8	73	34.5	18	8.5	20	9.4	23	10.8	**212**	**100**

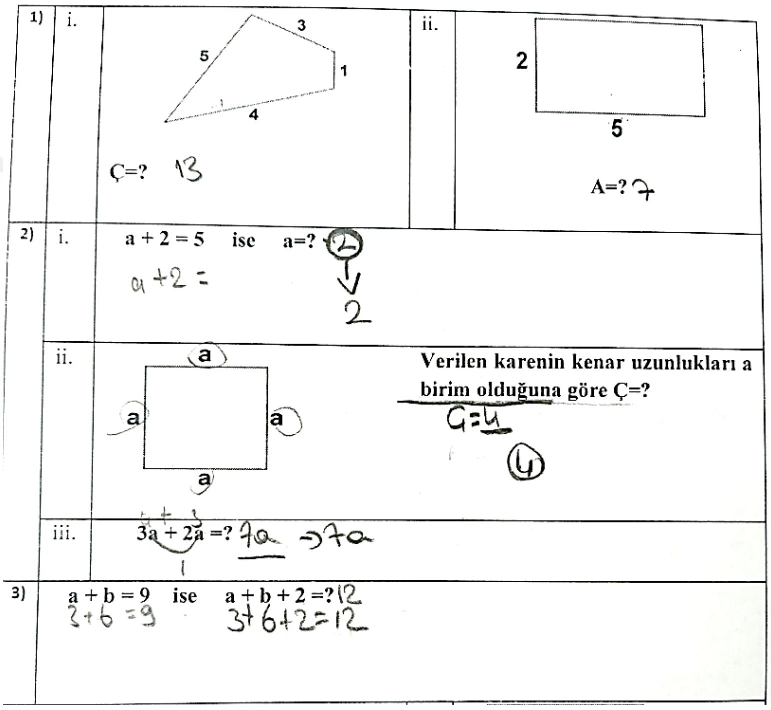
According to Table 4, 36.8% of 8th grade students are at Level 0, 34.5% of them are at Level 1, 8.5% of them are at Level 2, 9.4% of them are at Level 3, and 10.8% of them are at Level 4. Examples of students' answers are given below, respectively according to their levels. Since algebraic thinking levels are in an ordered structure, if the students have reached any of the levels, it means that they have successfully passed all the previous levels.

Answers of students at Level 0 and Level 1

A student who does not have at least 4 acceptable answers for questions 1i, 1ii, 2i, 2ii, 2iii and 3 is Level 0. There were students at Level 0 at most. A sample of a student's answer sheet at Level 0 is given in Figure 2.

Figure 2

A student's Answer Sheet at Level 0

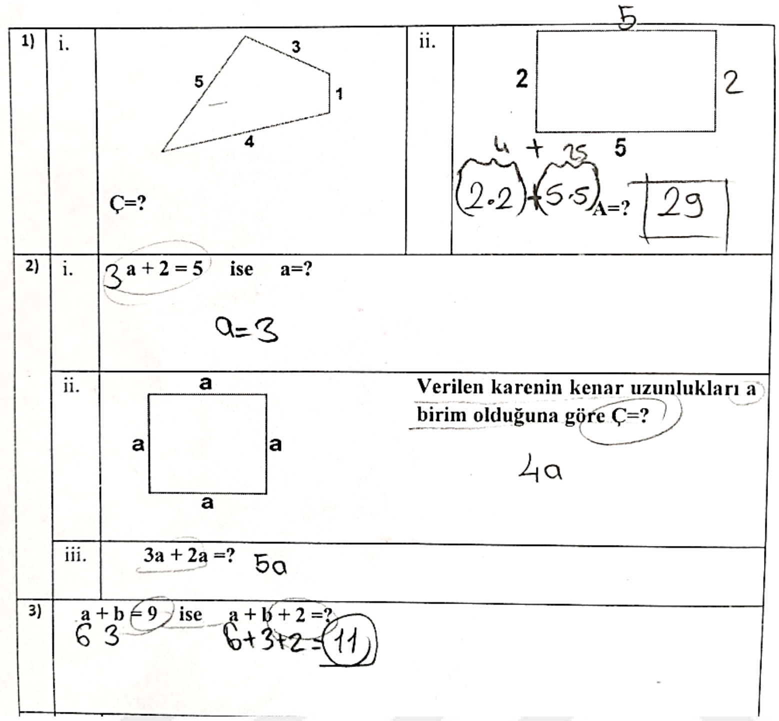


In the example of this student, s/he reached a different conclusion instead of the area in question 1ii and s/he could not find the correct answer in questions 2i, 2ii and 2iii. In the third question s/he tried to find it by giving values to the unknowns and her/his calculation was wrong.

Students must have at least 4 acceptable correct answers from questions 1i, 1ii, 2i, 2ii, 2iii and 3 for Level 1. A sample of a student's answer sheet at Level 1 is given in Figure 3.

Figure 3

A Student's Answer Sheet at Level 1



In the example of this student, s/he could not find the perimeter and area correctly in question 1. S/he reached the correct results in question 2 and s/he found the result by giving value to the unknowns in question 3.

The assessment questions for Level 1 and Level 0 are the same. The general evaluation of all student answers including these questions was given below.

- In question 1i the perimeter of the shape was asked. This was generally answered correctly. Some students made a mistake in the addition process. In question 1ii, the area of the shape was asked. Some students have calculated the perimeter instead of the area. Some calculated by adding only the two sides given in the question.

- In question 2i, the value of the unknown in operation was asked. Most of the students found the correct answer using the information given in the question. In question 2ii, the perimeter of the shape including the letter was asked. Some accepted the numeric value of "a ", which they found in question 2i as a side length of the shape and then calculated it. That is, they gave value to the letter. Also, some students' answers were “Ç = 4”, “4 = a”, “a+a+a+a = a” and “a+a+a+a = 4+a”. In question 2iii, the result of the operation containing the variable was asked. Some of them found the result by giving numerical value they found in question 2i to the letter. Some also gave random numerical values to the variable. Another different result was “5”.

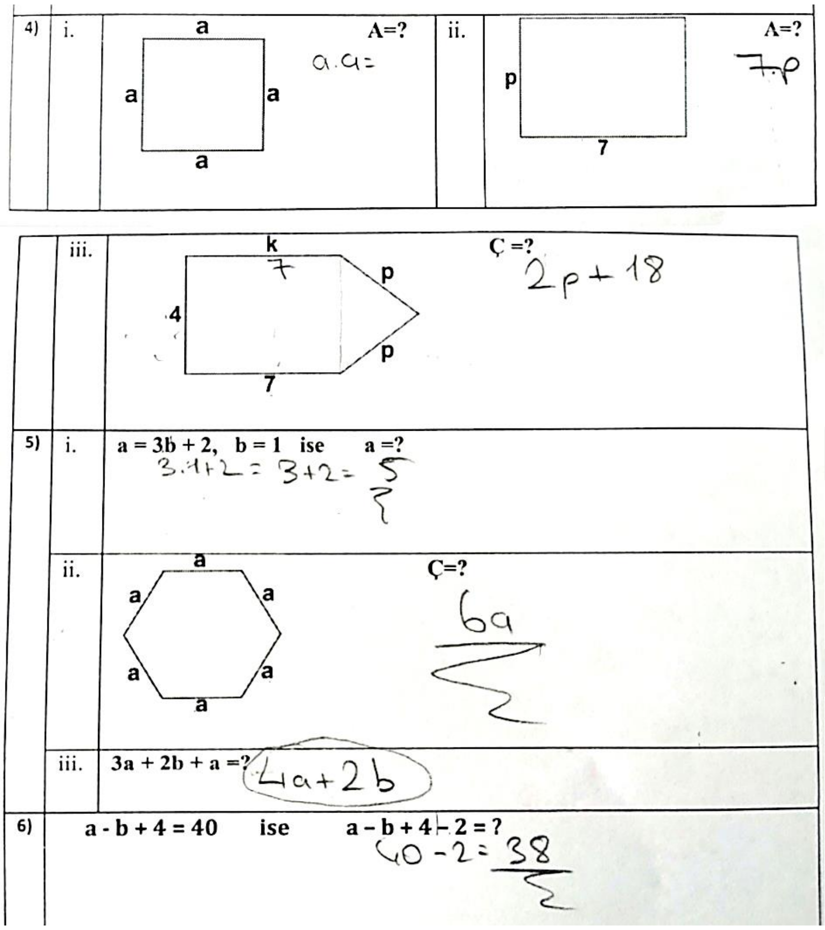
- In question 3, the result of the given operation was asked. There was given information that algebraic expression was equal to a number in the operation. Some students solved the operation by giving values to two different variables in the given information.

Answers of Students at Level 2

The student who gives at least 5 acceptable answers in question 4i, 4ii, 4iii, 5i, 5ii, 5iii and 6 is Level 2. A sample of a student's answer sheet at Level 2 is given in Figure 4.

Figure 4

A Student's Answer Sheet at Level 2



In the sample of this student, s/he had knowledge of the area and the perimeter. As can be seen in question 4i, s/he created the operation of the area of the shape but did not write the result of the multiplication of two letters. In question 4iii, s/he made a calculation by giving a numerical value to a side length given as a letter in the question. S/he reached the correct result in questions 5 and 6.

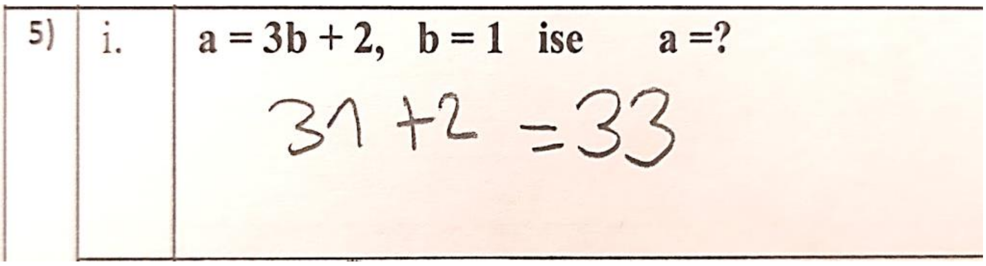
The general evaluation of all student answers including question 4, 5 and 6 was given below.

- In question 4i, the area of the shape was asked. Most of the students' answers to this question were as follows, finding the perimeter of the figure instead of the area, multiplying all the sides of the figure, giving a random numerical value to the side length given as a letter, and some students answered 2a. In question 4ii, the area of the shape was asked. This question was generally calculated correctly. Some students calculated perimeter, instead of area of shape. Some gave a random numerical value to the side length given as a letter. In question 4iii, the perimeter of shape was asked. Some side lengths of the shape in this question were given as letters. Some students gave numerical values to letters to be compatible with other sides that contain numerical values, then calculated perimeter. They found the result as a numeric value with no letters. On the other hand, some students just collected the sides containing numerical values, and then wrote down their collected value and letters adjacently. These' answers were “11ppk” and “11kp”.

- In question 5i, the value of the unknown in operation was asked. The number “1” has been assigned for “b” given in the question. Some students thought of “b” as the ones-digit of a two-digit number. That is, they solved the operation by replacing 3b with 31 as seen in Figure 5.

Figure 5

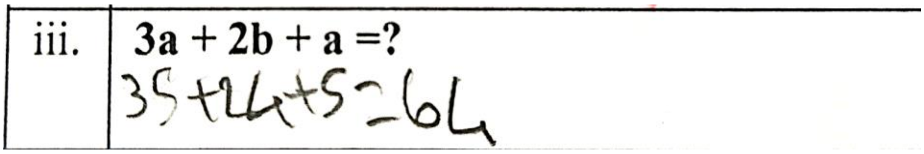
A Student's Answer to Question 5i



In question 5ii, the perimeter of shape was asked. Some accepted the numeric value of "a ", which they found in question 5i as a side length of the shape and then calculated it. Some created the operation of the perimeter of the shape, but they did not write the result of the sum of six letters. Some of these answers were "a+a+a+a+a+a" and "a+a+a+a+a+a = a". In question 5iii, the result of the operation containing variables was asked. Some students collected similar terms separately and wrote the result without putting any operation between the collected terms. One of these answers was "4a, 2b". Some summed only the numbers they saw in the process and wrote the letters adjacent to the number they collected. One of these answers was "5ab". Some students thought of the terms 3a and 2b as two-digit numbers. They calculated the operation by assigning a value of 5 for "a" found in question 5i, and a random value to b, as seen in Figure 6. Also, a few students wrote 5 and 5a as answers.

Figure 6

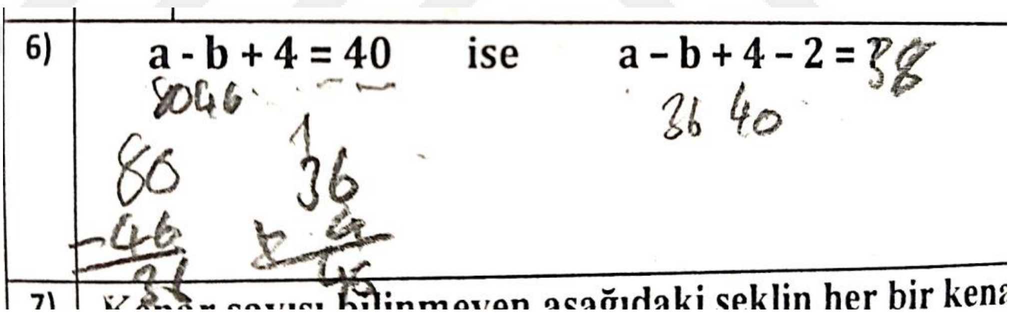
A Student’s Answer to Question 5iii



- In question 6, the result of the given operation was asked. In the question, information was given that an algebraic expression was equal to a number. Some of the students found results by giving numerical values to two different variables in the algebraic expression, as seen in Figure 7.

Figure 7

A Student’s Answer to Question 6

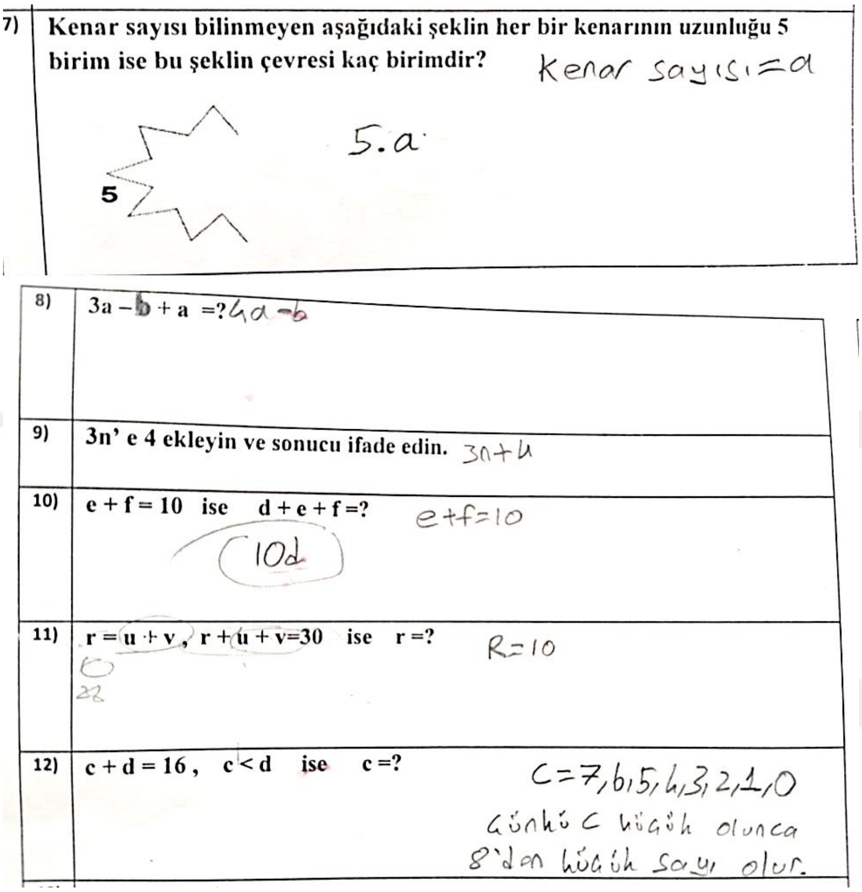


Answers of Students at Level 3

The student who gives at least 4 acceptable answers in question 7, 8, 9, 10, 11 and 12 is level 3. A sample of a student's answer sheet at Level 3 is given in Figure 8.

Figure 8

A Student's Answer Sheet at Level 3


7) Kenar sayısı bilinmeyen aşağıdaki şeklin her bir kenarının uzunluğu 5 birim ise bu şeklin çevresi kaç birimdir? Kenar sayısı=a

5

5.a

8) 3a – b + a =? 4a – b

9) 3n' e 4 ekleyin ve sonucu ifade edin. 3n+4

10) e + f = 10 ise d + e + f =? e+f=10

10d

11) r = u + v , r + u + v=30 ise r =? R=10

12) c + d = 16 , c < d ise c =? C=7,6,5,4,3,2,1,0

Çünkü c küçük olunca 8'den küçük sayı olur.

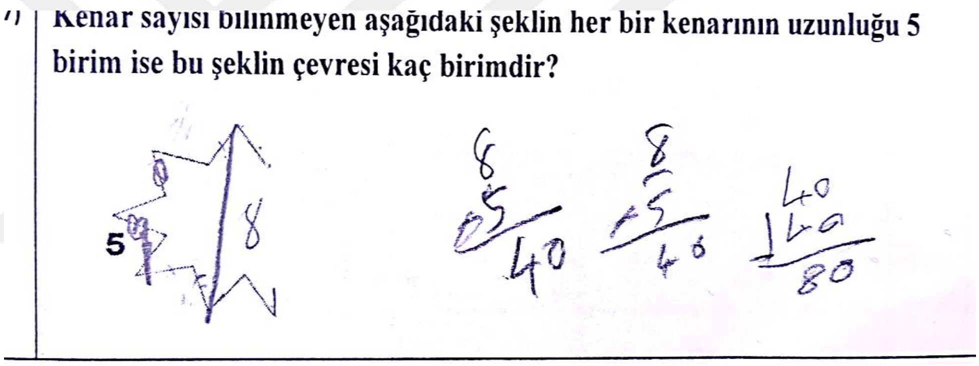
In the sample of this student, s/he wrote the correct answer by assigning a letter to the unknown side in question 7. S/he reached the correct answer in question 8 and 9. S/he did not find the correct answer in question 10 and 11. S/he found the answer using natural numbers according to the given information in question 12. S/he has the knowledge that “c” can be different numbers less than 8. Since a specific set of numbers was not given in the question, the set of natural numbers was accepted as correct.

The general evaluation of all student answers including question 7, 8, 9, 10, 11 and 12 was given below.

- In question 7, the perimeter of shape with an unknown number of sides was asked. Some students wrote results by only counting the sides of the given missing-sided shape, "5x11=55" was one of these answers. Some tried to complete the shape randomly and calculated a perimeter. A few students tried to divide the shape in half. They found the number of sides in one half is eight and by thinking that the other missing half would have the same number of sides, then they calculated a perimeter, as seen in Figure 9.

Figure 9

A Student's Answers to Question 7



Several of them tried to find the perimeter of the shape by writing 5 between the two sides, as seen in Figure 10 and Figure 11.

Figure 10

Another Student's Answer to Question 7

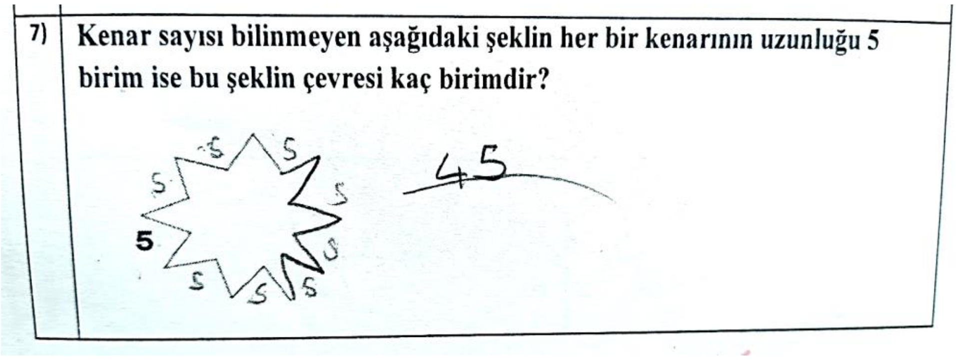
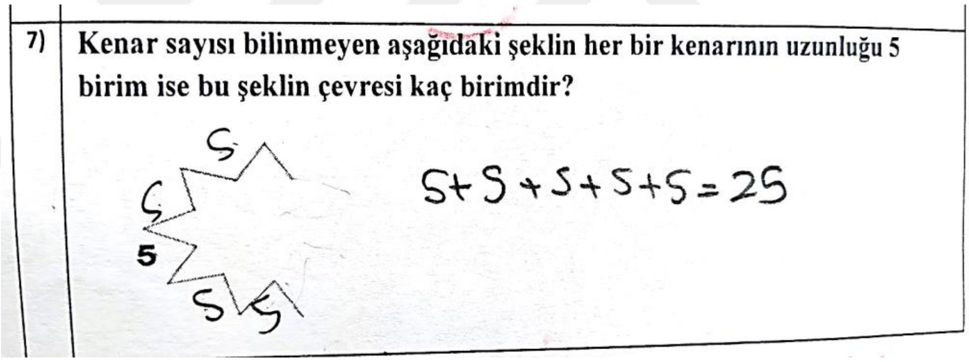


Figure 11

Another Student's Answer to Question 7



- In question 8, the result of the operation containing variables was asked. Some students gave value to variables and solved this question. Some students' answers also were "2a-b", "2a+b" and "3a"

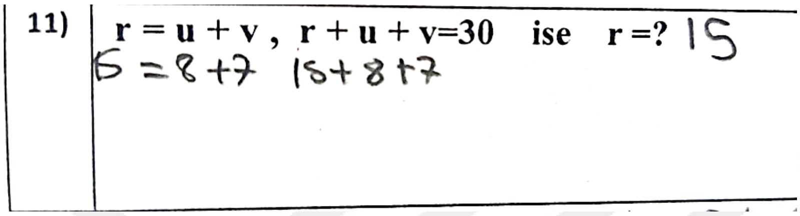
- In question 9, algebraic equivalent of verbal expression was asked. Most popular answer in this question was "7n". Some of students wrote "7"

- In question 10, the result of the given operation was asked. Some students gave numerical value to variables and solved this question. Most popular answer in this question was "10d"

- In question 11, the result of the given operation was asked. In this question, information of "r = u+v" and "r+u+v = 30" was given. Some students preferred to give value, as seen in Figure 12.

Figure 12

A Student’s Answer to Question 11



Some students gave answers by using given information incorrectly. Examples of this were given in Figure 13, Figure 14, and Figure 15.

Figure 13

Another Student's Answer to Question 11

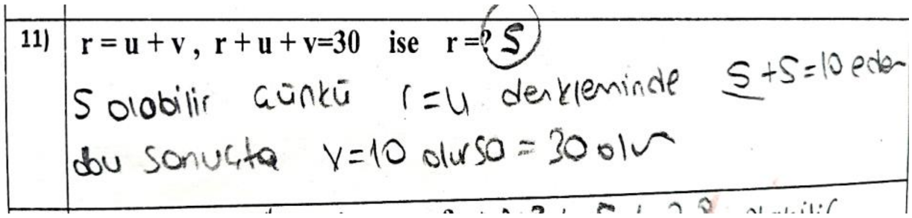


Figure 14

Another Student's Answer to Question 11

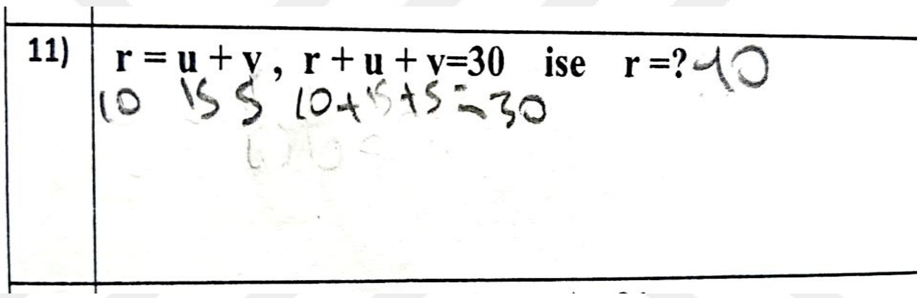
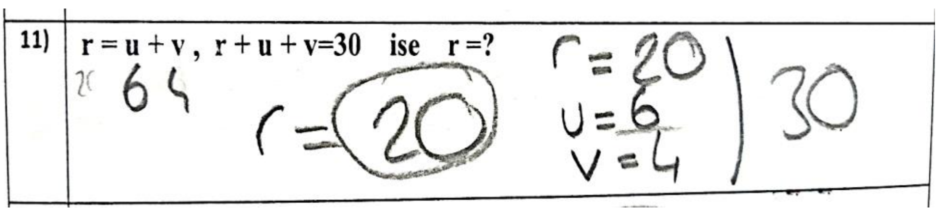


Figure 15

Another Student's Answer to Question 11



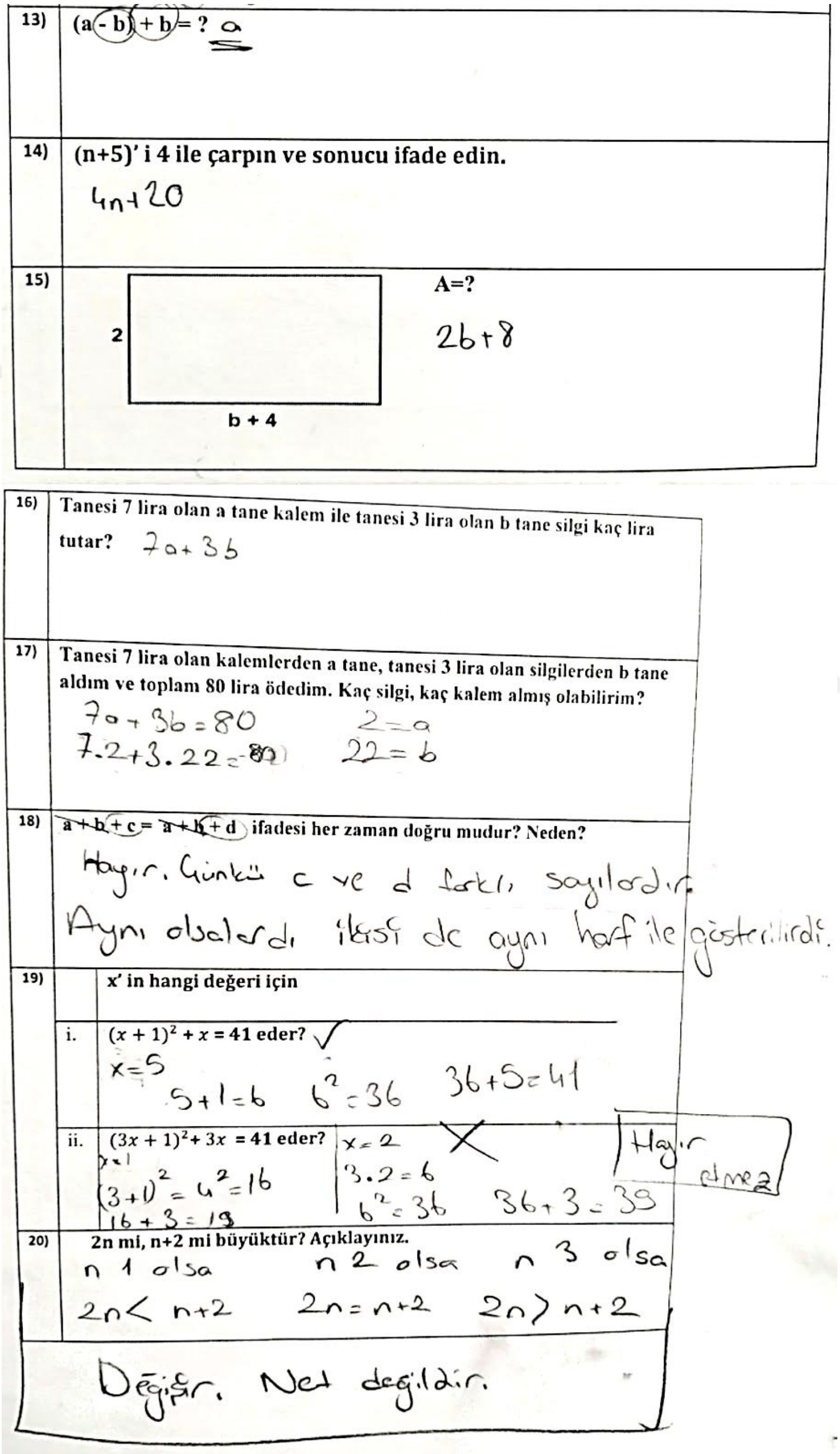
- In question 12, the result of the given operation was asked. In this question, students did not use rational numbers or negative integers. They made operations using only natural numbers and counting numbers. Since a specific set of numbers was not given in the question, the set of natural numbers and counting numbers were accepted as correct. The information of “c < d” given in the question indicates that there is no single answer to this question. Some students gave only one answer for c. Some of the students accepted 8 as an answer.

Answers of Students at Level 4

The student who gives at least 6 acceptable answers in question 13, 14, 15, 16, 17, 18, 19i, 19ii and 20 and is Level 4. A sample of a student's answer sheet at Level 3 is given in Figure 16.

Figure 16

A Student's Answer Sheet at Level 4



13) (a - b) + b = ? a

14) (n+5)' i 4 ile çarpın ve sonucu ifade edin.
4n+20

15) A=?
2
b + 4
2b+8

16) Tanesi 7 lira olan a tane kalem ile tanesi 3 lira olan b tane silgi kaç lira tutar? 7a+3b

17) Tanesi 7 lira olan kalemlerden a tane, tanesi 3 lira olan silgilerden b tane aldım ve toplam 80 lira ödedim. Kaç silgi, kaç kalem almış olabilirim?
7a + 3b = 80 2 = a
7.2+3.22 = 80 22 = b

18) a + b + c = a + b + d ifadesi her zaman doğru mudur? Neden?
Hayır. Çünkü c ve d farklı sayılardır. Aynı olsalardı ikisi de aynı harf ile gösterilirdi.

19) x' in hangi değeri için

i. $(x+1)^2 + x = 41$ eder? ✓
x=5
5+1=6 $6^2=36$ 36+5=41

ii. $(3x+1)^2 + 3x = 41$ eder?
x=1
$(3+1)^2 = 4^2 = 16$
16 + 3 = 19
x = 2
3.2 = 6
$6^2 = 36$ 36+3 = 39
Hayır olmaz

20) 2n mi, n+2 mi büyüktür? Açıklayınız.
n 1 olsa n 2 olsa n 3 olsa
2n < n+2 2n = n+2 2n > n+2
Değişir. Net değildir.

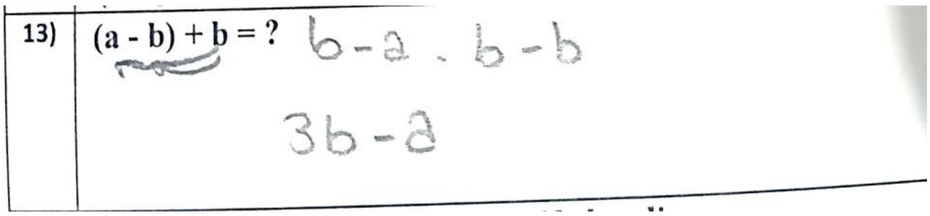
In the sample of this student, s/he answered questions 13, 14, 15, 16 and 17 correctly. In the 18th question, s/he stated that c and d were different numbers and said that the equality was not correct. S/he found a x value that satisfies the equation in question 9i. In question 9ii, s/he gave two different integer values to x and could not find the x value that satisfies the equality. In question 20, s/he tried three different values for n. Based on the result of these values, s/he commented that the result may change.

The general evaluation of all student answers including question 13, 14, 15, 16 and 17 was given below.

- In question 13, the result of the operation containing variables was asked. Some students gave numerical value to variables and found numerical value. Some students' answers were "a+b", "2b-a", "a+2b" and "a-2b" .
  One student tried to distribute the variable b outside the parentheses to the algebraic expression inside the parentheses and reached the wrong result, as seen in Figure 17.

  Figure 17

  A Student's Answer to Question 13

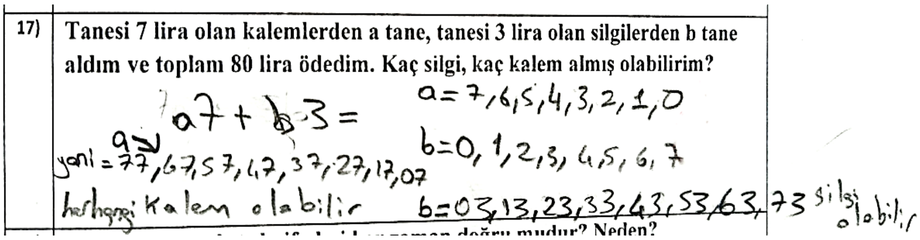


- In question 14, algebraic equivalent of verbal expression was asked. Some students wrote the result by multiplying only one of the terms in parentheses. Examples of this were "n +20" and "4n+5" Also, some of students' answers were "20n"

- In question 15, the area of shape containing algebraic expression was asked. Some students found an area by multiplying only one of the terms in the algebraic expression representing one side of the shape. Examples of this were " b+8" and "2b +4" Also, some of students answers were "b + 12" and "b" + 64"
- In question 16, a problem containing variables was asked. Some students wrote "7a + 3b" and tried to write an equality that they thought was equal to this algebraic expression like "10" and "10ab" Some students created a single variable for two different variables without using variables given in the question. One of these answers was " 7k + 3k =10k" Some students wrote just "7 + 3=10" without using any variables.
- In question 17, a question containing variables, an equation and operations was asked. That was a question with more than one answer. Some students wrote just "7a + 3b=80". Some found more than one correct numerical value for variables a and b. Some students thought of "7a" and "3b" as two-digit numbers and found results. The detailed answer of one student who finds it this way is in Figure 18.

Figure 18

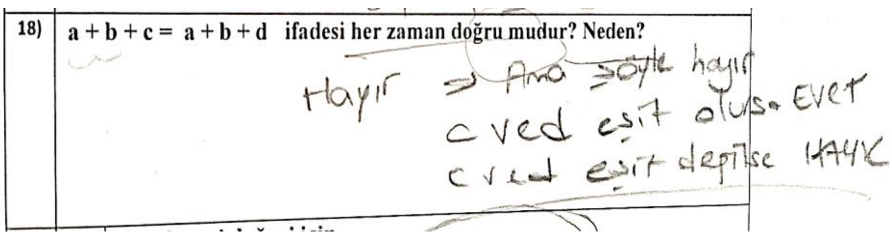
A Student's Answer to Question 17



- In question 18, a question requiring comment was asked. Some students wrote just "evet" or "hayır". Some students replied stating that c and d could be equal, while some replied stating that they could not be equal. A few students commented on the situations where c and d are equal and unequal together. One of these answers is in Figure 19.

Figure 19

A Student's Answer to Question 18

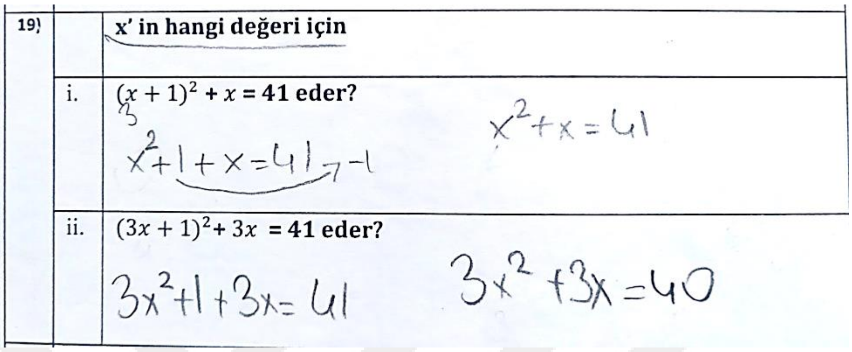


- In question 19, an equation was given. Value(s) of x satisfying this equation were asked. That was a question with more than one answer. Questions 9i and 9ii answers were evaluated together.

  Some students tried to find the result by trying numerical values for x. Most of them who tried in this way found a correct value in question 9i, and they could not find in question 9ii as in Figure 16. Some tried to solve the equation by squaring the algebraic expression. Most of them who tried to solve it in this way could not reach the correct result because they made a mistake while squaring the algebraic expression. An example of this is given in Figure 20.

Figure 20

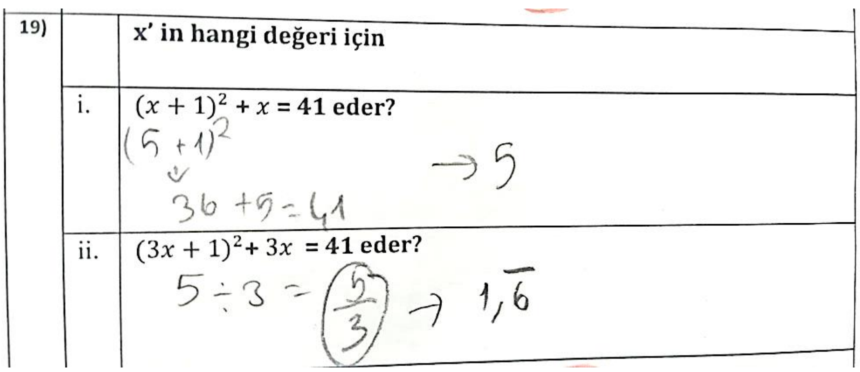
A Student's Answer to Question 19



Very few students reached the correct result in question 9ii. One of these students found the result without squaring the algebraic expression. This question has similarities with question 9i . Using these similarities, this student calculated question 9ii, as in Figure 21.

Figure 21

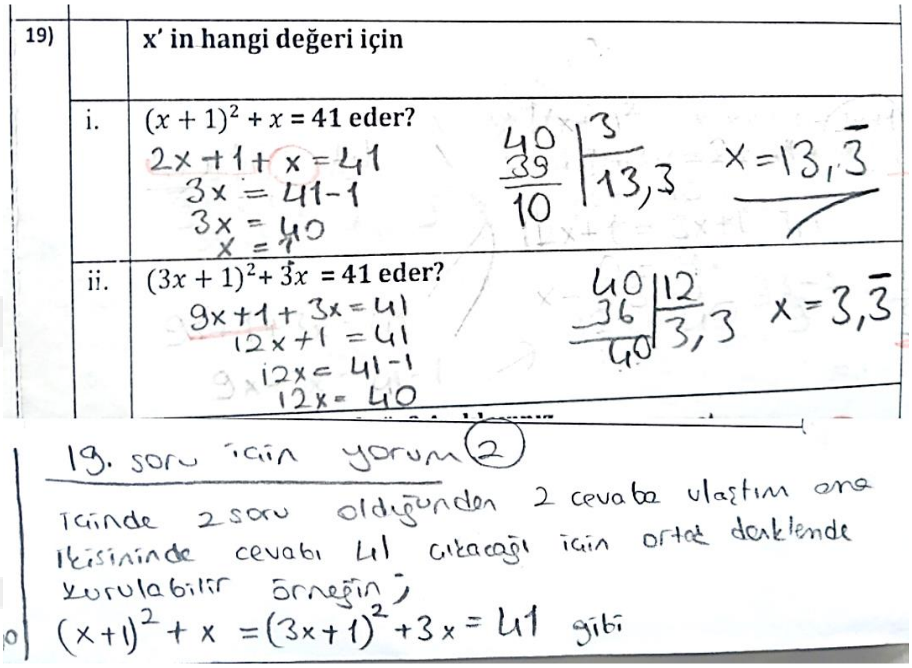
Another Student's Answer to Question 19



One of the students made a mistake while squaring the algebraic expression and could not reach a conclusion in questions 9i and 9ii. Also, this student wrote that a common equation can be established because the equation in both two questions is equal to the same numerical value. The answer of this student is as in Figure 22.

Figure 22

Another Student's Answer to Question 19



- In question 20, a question requiring comment was asked. Some students gave a single value to "n" and wrote the result. Those who gave the value 2 wrote equal, those who gave less than 2 wrote that "n+2" was greater and those who gave more than 2 wrote that "2n" was greater. Some wrote that 2n is greater stating that it involves multiplication. Some others wrote that "a clear result could not be obtained" and "the result was changeable" by giving different values to "n" , as in Figure 16. It can be said that most students interpret "n" not as a variable but as a certain value.

A general review of all the answers and the remarkable student answers are also given below.

There were equations containing squares of algebraic expressions in questions 19i and 19ii. Most students made mistakes while squaring and could not reach the correct result.

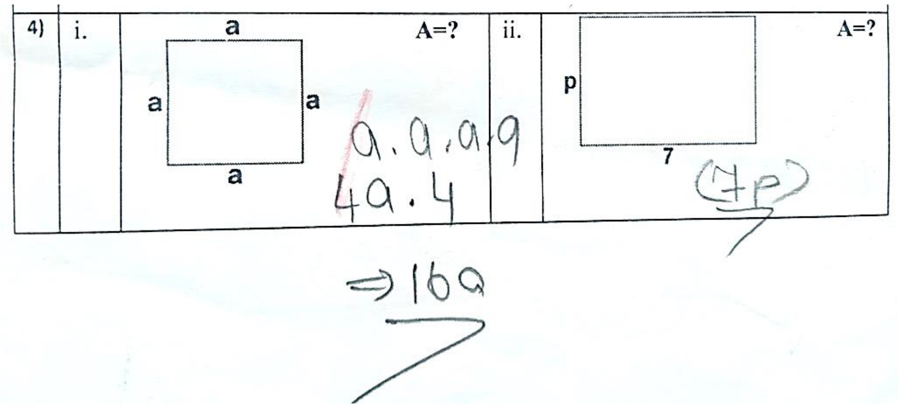
There were operations with similar variables in question 2iii and 5iii and operations with variables with both negative and positive signs in question 8 and 13. When the answers given by the students to these questions were examined, it was seen that the students had deficiencies in adding and subtracting similar variables.

Some students have deficiencies in terms of perimeter and area subjects. Some examples of this deficiency were given below.

Some students tried to find the area by multiplying only given side lengths in the question. If only two side lengths were given in the question, s/he multiplied the two sides, and if all the side lengths were given in the question, s/he found the area by multiplying all the sides. The answer of one of the students is given in Figure 23. In addition, this student could not write the correct result for the incorrect operation that s/he did in question 4i.

Figure 23

A student's Answer to Question 4



Most students regardless of level tried to find a solution by valuing the letter. For example, in question 3, they did not consider the information given as a whole. They divided the information into parts by valuing the letter, although it was not necessary. Question 3 in Figure 2, Figure 7, Figure 24 and Figure 25 can be given as an example.

Figure 24

Another Student's Answer to Question 3

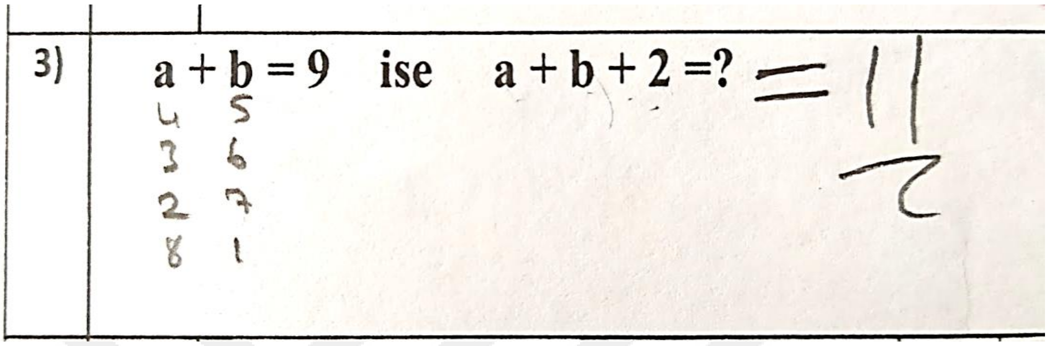
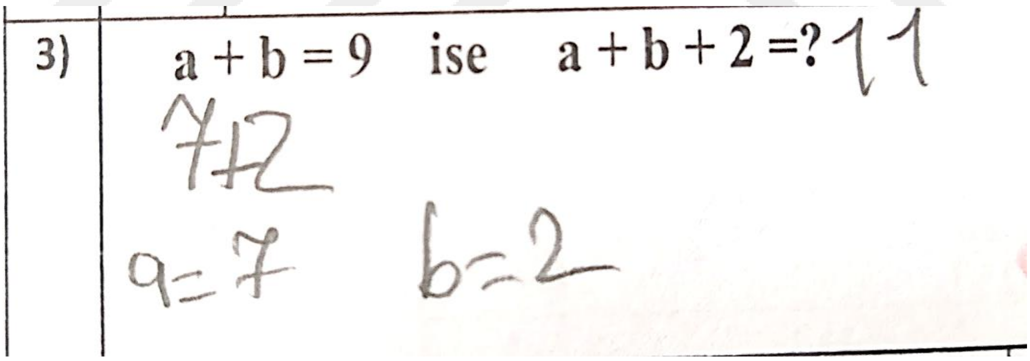


Figure 25

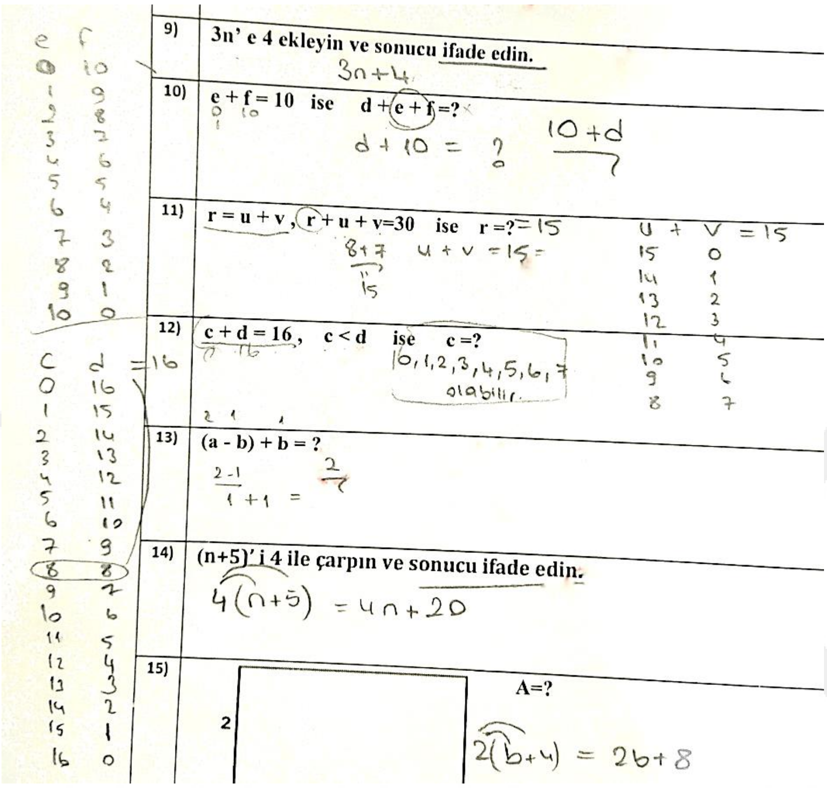
Another Student's Answer to Question 3



A student at Level 4 solved almost all the questions by valuing the variables. Some of the questions solved by this student were given in Figure 26.

Figure 26

A Student's Paper That Answers All Questions by Valuing the Variables



There were also students who found results by valuing letters in questions that included not only operations but also shapes. Question 4iii in Figure 4 was an example of this.

The reason why some students found perimeter instead of area in question 1ii may be that the previous question asked about the perimeter. Some students made perimeter calculations in a row without paying attention to what was asked in the next question. An example of this is given in Figure 27 and Figure 28. While a student made a mistake in question 1ii, the same student also found the correct answer in question 4ii which is similar to question 1ii.

Figure 27

A Student's Answer to Question 1

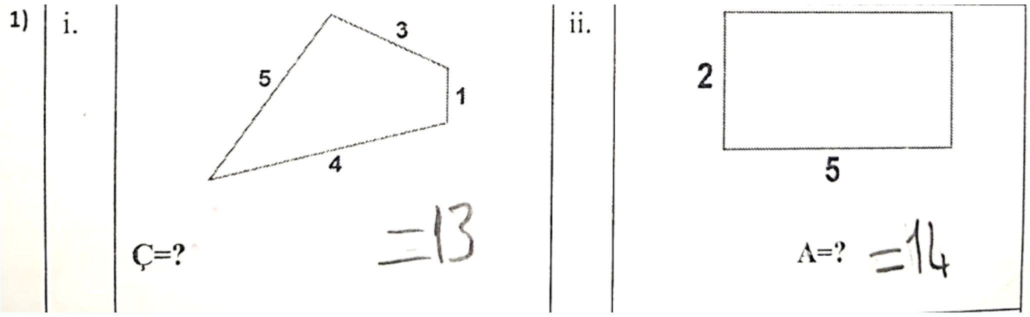
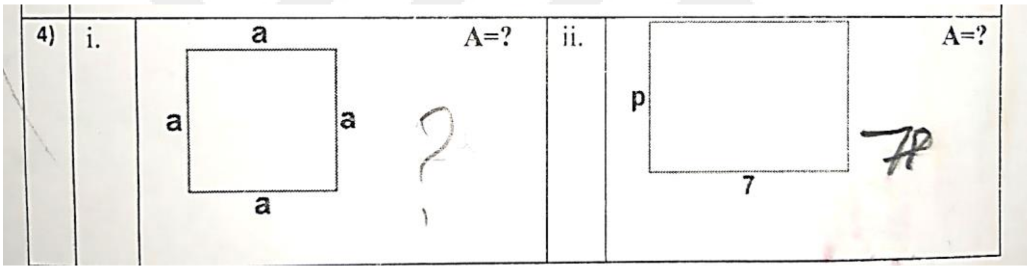


Figure 28

Same Student's Answer to Question 4



4.2. Findings Related to the Sub-Problem 2

The second sub-problem of this study is "What are the algebra learning field attitude scale score levels of the 8th grade students?" Findings related to algebra learning field attitude scale scores of students are shown in Table 5.

Table 5

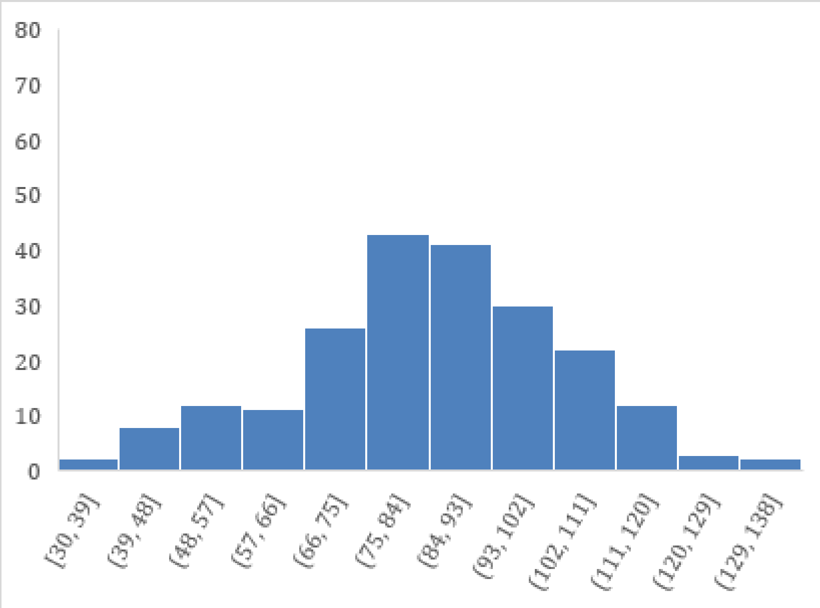
Descriptive Statistics of Students' Algebra Learning Field Attitude

ALFA	**Mean**	**Median**	**Standard Deviation**	**Total**
	$\bar{x}$		**SD**	**N**
Grade 8 students	84.9	85	19.1	212

According to Table 5, the mean of the students' algebra learning field attitude scale scores is 84.9, standard deviation of the students' scores is 19.1 and median of the students' scores is 85. The lowest score students get on this scale is 30 and the highest score is 131. The lowest score that can be taken from the scale is 28, and the highest score is 140. On average, the students marked "neutral" The standard deviation of these scores has a high value. This indicates that test results are spread quite far from the mean. Grade 8 students at this school have different levels of algebra learning field attitudes that are not close to each other. Histogram graph of the students' scores is given in Figure 29.

Figure 29

Histogram of Algebra Learning Field Attitude Scale Scores



According to Figure 29, the algebra learning field attitude of most students is at moderate level.

4.3. Findings Related to the Sub-Problem 3

The third sub-problem of this study is "What are the mathematical literacy self-efficacy scale score levels of the 8th grade students?" Findings related to mathematical literacy self-efficacy scale scores of students are shown in Table 7.

Table 6

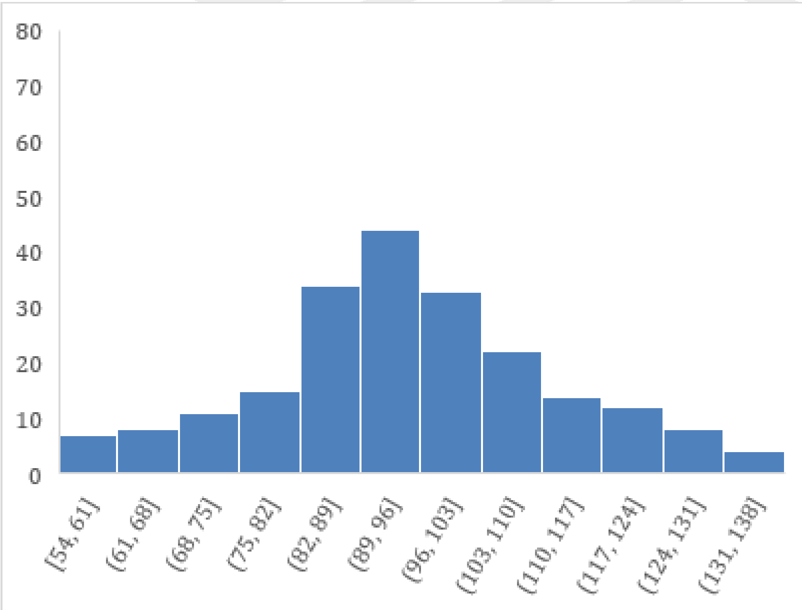
Descriptive Statistic of Students' Mathematical Literacy Self-Efficacy

MLSE	Mean	Median	Standard Deviation	Total
	$\bar{x}$		SD	N
Grade 8 students	95.2	94.5	16.8	212

According to Table 7, the mean of the students' mathematical literacy self-efficacy scale scores is 95.2, standard deviation of the students' scores is 16.8 and median of the students' scores is 94.5. The lowest score students get on this scale is 54 and the highest score is 135. The lowest score that can be obtained from the test is 30 and the highest score is 150. On average, the students marked "neutral" The standard deviation value of the test is high. This high value shows that the differences between students' mathematical literacy self-efficacy scores and the mean of these scores are high. Histogram graph of students' scores is given in Figure 30.

Figure 30

Histogram of Mathematic Literacy Self-Efficacy Scale Scores



According to Figure 30, the mathematic literacy self-efficacy of most students is at moderate level.

4.4. Findings Related to the Sub-Problem 4

The fourth sub-problem of this study is "Is there any relationship between students' algebra learning field attitude scale scores, mathematical literacy self-efficacy scale scores and algebraic thinking test scores?" Algebraic thinking test scores measure students' algebraic thinking levels, so it is expressed as algebraic thinking levels. Pearson correlation analysis was used for this question. Findings related to the relationship between algebra learning field attitude scale scores, mathematical literacy self-efficacy scale scores and algebraic thinking levels of students are shown in Table 9.

Table 7

Correlations of Study Variables

	ALFA	MLSE	ATL
ALFA	1		
MLSE	.57**	1	
ATL	.33**	.48**	1
** $p < .01$			

A correlation coefficient lower than .30 indicates a weak correlation, a moderate correlation between .30 and .70, and a strong correlation if it is greater than .70 (Büyüköztürk, 2017). If the p value is less than .05, the result is considered statistically significant. The smaller the significance value, the higher the confidence that the findings are valid (George & Mallery, 2018).

According to Table 9, there is a positive, moderate, and significant relationship between algebra learning field attitude and mathematical literacy self-efficacy scores of students. $r = .57$, $p < .001$

There is a positive, moderate, and significant relationship between algebra learning field attitude scores and algebraic thinking levels of students. $r = .33$, $p < .001$

There is a positive, moderate, and significant relationship between mathematical literacy self-efficacy scores and algebraic thinking levels of students. $r = .48$, $p < .001$

4.5. Findings Related to the Sub-Problem 5

In order for the multiple linear regression analysis to be valid, the normal distributions of the variables, linear relations between the variables and multicollinearity assumptions should be checked before the regression analysis. Normal distribution of the variables was checked at the beginning of the analysis, and the existence of a linear relation between the variables was checked with the result of the Pearson correlation test.

Also, the residual statistics were checked. For this statistics, Histogram distribution, Normal P-P plot and Scatterplot were examined to ensure that the assumptions of normality, linearity, homoscedasticity were not violated.

For the analysis to be valid there must be no multicollinearity. Situations showing multicollinearity are as follows: r coefficient between independent variables is .80 and above, Variance inflation factor (VIF) value is greater than 10, and Tolerance (t) value is less than .20 (Cevahir, 2020).

The Table 9, which includes the correlation test, show that the r coefficients are below .80. The VIF values are below 10 and tolerance values are above .20 of mathematical literacy self-efficacy scores (VIF=1,47, Tolerance= .68) and algebra learning field attitude scores (VIF=1,47, Tolerance= .68), so there is no multicollinearity.

The fifth sub-problem of this study is "Are students' algebra learning field attitude and mathematical literacy self-efficacy scores the predictors of their algebraic thinking? " Multiple linear regression analysis was used to predict students' algebraic thinking levels by using their mathematical literacy self-efficacy and algebra learning field attitude scores. Findings of multiple regression analysis are shown in Table 10.

Table 8

Multiple Regression Analysis of Study Variables

	unstandardized		**standardized**		
	B	**std. error**	$\boldsymbol{\beta}$	**t**	**p**
Constant	-38.46	9.08	-	-4.23	< .001
MLSE	.64	.11	.43	5.82	< .001
ALFA	.12	.10	.09	1.18	.23
R = .48 R^2 = .23					
F(*2,209*) = 31.83 *p* < .001					

If the p value is less than .05, the result is considered statistically significant. The smaller the significance value, the higher the confidence that the findings are valid (George & Mallery, 2018).

According to Table 8, the regression analysis is statistically significant. (F (2,209) = 31.83 , *p* < .001). The measure of the strength of the relationship between the independent variables and the dependent variable is R, which emerges in the regression analysis. The square of R represents the variation value of the effect of the independent variables on the dependent variable (George & Mallery, 2018). This research's R^2 value shows that mathematical literacy self-efficacy and algebra learning field attitude scores explain 23% of total variance in algebraic thinking levels (R^2 = .23). Mathematical literacy self-efficacy of students predicts their algebraic thinking positively and significantly (β =.43, t (209) = 5.82, $p < .001$) . Algebra learning field attitude of students does not predict their algebraic thinking significantly (β = .12, t (209) = 1.18, p = .23).

Regarding the regression analysis results, the regression equation was found as follows.

Algebraic thinking of students= -38.46 + .64*mathematical literacy self-efficacy + .12*algebra learning field attitude

5. DISCUSSION

Algebra has a large part in the mathematics curriculum. There is algebra in many subjects such as equations, inequalities, functions, polynomials, sequences, ratio, and proportion. It is also used in many subjects such as perimeter, area, and measurement. Algebra is needed not only for mathematics but also for many disciplines. This requires students to use their algebraic thinking skills efficiently (Kaya, 2017). Considering the place of algebra and algebraic thinking in education, it has become necessary to conduct study on these subjects. In this study, the concepts that can affect algebraic thinking affectively were emphasized. In this direction, the answer to the question "What is the predictive role of algebra learning field attitude and mathematical literacy self-efficacy on algebraic thinking of 8th grade students?" was searched. To answer this question, five sub-problems were identified and were examined.

In the first of the sub-problems, algebraic thinking of 8th grade students was examined. Algebraic thinking levels were determined using their answers to the algebraic thinking test. 10.8% of the students were Level 4, 9.4% of them were Level 3, 8.5% of them were Level 2, 34.5% of them were Level 1 and 36.8% of them were Level 0. The number of students at Level 0 and 1 was higher than other levels.

Acar (2019) applied the same test to 7th and 8th grades in her study. There were more students at Level 0 and 1 than other levels in both 7th and 8th grades. Students at Levels 2, 3 and 4 in 7th grade were distributed respectively as 11.4%, 2.9% and 2.9%. Students at Levels 2, 3 and 4 in 8th grade were distributed respectively as 20%, 7.1% and 5.8%. In Acar's (2019) study, the number of students at 2, 3 and 4 levels were higher in 8th grades. Sayı (2018) also applied the same test to 7th and 8th grades.

While the number of students at Level 0 and 1 in 7th grade was higher than other levels, the number of students at Level 2 and 4 in 8th grade was higher than other levels. The number of the students at Level 4 was 3% in 7th grade and 25% in 8th grade. In the study of Yaprak-Ceyhan (2012), algebraic thinking levels of 6th, 7th and 8th grade students were measured. While there were few students at Level 4 in 6th grade, the number of students at Level 4 in 7th and 8th grades was more. On the other hand, while there were more students at level 0 in the 6th grade, this number decreased as the grade level increased. In the study of Usta and Gökkurt-Özdemir (2018), a different test was created that measures the same levels. Using the case study method, this test was applied to 6th, 7th and 8th grades. The students in the 7th and 8th grades were able to give correct answers to the questions at Level 3 and 4. Küchemann (1981) conducted a study measuring the same levels. The students were evaluated according to three different ages 13, 14 and 15. The number of students at low levels in the 13-age group was higher than in the 14-age group . The number of students at the high levels in the 14-age group was higher than in the 13-age group. There was no significant difference between the low and high levels of students in the 14 to 15 age group. Chrysostomou & Christou (2019) applied a test measuring algebraic thinking skills to 5th, 6th and 7th grade students. In this test, "Class" was used to determine student levels. In the 5th grade, Class 1 had 34% of the students, while Class 4 had 3%. In the 7th grade, while there were 14% of students in Class 1, there were 13% of students in Class 4. In general, as the grade level increases, there is a decrease in the number of students at Level 0 and an increase at Level 4.

The mentioned studies above support the conclusion that the level of algebraic thinking increases as the grade level increases. Usta and Gökkurt-Özdemir (2018) associated the high number of students at the upper level in the 8th grade with the fact that they deal in more algebra subjects than other grades. According to Schunk (2008/2014), older children perform better than younger children because they have more information.

In this study, the remarkable answers given by the students to this test were examined. Most students did not conclude the operations without giving value to the letters representing the variable or the unknown in the questions. For example, in the 3rd, 6th, 10th and 11th questions, the students did not consider the information given in the question as a whole. They tried to solve the question by giving numerical values to the letters in the given information, although not necessary. On the other hand, some students valued letters not only in operation questions, but also in the questions containing shapes. For example, they did not include the letter representing the side of the shape in the operation. They gave the letter a numerical value during operation. Also, when there was a number next to the letter representing the variable or the unknown in a question, some students thought of it as a two-digit number. For example, for the letter "b" in the term "3b" in the algebraic expression, they did operation as the ones digit of a two-digit number in question 5i. Considering that the test determines students' levels, there is concluding an operation without giving a value to letters at Level 1, and there is perceiving the letters as unknown and using them in questions at Level 4. However, in this study, some students could not perceive the letters as unknown in the questions that should be perceived as unknown, and they also gave numerical values to the letters in the question that should be done without value to the letters. Similarly, in the study of Oral, İlhan and Kınay (2013), students had difficulties in understanding the concept of variable and what it does. According to Acar's (2019) study, students had difficulty in concluding the operations without giving value to the letters, and they always tended to find a numerical result while solving a mathematical problem. Some students think that letters have place values and can only be numbers (Akkaya & Durmuş, 2010)

One of the reasons for the student answers in this study and similar studies results given above, may be individual differences. Students at a certain educational level may be at different cognitive development levels (Erden & Akman, 2017). According to Piaget, 8th grade students are in the formal operational stage (symbolic reasoning), but cognitive development occurs at different speeds in different areas (Shuck, 2008/2014). All students may not be at the same level of development in algebraic thinking. They may be in different developmental stages or in the transition phase between stages. Regarding the answers given by the students in this and similar studies, Çelik and Güneş (2013) draw attention to the students' prior knowledge about symbols with letters. Students have used symbols with letters for different purposes in math education since the 6th grade such as making abbreviations, naming corners and sides, and measuring units. It is not possible for students to use the letter as an unknown or variable all at once, they need a strong foundation to support their use as an unknown and variable appropriate.

In addition, the difficulties of students in learning algebra may be related to the proficiency of their conceptual and procedural knowledge. When they do not learn enough conceptual information such as equality, equation, variable, and algebraic expression, they make many mistakes when they encounter these concepts. In the results of this research, some students could not understand the letters as variables, or even if they understood them as variables, they could not use this knowledge when they encountered the equal and less-than signs. Chirove and Ogbonnaya (2021) focused on conceptual knowledge in teaching algebra. Conceptual knowledge provides an understanding of basic concepts, which facilitates the understanding of procedural knowledge. In other words, the fact that the students in this study did not have enough conceptual knowledge in algebra might have prevented them from doing the questions in the algebraic thinking test.

Furthermore, there are questions that require using arithmetic operations and geometry in the algebraic thinking test of this study. In this test, students' deficiencies in arithmetic and geometry knowledge were revealed. Students were observed to have errors in finding the perimeter and area, squaring the given expression, and adding and subtracting similar terms in the given operation. Students' lack of prior knowledge may also be the reason for the high number of students at low levels in the algebraic thinking test. According to Warren (2005), lack of prior knowledge can be challenging for students in the transition between arithmetic and algebra. Lack of knowledge in arithmetic and geometry affects negatively the development of algebraic thinking skills (Birgin & Demirören, 2020).

In general, the low level of algebraic thinking of the students was caused by the students' lack of conceptual knowledge such as variable unknowns, equality, equations, confusing the concepts of algebra with the subjects they learned before algebra, and the lack of knowledge in arithmetic and geometry.

In the second sub-problem, the algebra learning field attitudes of 8th grade students were examined. Algebra is a learning field. The attitudes of the students were determined by using their answers to the attitude scale created for the learning field of algebra. The highest score that can be obtained from this test is 140 and the lowest score is 28. According to the results of the scale, the mean of the students’ attitude scores was 84.8, and the standard deviation of them was 19.1. The majority of the students have moderate level algebra learning field attitude. According to the result of

Pearson's correlation analysis carried out for the fourth sub-problem, the students' algebra learning field attitudes and algebraic thinking were moderately related to each other. Students' attitudes towards a subject can affect their behavior or success in that subject. According to the result of regression analysis carried out for the fifth sub-problem, a unit change in students' algebra learning field attitudes created a .12 change in their algebraic thinking, but this effect was not statistically significant.

That is, the low or high algebraic thinking of the students was not due to their algebra learning field attitudes. Many studies have been conducted that deal with algebra and attitude together.

Okuducu (2020) applied the same attitude scale to the experimental and control groups using pre-test and post-test. Algebra courses were taught in accordance with the curriculum in the control group, visual support and interactive whiteboard were used in these courses, and Scratch activities were also included in the experimental group. Post-test attitude scores of both groups increased. In general, similar effects were observed in both groups in the pre- and post-test results. In other words, it has been found that the visual materials and computer-aided applications used in the curriculum have positive effects on the students' algebra learning field attitudes and algebra success. Temür (2022) also used the same attitude scale. In her study, the teaching process enriched with the virtual manipulative in algebra courses had increased students' attitudes and success towards this course. In the research of Tok, Bahtiyar and Karalök (2015), techniques such as analogy, drawing, problem solving, brainstorming, tangram, story, thinking aloud, origami were used in mathematics courses, including algebra. As a result of these techniques, students ' attitudes towards mathematics and success increased significantly. Collaborative learning techniques such as Cooperative Learning and Team Game Tournament used in the field of algebra learning are also effective in developing positive attitudes towards mathematics and success (Gelici & Bilgin, 2012). In these studies which deal with algebra and attitude together, the experimental research method was generally used. These studies have been conducted in the subjects that affect student attitudes in algebra courses. Considering the results of these studies, teaching techniques used correctly and at the right time are effective in developing success and positive attitudes towards a math subject.

This study is the correlational research and the relationship between students' algebraic thinking scores and algebra learning field attitude scores was not statistically significant. In other words, there was no factor that would affect students' algebraic thinking in the algebra learning field attitude scale.

In the third sub-problem, the mathematics literacy self-efficacy of 8th grade students was examined. It was determined by using the answers they gave to the self-efficacy scale created for mathematical literacy. The highest score that can be obtained from the scale is 150 and the lowest score is 30. According to the results of the scale, the mean of the students' self-efficacy scores was 95.2, and the standard deviation of them was 16.8. The majority of the students have moderate level mathematic literacy self-efficacy. Mathematics literacy and mathematics self-efficacy are important in teaching algebra and mathematics teaching, and many studies have been conducted. Ayotolo &Adedeji (2009) found a positive relationship between mathematics self-efficacy and mathematics achievement. After the application of McGee (2019) including mathematical literacy components, there was an increase in students' algebra success. The affective efficiencies towards mathematical literacy also affect individuals. As mentioned in this study, mathematical literacy self-efficacy is one of these efficiencies. In this study, students' mathematical literacy self-efficacy and algebraic thinking were related to each other moderately according to Pearson correlation analysis carried out for the fourth sub-problem. According to the regression analysis carried out for the fifth sub-problem, a unit change in students' mathematical literacy self-efficacy created a .64 change in their algebraic thinking.

That is, students' mathematical literacy self-efficacy has a significant effect on students' algebraic thinking. Mathematical literacy self-efficacy is an important variable for increasing the level of algebraic thinking. Examining the studies in algebra and mathematics on mathematical literacy self-efficacy will enable us to have information about the effects that will increase this self-efficacy. By using these effects, students' mathematical literacy self-efficacy levels can be increased and increased self-efficacy can also increase their algebraic thinking levels.

In study of Özgen and bindak (2011) with high school students, it was found that mathematics grades and achievements were related to mathematics literacy self-efficacy. According to them, students' self-efficacy can change and teaching strategies that are used correctly will increase their self-efficacy. For secondary school students, there are not enough studies on mathematics literacy self-efficacy in algebra or mathematics teaching. There are studies on visual mathematical literacy self-efficacy. According to the study of Duran and Bekdemir (2013), visual mathematics literacy self-efficacy is a predictor of visual mathematics success. In the study of Ev-Çimen and Aygüner (2018), there was no significant relationship between students' visual mathematical literacy self-efficacy and their actual performance in this field. They interviewed students to find out why there was no significant relationship, and then they stated that students in this age group were not aware of their own learning levels and cognitive processes. Katrancı and Şengül (2019) found a high level of correlation between students' mathematical literacy and visual mathematical literacy self-efficacy. According to them, the active use of smart boards and technologies in schools, teachers' effective use of mathematical language, and visual materials contributed to this high correlation. In short, students' success in mathematics lessons, their mathematical literacy, the use of technology and visual materials in the lessons are related to their mathematical literacy self-efficacy.

Mathematical literacy of students is related to their self-efficacy in this field. The low mathematical literacy of the students may have been the reason for the low number of students with low mathematical literacy self-efficacy in this study. On the other hand, crowded classes have an effect on the low mathematical literacy (Shah & Inamullah, 2012). The classrooms in which this study was applied are crowded and have approximately 40 students. In such classrooms, it is difficult for the student to interact adequately with the teacher and other classmates during the lesson. When the students cannot share their question or thought with the teacher and their classmates in the lesson, it may affect their next orientation. They may stop being active in the lesson by thinking that they will not receive feedback for their questions and thoughts. In crowded classrooms, techniques such as group work, students' presentations, in-class writing, outside reading and role playing can be used to attract students' attention and make them active in the lesson (Ayub, Saud & Akhtar, 2018). In addition, classrooms should be between 15-20 students so that students can make self-learning, self-regulation, and self-assessment (Hattie, 2005).

PISA and TIMSS questions contain algebra questions. These questions require using their cognitive skills because they include questions that require knowing, applying, and reasoning (Mullis et al., 2020) and locating information, understanding, evaluating, and reflecting (OECD, 2019). In addition, skill-based questions called "yeni nesil (new generation)" in our country contain algebra questions and skill-based questions measure high-level skills such as interpretation, inference, problem solving, analysis, and critical thinking (MEB, 2018). Mathematical literacy levels of students are effective in understanding, interpreting, and solving these questions. Mathematical literacy levels of students are related to their mathematical literacy self-efficacy beliefs. In this study, it was revealed that mathematic literacy self-efficacy is also related to algebraic thinking and furthermore has an effect on algebraic thinking. In other words, students' mathematical literacy self-efficacy can be effective in answering the algebra questions in the algebraic thinking test, as well as in answering algebra questions in skill-based exams in our country and international exams such as PISA and TIMSS.

In addition, there was a moderate relationship between the independent variables in this study. According to the result of Pearson's correlation analysis carried out for the fourth sub-problem, the value of this relationship between algebra learning field attitude and mathematical literacy self-efficacy scores of students was .57. Attitudes and self-efficacy of students towards a course can be affected by their experiences in that course. As a result of the studies examined in this study, it can be concluded that the teaching strategies and materials used in the math course, student-student and student-teacher interactions, and students' achievements affect attitude and self-efficacy. Any study done to increase students' algebra learning field attitudes will have a positive and a moderate effect on students' mathematical literacy self-efficacies. At the same time, any study done to increase students' mathematical literacy self-efficacies will also have a positive and a moderate effect on students' algebra learning field attitudes.

To summarize, in this study, the predictive effect of 8th grade students' algebra learning field attitude and mathematical literacy self-efficacy on their algebraic thinking was investigated. Algebra learning field attitude scores of students did not have a significant effect on their algebraic thinking. In other words, there was no factor that would affect the algebraic thinking of the students in the items in the algebra learning field attitude scale. A unit change in students' mathematical literacy self-efficacy constitutes a .64 significant change in their algebraic thinking. The contribution to be made for this self-efficacy will affect their algebraic thinking. These results are the answer to the research question “What is the predictive role of algebra learning field attitude and mathematical literacy self-efficacy on algebraic thinking of 8th grade students?” The predictive effects of independent variables in this study and their effects in other studies were given in the discussion paragraphs above.

5.1. RECOMMENDATION

In this chapter, there are recommendations prepared by using the results of this study.

- According to the algebraic thinking test score in this study, the number of students at Level 0 and 1 was more than the number of students at Level 2, 3 and 4. The reason for this is that most of the students in this study could not answer algebra questions correctly because they were unable to fully comprehend the conceptual knowledge, such as variables, unknowns, equality, and equations. The lack of these concepts prevented them from correctly answering questions that require procedural knowledge. More time should be devoted to teaching conceptual knowledge in algebra courses in the curriculum so that students can understand the algebraic concepts, understand questions using these concepts, and solve them by understanding. After conceptual knowledge is provided, procedural knowledge should be taught in the algebra courses.

- The number of students with low algebraic thinking levels is high since students cannot solve algebra questions. According to this study results, students' mathematical literacy self-efficacy levels predict their algebraic thinking levels. Also, students' mathematical literacy levels may be effective in understanding and solving algebra questions. Algebra courses that support literacy can be included in the curriculum so that students can solve more algebra questions and then increase their algebraic thinking levels.

- In this study, it was observed that the students had deficiencies in arithmetic and geometry. This deficiency prevented them from doing some questions in the algebraic thinking test. Studies can be carried out to eliminate the deficiencies of students in arithmetic, geometry, and other subjects, before starting the teaching of algebraic concepts.

- International exam questions such as in PISA and TIMSS and skill-based questions called "yeni nesil (new generation)" in our country require being a mathematically literate individual. This requirement gives importance to study on mathematical literacy, and as well as study that will affect behavior affectively such as mathematical literacy self-efficacy. In literature, there are not enough studies that deal with mathematics literacy self-efficacy and algebra or mathematics teaching in secondary schools. More study can be conducted on this subject.

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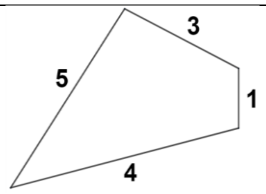
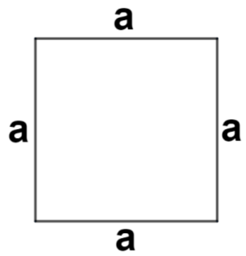
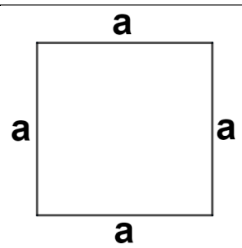
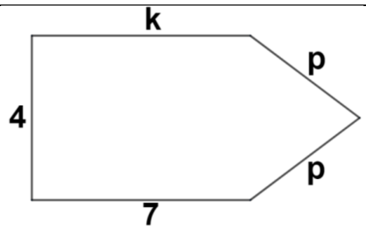
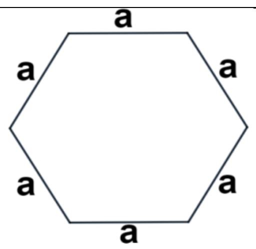
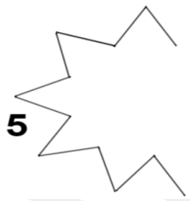
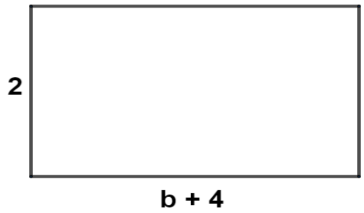
APPENDİCES

Appendix A: Algebraic Thinking Test

1)	i.	 **Ç=?**	ii.	 **A=?**
2)	i.	**a + 2 = 5 ise a=?**		
	ii.			**Verilen karenin kenar uzunlukları a birim olduğuna göre Ç=?**
	iii.	**3a + 2a =?**		
3)	**a + b = 9 ise a + b + 2 =?**			
4)	i.	 **A=?**	ii.	 **A=?**
	iii.			**Ç =?**
5)	i.	**a = 3b + 2, b = 1 ise a =?**		

	ii.	 **Ç=?**
	iii.	**3a + 2b + a =?**
6)	**a - b + 4 = 40 ise a – b + 4 – 2 = ?**	
7)	**Kenar sayısı bilinmeyen aşağıdaki şeklin her bir kenarının uzunluğu 5 birim ise bu şeklin çevresi kaç birimdir?** 	
8)	**3a – b + a =?**	
9)	**3n' e 4 ekleyin ve sonucu ifade edin.**	
10)	**e + f = 10 ise d + e + f =?**	
11)	**r = u + v , r + u + v=30 ise r =?**	
12)	**c + d = 16 , c < d ise c =?**	
13)	**(a - b) + b = ?**	
14)	**(n+5)' i 4 ile çarpın ve sonucu ifade edin.**	
15)	 **A=?**	
16)	**Tanesi 7 lira olan a tane kalem ile tanesi 3 lira olan b tane silgi kaç lira tutar?**	

17)	**Tanesi 7 lira olan kalemlerden a tane, tanesi 3 lira olan silgilerden b tane aldım ve toplam 80 lira ödedim. Kaç silgi, kaç kalem almış olabilirim?**	
18)	**a + b + c = a + b + d ifadesi her zaman doğru mudur? Neden?**	
19)		**x' in hangi değeri için**
	i.	$(x+1)^2 + x$ **= 41 eder?**
	ii.	$(3x+1)^2 + 3x$ **= 41 eder?**
20)	**2n mi, n+2 mi büyüktür ? Açıklayınız.**	

Appendix B: Algebra Learning Field Attitudes Scale

Sevgili öğrenciler
Bu ölçek sizin matematikte cebir öğrenme alanına yönelik tutumunuzu ölçmek amacıyla hazırlanmıştır. Ölçekte verilen ifadelerin kesin bir cevabı yoktur. Maddelere vereceğiniz cevaplar sizin kendi düşüncenizi yansıtmaktadır. Lütfen bu maddeleri dikkatli bir şekilde okuyunuz ve belirtilen ifadeleri samimi bir şekilde sizin yaşamınızdaki anlam ve önemine göre karşısındaki puanlama cetvelinden duygu ve düşüncenizi en iyi yansıttığını düşündüğünüz seçeneği işaretleyiniz. Bu ölçekte doğru veya yanlış yoktur. Önemli olan sizin gerçek düşüncelerinizdir.

Lütfen her madde için yalnız bir seçeneği işaretleyiniz ve hiçbir maddeyi cevapsız bırakmayınız. İşaretlemelerinizi cümlelerin karşısındaki boşluklardan size en uygun olana (x) koyarak yapınız. Çalışmamıza sağladığınız katkı için teşekkür ederiz.

	Maddeler	**Kesinlikle Katılıyorum**	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç Katılmıyorum**
1	Günlük hayatta karşılaştığım problem durumlarını cebir ifadeleri kullanarak ifade etmeyi severim.					
2	Cebirsel ifadeleri günlük hayatta kullanırım.					
3	Cebir alanına ait konuları öğrenmek her zaman ilgimi çeker.					
4	Cebirsel ifadeleri modellemek cebire karşı ilgimi arttırır.					
5	İçimde cebire karşı aşırı bir öğrenme isteği var.					
6	Cebirin gerçek yaşama uygulaması olan bir alan olduğunu düşünürüm.					
7	Verilen bir matematiksel modellemeyi cebirsel olarak ifade etmek beni heyecanlandırır.					
8	Cebirle ilgili problemleri çözmek beni mutlu eder.					
9	Sınavlarda soruları çözmeye cebire ait konulardan başlarım.					
10	Cebirsel olarak verilmiş bir ifadeyle ilgili matematiksel cümle kurabilirim.					
11	Verilen bir sözel ifadeyi cebirsel olarak ifade etmekte zorlanırım.					
12	Cebir alanına ait konulara çalışmak problem çözme yeteneğimi arttırır.					
13	Cebire ait konulara uğraşmak vakit kaybıdır.					
14	Cebire ait hiçbir konu bana anlamlı gelmez.					

15	Cebirsel ifadelerin matematikten çıkarılması gereklidir.					
16	Matematik dersinde cebirsel ifadelerden sorumlu tutulmak istemem.					
17	Cebir ile ilgili problemler cebire karşı beni soğutur.					
18	Cebire zorunda kaldığım için katlanırım.					
19	Cebirsel ifadeleri yorumlamak hoşuma gidiyor.					
20	Cebir matematiğin öğrenmesi zor alanlarından biridir.					
21	Cebirsel ifadeleri bilmek veya bilmemek çok önemli değildir.					
22	Cebir olmasaydı matematik bir şey kaybetmezdi.					
23	Matematikte sayılar varken harflerin kullanılması bana saçma gelir.					
24	Cebir konularının işlendiği matematik derslerine katılmaktan zevk duyarım.					
25	Cebirsel ifadeleri modellemek bana anlamsız gelir.					
26	Cebir sorularını çözememek beni korkutmaz.					
27	Cebirle ilgili problemleri yapamamak beni endişelendirir.					
28	Cebir ile ilgili soruları çözememek beni umutsuzluğa düşürür.					

Appendix C: Mathematical Literacy Self-Efficacy Scale

Değerli Öğrenciler;

Aşağıdaki soruları dürüst ve samimi olarak cevaplamanız çalışmanın güvenirliliği açısından önem taşımaktadır. Her bir ifadeyi dikkatlice okuduktan sonra verilen ifade ile ne kadar uzlaştığınızın veya ayrıldığınızın derecesini ifadenin karşısına yalnız bir kutucuğa (x) sembolü koyarak işaretleyiniz. Vereceğiniz cevaplar bilimsel bir araştırmaya ışık tutacağından boş bırakmamanızı önemle rica ederiz. Katkılarınız için teşekkür ederiz.

ORTAOKULMATEMATİK OKURYAZARLIĞI ÖZYETERLİK ÖLÇEĞİ	**Tamamen Katılıyorum**	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç Katılmıyorum**
Matematiksel Beceri Boyutu					
1. Matematiksel dili kullanarak ispat yapabilirim.					
2. Verilen bir ifadeyi matematiksel dili kullanarak açıklayabilirim.					
3. Bilimsel olaylarda matematiksel ilişkileri görebilirim.					
4. Günlük yaşantımda gerçekleşen olaylar arasındaki matematiksel ilişkileri görebilirim.					
5. Farklı derslerde karşıma çıkan durumlarda matematik kullanabilirim.					
6. Sosyal ve güncel olaylarda matematik kullanma becerisine sahibim.					
7. Yaşam içindeki her türlü probleme matematiksel yaklaşımla çözüm önerileri getirebilirim.					
8. Farklı şekillerde sayısal modeller düzenleyebilirim.					
9. Matematiksel düşüncelerimin ifadesinde matematiksel dili kullanabilirim.					
10. Günlük yaşantımdaki bir olayı/durumu test ederken olayı/durumu denklem olarak ifade edebilirim.					
11. Günlük yaşantımdaki bir olayı veya durumu test ederken örüntü, tablo ya da grafik gibi matematiksel model kurabilirim.					
12. Karşılaştığım bir olayı ya da bir problemi matematik dilinde ifade edebilirim.					
13. Günlük hayattaki bir problemin çözümünde doğru olan matematiksel yöntemi seçebilirim.					

14. Günlük yaşantımdaki bir olayı veya durumu test ederken matematiksel araç ve gereçleri kullanabilirim.					
15. İki şehir arasındaki mesafeyi harita kullanarak bulabilirim.					
Kişisel Deneyim Boyutu					
16. Matematik çalışırken kendime olan güvenimin azaldığını fark ederim.					
17. Herhangi bir durum/olayda matematiksel iletişim kurmada zorlanırım.					
18. Problem çözerken yanlış yapıyorum duygusu taşırım.					
19. Günlük yaşantımda matematiğe ihtiyaç duymayacağıma inanırım.					
20. Geometrik kavramları algılamakta güçlük çekerim.					
21. Güncel olaylarda matematiksel ilişkileri fark edemem.					
Bilimsel Modelleme Boyutu					
22. Karşılaştığım grafikleri okumakta zorlanmam.					
23. Farklı şekillerde tablo oluşturabilirim.					
24. Farklı şekillerde örüntüler oluşturabilirim.					
25. Farklı şekillerde grafik oluşturabilirim.					
Sosyal Bağlam Boyutu					
26. Günlük yaşantımdaki bir olayı/durumu test ederken önemli değişkenleri belirleyebilirim.					
27. Bilgiye dayalı kararlar verirken verilen bilgileri analiz edebilirim.					
28. Günlük yaşantımdaki bir olayı veya durumu test ederken fazladan verilen bilgileri sadeleştirebilirim.					
29. Şekil-uzay ile ilgili deneyimleri duyularımı kullanarak tanımlayabilirim.					
30. Zaman-hareket ile ilgili deneyimleri duyularımı kullanarak tanımlayabilirim.					