Investigation of the solutions to the problems in the Equations and Inequalities subject in the ninth Grade Mathematics Textbook in terms of Developing Students' Metacognitive Skills and Motivation

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Abstract: *The aim of this study is to examine the problem solutions in the Equations and inequalities topic in the ninth grade Mathematics Textbook in terms of developing students' metacognitive skills and motivation. The study method is qualitative research and the research pattern is document analysis. The textbook distributed to ninth grade students by the Ministry of Education in the 2022-2023 academic year was used as the data collection tool. 23 problem solutions related to the subject were examined in the secondary school ninth grade Mathematics Textbook. The analysis of the data was done with the descriptive analysis method. As a result of the analysis of the data, it was concluded that the correct approach was followed in terms of improving metacognitive skill levels in the problem solutions in the textbook. In addition, it was determined that the solutions were weak in terms of providing motivation.*

Key Words: Textbook, problem solving, metacognitive skills, motivation.

1. INTRODUCTION

It cannot be considered independently of the changes taking place around the individual. Therefore, education systems and learning theories that center on "individuals" must also keep up with change and adapt to the environment. Of course, this is not defined as intelligence for education systems, but it can be expressed as the success criterion of the system. In this context, learning approaches that care about raising individuals who are aware of their own learning, have developed problem-solving skills, take responsibility for their own learning process, question, have time and process management, are productive and active in the learning process have also come to the fore. At this point, we encounter the concept of metacognition. According to Flavell (1976), metacognition means the individual's cognitive processes and the output, product, and knowledge of them as a result of these processes. Welton and Mallan (1999) define metacognition as a structure in which the individual controls and interprets thinking processes and reflects on and evaluates the process. According to Baltacı and Akpınar (2011), metacognition; It is all of the cognitive abilities and skills that enable being aware of one's own mental actions throughout the learning activity and actively monitoring, managing and evaluating the entire process. Metacognitive skills consist of four different sub-dimensions. These; forecasting, planning, monitoring and evaluation (Baloğlu and Demir, 2017). In this process, the individual is expected to focus his attention on a task, make predictions, plan the work to be done, monitor and evaluate the entire process, and make various corrections (Öztürk, 2017). Estimation directs the student to think about the goals of the learning process, how long the process will take, and the consequences; Planning gives the student the message of what information can help him/her in the learning process and what he/she should do first. The application gives the student ideas about whether he is progressing correctly in his learning process, what he should do next, and what he should change. Evaluation; It enables

the student to question whether he/she did everything correctly and what he/she learned from the learning process (Özsoy, 2008). Due to the contributions of metacognitive skills to the student, teaching these skills is thought to be important. Various strategies are available for teaching metacognitive skills. These are role-playing; examining, asking questions, reading, explaining, repeating; Many examples of strategies can be given, such as mutual teaching (Doğan, 2013). Schonfeld (2002) argued that problem solving and problem solving stages should be included in lessons in order to develop metacognitive skills. Because at each step of the problem solving stages, the student develops high-level cognitive processes such as logical, analytical, pragmatic and creative thinking (Arıkan and Ünal, 2012).

During problem-solving activities, one of the things that should not be forgotten is not to neglect the factors that affect problem-solving ability. Factors affecting problem solving ability are grouped under the headings of cognitive, affective and experience. These three factors also affect the student's success in problem solving. Motivation is seen among affective factors. Motivation is one of the affective features that affects an individual's success and is the most important (Salwa, Nurhuda and Azlin 2021).

Motivation is a force or stimulus that pushes an individual to take action, therefore it plays an effective role on the direction, intensity and determination of behavior (Acat and Köşgeroğlu, 2006; Duy, 2011). Motivation increases student performance (Funa, Gabay and Ricafort 2021). It is very important to have motivation in all subjects, including mathematics. Motivation towards mathematics refers to students' willingness to learn mathematics and includes their active participation in mathematics-related studies (İspir, Ay and Saygı, 2011). Therefore, it is necessary to consider motivation. Another thing to consider is textbooks. According to teachers, textbooks should be arranged in accordance with the curriculum, should be able to present the content in an orderly, gradual and complete manner, and should also be a powerful tool that includes homework to be given to students. From this perspective, it is stated that textbooks are an important guide for teachers (Altun, Arslan and Yazgan, 2004). Therefore, it is of great importance that textbooks are qualified in every aspect.

When we look at the literature, it can be seen that many studies have been conducted on metacognitive skills. In the study titled The effect of metacognitive strategies application on students' reading comprehension success, it was revealed that metacognitive strategies have an effect on students' reading comprehension success (Muhid, Amalia, Hilaliyah, Budiana and Wajdi, 2020). In the study examining the effect of teaching metacognitive strategies on the mathematical reasoning skills of fifth grade primary school students, positive results were obtained. It was concluded that teaching with metacognition strategies is effective in developing students' mathematical reasoning skills (Pilten, 2008). In the study examining the effects of different teaching strategies on metacognition skills and academic performance, it was recommended to use such activities in lessons (Langdon, Botnaru, Wittenberg, Riggs, Mutchler and Syno, 2019). In their study, Kahramanoğlu and Deniz (2017) examined the relationship between secondary school students' metacognitive skills, mathematics self-efficacy and mathematics achievement, and revealed that there was a significant relationship between variables related to students' metacognitive skills and mathematics self-efficacy beliefs and mathematics achievement. Tuncer and Kaysi (2013) examined the metacognitive thinking skills of teacher candidates. Comparisons made according to the department in which teacher candidates studied showed that there were significant differences in terms of metacognition skills.

When studies on motivation are examined, it has been revealed that mathematics motivation and mathematics achievement affect each other and that there is a

positive and significant relationship between them (Eklöf, 2007; Kesici and Aşılıoğlu, 2017; Shores and Shannon, 2007; Üredi and Üredi, 2005). Regarding the textbook review, in the study titled Examining the abstraction skill in secondary school mathematics textbook activities, it was concluded that there is no abstraction skill in the textbook activities (Kılıçoğlu,2020). Şirin and Yıldız (2020) examined the 8th grade mathematics textbook according to PISA basic mathematics skill levels and emphasized that, based on the research results, the questions in the mathematics textbook should be prepared to consist of the questions included in the PISA application exams. Haggarty and Pepin (2002), in their research in which they tried to reveal the similarities and differences of secondary school mathematics textbooks from England, France and Germany, stated that the books of the three countries show similarities and differences in various aspects. Randahl (2016) examined the mathematics book used by engineering students in their courses and stated that the examples and questions in the book were at an operational level.

It was observed that metacognitive skills, motivation and textbooks were not examined in relation to each other. In this study, it is thought that it is important to fill the mentioned gap. Additionally, one of the desirable qualities of a textbook is that it develops metacognitive skills and motivation. In the study, the textbook will be evaluated in terms of developing metacognitive skills and motivation, and a photograph will be created. On this occasion, we believe that by providing information to our textbook authors, more qualified textbooks will be produced.

Therefore, the purpose of our research is to examine the solutions to the problems in the Equations and Inequalities subject in the ninth Grade Mathematics Textbook in terms of improving students' metacognitive skills and motivation. Since there are many solutions to the problems in the textbook on Equations and Inequalities, only the solutions to the problems related to this subject have been investigated.

In the research, to what extent do the solutions to the problems in the Equations and Inequalities subject in the ninth Grade Mathematics Textbook contribute to the development of students' metacognitive skills and motivation? The answer to the problem question has been sought. Two sub-problems were created for this problem.

1. How should the solution stages of the problems in the Equations and Inequalities lecture in the Ninth Grade Mathematics Textbook be evaluated in terms of developing students' metacognitive skills?
2. Are the solution stages of the problems in the Equations and Inequalities subject in the Ninth Grade Mathematics Textbook arranged in a way that will motivate the students?

2. METHODOLOGY

2.1. Model of the Research

The method of this study is qualitative research. The research design is document analysis. Document review is the analysis of written materials containing information about the facts and facts that are desired to be investigated (Yıldırım and Şimşek, 2021).

2.2. Data collection tool and analysis

In the study, the High School Ninth Grade Mathematics Textbook distributed by the Ministry of National Education in Turkey and taught in 2022-2023 was used. The data of the study consists of 23 problem solutions in the High School Ninth Grade Mathematics Textbook. Of the 23 problems, four are ratio-proportion, two are Equation Formation, three are age, two are percentage, two are profit-loss, two are

mixture, two are work-worker, three are speed and motion, and three are non-routine problems. There are solutions to 23 problems in the book. In the solution of each problem in the book, the sections Let's Understand the Problem, Plan, Implement the Plan and Evaluation are given in detail.

For the analysis of the data, criteria for developing metacognitive skills and providing motivation were prepared by the researchers. The document examined in the research was analyzed according to the descriptive analysis method. Descriptive analysis is a qualitative analysis method based on summarizing and interpreting the data according to previously determined categories (Yıldırım and Şimşek, 2021).

The criteria for developing metacognitive skills in problem solving stages have been prepared in line with the information below.

Every activity that students will do in each of the problem solving stages will lead them to think deeply and cause them to question themselves (Özsoy, 2006). As long as questioning develops in students, they will assume the same responsibilities in the learning task given to them or that they want to do, that is, in metacognition (Akın and Abacı, 2011). Responsibilities gained in problem solving may lead to the formation of metacognitive skills.
These responsibilities cause students to ask themselves the questions “What do I know about the problem?, What are the given and requested?, How long will it take to solve the problem?” in the understanding the problem stage.
Let's understand the problem, the first stage of metacognitive skills, estimation "What do I know about this topic? How long will it take me to learn this topic?" develops.
In the problem planning stage, the student asks himself "How should I make a plan that will lead me to the right solution?" In the planning stage, the second stage of metacognitive skills, "What kind of plan should I make to learn the topic?"
In the plan implementation stage of the problem solving stage, the question "Is the plan I am implementing appropriate?" brings with it the question "Will the plan I made to learn this topic reach my goal?" in the monitoring stage, the third stage of metacognitive skills.
In the last step of the problem solving stage, which is the checking stage, a student who is interested in the question "Did this solution lead me to the right result?" asks himself/herself the question "What did I learn? Does the product I obtained meet my expectations?" at the end of the learning process in the evaluation stage, which is the last stage of metacognitive skills (Senemoğlu, 2000; Özsoy, 2006). Based on this idea, it was decided that the problem solving stage develops the first step of metacognitive skills, estimation, in the understand the problem stage; the second step of metacognitive skills, planning, in the make a plan stage; the third step of metacognitive skills, monitoring, in the implement the plan; and the last step of metacognitive skills, evaluation, in the check stage. The solutions of the problems were analyzed by writing the metacognitive skills they developed against the solution stages of all problems. An analysis example of a problem is given in Table 1 for the reader to understand better.

Table 1

An example of analysis of a problem

Problem: The high-speed train moving between Konya and Ankara reaches Ankara in 1.5 hours at an average speed of 200 km/h. If the high-speed train were to travel the same distance at an average speed of 150 km/h, how many hours would it take to reach Ankara?

Problem Solving Stages	Metacognitive Skill Stages
Let's Understand the Problem: Given: The train travels 1.5 hours between Konya and Ankara at an average speed of 200 km. Requested: How long will The train travel between Konya and Ankara at an average speed of 150 km.	**Forecasting:** "What do I know about this subject? How long will it take to learn this subject?"
Plan: As the speed of the train decreases, it will take longer to reach Ankara, so there is an inverse proportion between speed and time.Therefore, since the distance between Konya and Ankara will not change, multiplying the speed and time will remain constant. Here, the multiplication of the speed of the train and the time is equalized and how much is it when it travels at a speed of 150 km? It is found on time to go.	**Planning:** "What plan should I make to learn the subject?"
Implement the Plan: If it arrives in 1.5 hours at a speed of 200 km Arrives in x hour at a speed of 150 km 200 .1.5 = 150.x 300 = 150.x x = 2 hours is obtained.	**Monitoring:** "Will the plan I made to learn this subject lead me to my goal?"
Evaluation: If 6 workers weave 20 square meters of carpet in 10 days 4 workers will weave x square meters of carpet in 12 days. 20 .4. 12 = x..6. 10 x = 16 is obtained, which is correct.	**Evaluation:** "What did I learn, does the product meet my expectations?"

The criteria for the motivation of the students in the problem-solving stages have been prepared in the light of the following information. Course materials that provide many benefits to the student (Johnson, 2012) are classified as visual, auditory, audio-visual and technology-supported tools. Textbooks, like other materials, contain physical stimuli and are visual tools. The vast majority of teachers accept the textbook as a curriculum program and organize the teaching-learning process in parallel with the general structure of the book and the narrative techniques it contains (Güneş and Çelikler, 2010). Therefore, it is impossible for the teaching-learning process not to be affected by the features of the books. (Kılıç, Kılıç and Akan, 2021; Hong, Huang, Hsu and Shen, 2016).

Student motivation, which is among the basic dimensions of the teaching-learning process, can be affected by textbooks and motivation can be provided in this way. Sun (2010) stated that motivation depends on the content of the books and the features they carry. Based on the idea that textbooks are a motivation tool, the answer to the question "What are the features of the problem solving stages in the textbook that motivate the student?" was sought.

Keller (1987) stated in his motivation model, which he developed and explains the ways to motivate students, that students should be given the opportunity to solve problems that will develop their active thinking skills. In this process, students should be given the necessary clues and made to work on the solution stages in order to reach the result (Kutu and Sözbilir, 2011). The solution stages of the problems should cause the student to think and work on the ways to reach the solution. Students should feel that they have an effect and dominance while solving the problem. Students should be provided with control and autonomy over the problem solving stages.

Each problem stage should arouse curiosity in the student and lead the student to innovations by providing experiences different from existing ideas (Akbaba, 2006). For these reasons, in order to reveal whether the problem solving stages motivate the student, three criteria were determined: the first criterion is that the solution stages should challenge the student; the second criterion is that the student should be able to provide control and autonomy over them; and the third criterion is that the student should be curious and lead them to innovations.

In line with the explanations provided, the problem solving stages were examined according to these criteria in providing student motivation. In the Equations and Inequalities in the Ninth Grade Mathematics Textbook, the criteria for the development of metacognitive skills and motivation in the problem solving stages were determined by consulting expert opinions and the researchers gave their final forms. In order for the research to be credible, the researchers took care to reflect the truth and to have the research process evaluated by experts. While obtaining the research findings, the researchers tried to convey the truth as it is, completely impartially.

In this study, the solution stages of 23 problems in the textbook were analyzed according to the metacognitive skill development criteria determined by two experts. As a result of the analyzes, the agreement between the coders was calculated with the Miles and Huberman (1994) agreement percentage formula and was found to be approximately 89%. Again, the solution stages of 23 problems were examined one by one by two experts, and analyzes were made to determine whether the criteria determined to provide motivation to the student were present in the stages. As a result of the analyzes, the agreement between the coders was calculated with the Miles and Huberman (1994) agreement percentage formula and was found to be approximately 87%. Coefficients above 0.70 are considered reliable (Şimşek and Yıldırım, 2021)

3. FINDINGS

In this section, findings related to the first and second sub-problems have been tried to be given.

3.1. “How should the solution stages of the problems in the Equations and Inequalities subject explanation in the ninth grade Mathematics Textbook be evaluated in terms of developing students’ metacognitive skills?” Findings related to the first sub-problem

Four problems related to ratio-proportion; two problems related to equations and inequalities, two equation formation, three age, two percentage, two profit-loss, two mixtures, two work-worker, three speed and motion, and three non-routine problems in the Equations and Inequalities subject explanation in the ninth grade Mathematics Textbook have been analyzed according to the criteria of developing metacognitive skills and findings have been tried to be given.

Tablo 2

Stages of Problem Solving Related to Ratio-Proportion and Metacognition Skills Stages

Ratio-Proportion Problems	Problem Solving Stages				Metacognition Skill Stages			
	Understand the Problem	Devising a Plan	Implement the Plan	Evaluation	Forecasting	Planning	Monitoring	Evaluation
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Problem 3	✓	✓	✓	✓	✓	✓	✓	✓
Problem 4	✓	✓	✓	✓	✓	✓	✓	✓

Table 2 was created according to the data collection tool specified in Table 1. When Table 2 is examined, in the solution of four problems related to Ratio and Proportion in the textbook, there are the problem solving stages of "understand the problem, make a plan, apply the plan and check". It is seen that problem solving stages can improve the metacognitive skills "Prediction, planning, monitoring and evaluation" stages.

Table 3

Equation Formation and Age-related problem solving stages and metacognitive skill stages

Establishing Equations Problems	Problem Solving Stages				Metacognition Skill Stages			
	Understand the Problem	Devising a Plan	Implement the Plan	Evaluation	Forecasting	Planning	Monitoring	Evaluation
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Age Problems								
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Problem 3	✓	✓	✓	✓	✓	✓	✓	✓

As can be seen from Table 3, in the textbook, there are two stages of Establishing an Equation and three stages of Let's understand the problem, make a plan, implement the plan and check, which are the problem solving stages of Age problems. It is observed that as a result of the existence of the stages, all stages of metacognitive skills can be developed.

Table 4

Stages of Solving Problems related to Percentage and Profit-Loss and Stages of Metacognition Skills

	Problem Solving Stages				Metacognition Skill Stages			
Percentage Problems	Understand the Problem	Devising a Plan	Implement the Plan	Evaluation	Forecasting	Planning	Monitoring	Evaluation
Problem1	✓	✓	✓	✓	✓	✓	✓	✓
Problem2	✓	✓	✓	✓	✓	✓	✓	✓
Profit-loss problems								
.Problem1	✓	✓	✓	✓	✓	✓	✓	✓
.Problem2	✓	✓	✓	✓	✓	✓	✓	✓

Table 4 provides information about the problem solving stages and metacognition skill stages of solving problems related to Percentage and Profit-Loss. In line with this information, the problem solving stages of solving problems related to Percentage and Profit-Loss are included in the textbook. In parallel with this, it is understood that the stages of "prediction, planning, monitoring and evaluation" can develop metacognitive skills in students.

Table 5

Stages of Problem Solving related to Mixture And Job-Worker And Stages of Metacognition Skills

	Problem Solving Stages				Metacognition Skill Stages			
Mixture Problems	Understand the Problem	Devising a Plan	Implement the Plan	Evaluation	Forecasting	Planning	Monitoring	Evaluation
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Job-Worker problems								
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓

Table 5 tells us that the problem solving stages of Mixture and Worker-Worker related problems are found in the textbook. According to the information in the data collection tool, it was found that the stages of problem solving were included in the book, and therefore the stages of prediction, planning, monitoring and evaluation of metacognitive skills could be improved.

Table 6

Speed and Movement, Stages of Non-routine Problem Solving and Metacognitive Skill Stages

Speed and Movement Problems	Problem Solving Stages				Metacognition Skill Stages			
	Understand the Problem	Devising a Plan	Implement the Plan	Evaluation	Forecasting	Planning	Monitoring	Evaluation
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Problem 3	✓	✓	✓	✓	✓	✓	✓	✓
Non-routine Problem Solutions								
Problem 1	✓	✓	✓	✓	✓	✓	✓	✓
Problem 2	✓	✓	✓	✓	✓	✓	✓	✓
Problem 3	✓	✓	✓	✓	✓	✓	✓	✓

According to the information given in Table 6, the problem solving stages of Speed and Motion and Non-Routine problem solutions are included in the textbook. With the replacement of problem solving stages, it has been revealed that metacognitive skills can be developed through the stages of prediction, planning, monitoring and evaluation.

“Are the solution stages of the problems in the Equations and Inequalities subject in the Ninth Grade Mathematics Textbook arranged in a way that will motivate the students?” Findings regarding the second sub-problem

Four related to ratio-proportion in the Equations and Inequalities topic in the Secondary Education Ninth Grade Mathematics Textbook; Solutions of 23 problems related to equations and inequalities, including two problems of establishing an equation, three of age, two of percentage, two of profit and loss, two of mixture, two of work and worker, three of speed and motion, and three of non-routine problems, meet the criteria determined to motivate the student. The findings were tried to be given by analyzing them accordingly.

The solution stages of 23 problems, the first criterion in ensuring student motivation is that the determined solution stages bother the student; The second criterion is that the student can maintain control and autonomy; It was examined one by one according to three criteria, the third criterion being the ability of the student to be curious and lead to innovations. Apart from reading and understanding the problem stages, no findings were found that would enable the

student to struggle. It was observed that the student was not given any tasks regarding control and autonomy over the problem solving stages. It was observed that the problem stages were not arranged in a way that would arouse curiosity and create innovation in the solution of each problem.

4. Conclusion

In this section, results and discussion regarding the findings are included.

In the study, results were obtained that support the studies in the literature. Metacognitive skills can be developed in students with the right resources and correct guidance (Akın and Abacı, 2011). One of the ways to develop metacognitive skills is to allow students to use strategies both in and outside the classroom (Schraw, Horn, Thorndike-Christ and Bruning, 1995). One of the resources that offer this opportunity is textbooks. (Cross and Paris,1988, cited in Schraw,1998). Textbooks can be prepared in a way that can develop the metacognitive skill levels of prediction, planning, monitoring and evaluation. When the textbook was examined, the solution stages of the problems in the Equations and inequalities topic in the Ninth Grade Mathematics Textbook were presented to the students and it was seen that the level of development of metacognition skills was high.

The solving stages of the problems in the Equations and Inequalities course in the Ninth Grade Mathematics Textbook are not arranged in a way that will motivate the student. According to the "Challenging, Control and Autonomy, Curiosity and Innovation" criteria determined in the study to motivate the students, the solution stages of all problems were not prepared to provide motivation. The task given to the student was to simply read and understand the problem stages. In the problem solving stages, instead of giving the student the opportunity to think about certain parts of the solution stages by giving necessary clues, the solution stages were given directly to the student. In his study comparing Turkey and the United States 5th Grade Mathematics Coursebook samples, Yağan (2020) shared the conclusion that in the solved questions in the textbook in Turkey, solutions are presented directly instead of reaching conclusions with hints. This situation negatively affects the student's motivation for the course.

Low motivation not only hinders the student's desire to learn, but also puts the teacher in a difficult situation in the process of teaching and learning. The teacher teaches the lesson without motivation, which is one of the basic dimensions of the teaching and learning process.

If the problem-solving stages are created in a way that motivates the student, the student will focus on the lesson and the metacognitive skills development feature of the book can be more effective on students.

In line with these results, our recommendations are given below.

Textbooks, as here, should be prepared to develop metacognitive skills. Regarding the subject of the research, arrangements should be made to increase student motivation. One or two examples of problem solving stages can be given directly to the student as an example, but not all of them should be given. During the problem solving stages, some stages should be left blank and the student's thoughts on the subject should be included with encouraging titles such as "It's your turn". Students should be asked to determine the solution stages by finding other alternative solutions. You may be asked about the positive and negative aspects of some parts of the problem solving stages in solving the problem correctly. They may be asked to establish relationships between the solution stages of similar problems.

Additionally, the level of developing metacognitive skills and providing motivation can be evaluated for different grade levels or different subjects.

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