Examining The Problem Solving Skills and The Strategies Used by High School Students in Solving Non-routine Problems

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Abstract

The main purpose of this study was to investigate how well certain students in a high school solve non-routine problems. These problem situation required the use of their conceptual understanding of mathematics and their procedural knowledge of the algorithm involved in the solution. Results of analysis of students' solutions showed that each student employed at least three problem solving strategies. Nine out of the ten possible problem solving strategies were used at least once to solve the eight non-routine problems. The most frequently used strategies were making systematic list, looking for patterns, logical reasoning and making a model or diagram. Those who performed well were also proficient in the use of solution strategies.

Keywords: *Mathematics education, Non-routine problem, Problem solving strategy*

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Introduction

Problem-Solving may appear at any point in our lives. For example, when you are thinking where to stay on holiday or when you want to organize a surprise birthday party or when you are considering which route to take to travel to a city to which you have never traveled before, you definitely make use of Problem-Solving steps. When individuals face Problem-Solving process, which is included within life at a very high rate, at school, they also face several difficulties. According to NCTM (The National Council of Teachers of Mathematics), Problem-Solving skill is among the most important skills in which mathematical knowledge and skills are used at the highest level (Cai and Lester, 2010). Problem-Solving is an important skill student must have when they start life after graduation (Krulik and Rudnick; 1996). It is among the skills that are aimed to be developed as of basic education years. Verbal problems are one of the areas that contribute to the development of this skill at the highest level. When solving these problems, students not only make use of their existing mathematical knowledge but they also develop them (Wyndhamn and Saljö, 1997).

Problem-Solving process is explained as a complex process that requires many skills to be used together. The elements of this process are Understanding the Problem, Choosing the Necessary Information among the Given Choices, Converting the Obtained Information into Mathematical Symbols and Reaching the Solution after Performing the Necessary Operations. These elements do not follow a linear route (Olkun and Toluk, 2004). The first step of Problem-Solving is understanding what is read, and when this step is not achieved, it is considered that the individual will reach meaningless results by using the numbers given in the problem in a random manner (Artzt and Thomas, 1992; Goos, Galbraith and Renshaw, 2000; Mayer, 1985; Polya, 1997).

When the literature is reviewed, two types of problems are observed: Routine (Ordinary) problems and non-routine problems (Altun; 1998). Routine problems may be solved with a formula, equation or with a known method (Polya; 1957). Routine problems are the ones that help to establish a connection between mathematical knowledge and life (Xin, Lin, Zhang and Yan, 2007).

Mathematics instructors agree in that routine problems are as important as non-routine problems in teaching Problem-Solving. When the literature is reviewed, it is observed that generally non-routine problems develop the Problem-Solving skill and this skill develops the skill of using them in real life situations (Polya, 1957; Schoenfeld, 1992; London, 2007).

Non-routine problems are the ones whose results cannot be guessed in advance. They cannot be solved with a known method or formula. Analysis, synthesis, trial-error and creative enterprise are needed to solve them (Tarım and Artut, 2009; Woodward, Beckmann, Driscoll, Franke, Herzig, Jitendra, Koedinger, & Ogbuehi, 2012). Upper-level thinking skills and reasoning are important in solving these problems. In addition, mastery is also necessary in procedural skills (Elia, Van den Heuvel-Panhuizen, Kolovou, 2009). According to Inoue (2005), non-routine problems disrupt the cognitive balance and force the students in mental terms. Polya stated that teaching how to solve routine problems was important in order to develop Problem-Solving skills; however, he also added that nonroutine problems should also be included in teaching in order to develop critical thinking and creative skills. Furthermore, since non-routine problems require that one or two of Problem-Solving strategies are used, this is also beneficial in this aspect. For this reason, it helps to develop critical and creative thinking (Mabilangan, 2011).

In solving Non-routine problems, the thoughts and approaches used in solution process are more important rather than achieving the accurate answer (Mayer, Sims and Tajika, 1995). In other words, how the result is achieved is much more important (the strategies used, logical predictions about the result, etc.). Non-routine problems require that the skills and knowledge of individuals are used in extra-ordinary ways. In solving such questions, it is important that self-corrections are made when necessary, meta-cognition is used and the solution process is run in a controlled manner (Hartman, 1998; Nancarrow, 2004). The characteristics of Non-Routine Problems may be listed as follows (London, 1993):

- Such problems require that three steps are fulfilled: recognition-understanding of the problem, and adopting it to the individual, trying solution methods, being persistent to solve the problem.
- Such problems are open-ended; they allow different kinds of solutions.
- Student may approach the problem in a different manner, seek alternative solutions, and become aware of his/her potential to produce different solutions.
- Such problems require high-level thinking skills.
- In order to solve such problems, the contents of the problem must be selected from among the subjects learnt by each student.

Baki and Kartal (2004), Kaur and Yeap, (2009); Teong (2000) and Polya (1997) emphasized that different types of problems, i.e. non-routine problems would contribute more to the development of students rather than the same kind of problems i.e. routine problems. Procedural skills are not adequate to solve non-routine problems, it is also necessary to have some additional skills and processes like organizing the data, classification, seeing the relations, adopting them to real life and Problem-Solving strategies, which require thinking (Altun, 2005; Yazgan, 2007). Kaur and Yeap (2009), on the other hand, the authors stated that both problem types are beneficial in different stages of education; and routine problems should be made use of when teaching a topic for the first time, and non-routine problems should be involved for conceptualization.

Any student can solve problems. The solution emerges in agreement to the skill and effort of the student. The best solutions are made by students who can use the best strategy by evaluating the problem. Each problem requires consideration and effort for a long time. After this effort is given, which corresponds to a few hours a week, the student will write the result with its reasons (London, 1993). For this reason, if a student cannot solve a problem, s/he must be given problems ranging from simple ones to complex ones, and it must be ensured that the student focuses on the solution without any time limits.

Previous studies had proofs saying that using strategies facilitated reaching solutions in Problem-Solving process (Elia, Van den Heuvel-Panhuizen, & Kolovou, 2009). The most frequently observed strategies in the literature are as follows: Looking for Patterns (LP), modeling, finding pattern-relations, making systematic lists, reverse working, guessing and checking, writing equations, simplifying the problem, making tables, eliminating possible situations, thinking in a logical way, and making estimations (Altun, Bintas, Yazgan & Arslan, 2007**;** Herr & Johnson, 2002; Leng, 2008; Posamentier & Krulik, 2008; Posamentier & Krulik, 2009).

Non-routine Problem-Solving strategies are based on discovering, analyzing and on the struggle to produce a formula to solve. These are the processes that have vital importance for a student in solving non-routine problems. Teaching these strategies to students or not, or how to teach them to students have constantly been debated among mathematics instructors. However, instead of teaching the strategies to students, or in other words, telling the names of the strategies and how to use them to students, bringing a non-routine problem to the

classroom and letting students tell the solution ways may be more beneficial and more instructive (Boesen, Lithner & Palm, 2010; Nancarrow, 2004). Non-routine problems require that individuals use their skills and knowledge in unusual ways. It is important that the solution processes of such questions are run in a controlled manner, and individuals use their knowledge and skills in an unusual way. It is also important that the solution process of such questions are run in a controlled manner, and self-corrections are made when necessary (Hartman, 1998; Nancarrow, 2004).

Polya (1957) claimed that not introducing non-routine problems to students was an unforgivable mistake, and added that it was a necessity to include these problems in Mathematics education. Polya also claimed that routine problems could not improve the imagination of students because that had mechanical solutions, and said that a successful Problem-Solving process could be achieved in four steps :

-Understanding the problem
-Choosing the strategy to be used
-Solving the problem
-Checking the Problem

The strategies used in Problem-Solving process and their definitions are given by Krullik and Rudnick (1996) as follows:

1. Calculating or Simplifying (CA); involves using arithmetic rules directly.
2. Using Formula (UF); involves using a ready-made formula or formulating the given ones.
3. Making Model or Diagram (MD); involves using objects, drawing, animating.
4. Making a Table, Chart or List, etc. (TCL); involves using tables, etc. to organize data.
5. Guessing, Checking, and Revising (GCR); involves estimating the results, and checking the accuracy. If there is mistake, it requires that the estimation is re-organized and checked.
6. Thinking about Simple Situations (TSS); involves the re-writing of the problem in a simpler way. In this way, the problem is converted into a previously-solved-usual problem to find the solution. When possible, working-backwards is also included in this strategy.
7. Elimination (E) involves the elimination of the wrong answers and the ones that may possibly be wrong, or eliminating when the data and the solutions do not comply.
8. Looking for Patterns (LP) involves the generalization of the solution of the problem by seeing and using common properties.

When routine problems are considered in the context of all the above-mentioned strategies, it is noticed that these problems are solved with fewer strategies. This situation poses a barrier in the development of Problem-Solving skills of the students. For this reason, it is important that students are faced with non-routine problems. These problems are suitable to use different strategies. They require that students use upper-level thinking skills (analysis, synthesis, generalization, etc.) in an intense manner (Mabilangan, 2011; Altun, 2005).

The understanding levels of students in non-routine problems were defined by Oregon Educational Faculty (1991) based on three items, which are *Conceptual Understanding*, *Using Operative Knowledge*, and *Problem-Solving Skills and Strategies*. *Conceptual Understanding* is the awareness of student in the relations between mathematical knowledge. Remembering mere methods by students generally produces incorrect results, and makes them reach correct results although they do not know the method. Devlin (2007) stated that *Conceptual Understanding* is the most important part of Mathematics education. In order to achieve *Conceptual Understanding*, it is necessary that students show efforts by applying the rule/method first (Devlin, 2007).

Ben-Hur (2006) defined the use of procedural knowledge as the symbolic representations of the problem, or as the formal language; and stated that this was related with paper, pencil, calculator, computer, etc. Procedural knowledge is the one about how to run the procedures, in other words, it is the process algorithm.

Problem-Solving skills and strategies, on the other hand, are related with the necessary basic thinking skills and upper-level thinking skills. In addition, it is also related with knowing which strategy is useful, and if not, transition to another suitable strategy. In solving problem, it is necessary that student has self-confidence and acts in accordance with Problem-Solving steps (Mabilangan, 2011).

It is known that the countries that are successful in Mathematics in international assessment exams like PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) allocate more time for non-routine problems (Arslan and Yazgan, 2016). In this context, it is observed that the following acquisition is included for 9^{th} Grades in the Mathematics Curriculum Draft for Secondary Education Institutions, which will be renewed soon in our country: Non-routine problem types are included in the curricula and it is ensured that students use different Problem-Solving strategies (Ministry of National Education, 2017). By considering this acquisition, it is possible to claim that students will face non-routine problems more with the new curriculum. With this study, it will be determined how much vocational school students are ready for non-routine problems, although it will be in a relatively smaller perspective. As it is known, students who arrive at vocational high schools are generally the ones who receive lower points from the TEOG Exam (Transition to Secondary Education from Basic Education). Because students who are successful at TEOG prefer Science High schools of other high schools with higher points. According to 2015 YGS (Transition to Higher Education), the average points of students studying at state high schools in Mathematics was 2,92. Based on this, we can conclude that the students studying at vocational high schools are the ones who are unsuccessful at Mathematics.

This study may provide ideas on the Problem-Solving success levels of students in mathematics although it is limited with one single high school. The number of the studies conducted on non-routine problems in secondary education level is extremely limited in Turkey. This study, which was conducted on Vocational High School students, seems to be important in that it provides ideas on the Problem-Solving skill levels of students who are less successful than their peers in transition to secondary education from primary education. In this way, an idea might be obtained about the reasons of the failures of Vocational High School Students in mathematics. In addition, it is also important in that it enables specialists of this field to compare the findings of this study with the results of previous studies by considering the distribution of the strategies used by students in Problem-Solving and their success levels.

The Aim of the Study

It is aimed that the Non-Routine Problem-Solving Skill levels of high school students and the strategies used by them are determined according to their success levels. In order to achieve this, answers for the following questions were sought in the study:

1-What are the performance levels of students in non-routine problems?

a) What are their conceptual understanding levels?

b) What are their procedural information levels?

c) What are their levels in Problem-Solving skills and the strategies used in this process?

2-How is the distribution of strategies used by students according to their success levels?

METHOD

The Method of the Study

This study aims to investigate the non-routine problem-solving skills of high school students and to determine the distribution of their strategies used to solve these problems according to their success status. The study is in the Descriptive Design, which is the requirement of its nature. Since descriptive studies may be quantitative or qualitative, the present study was constructed according to the Case Study Design, which is one of the qualitative research methods. The Qualitative Research Approach was adopted in the present study.

Qualitative studies are preferred because they facilitate making use of the experiences of other people and understanding the feelings and ideas of people who are involved in a study (Ekiz, 2009). The Case Study Design, which is based on this approach, facilitates the investigation of one or more situations in all aspects by using a limited number of sampling (Çepni, 2012). In this study, this method was preferred because the conceptual and operational knowledge and problem-solving skills of students were investigated in detail. Since each student was assessed on his/her own within the context of the study, the Integrated Multi-State Design was also applied in the study, and the results of each student were compared.

The Scope and Limitations of the Study

This study was conducted on 18 voluntary students, who were selected from among 285 students according to success status in Summer Period in Çanakkale Kepez Vocational and Technical Anatolian High School in 2016-1017 Academic Year. The data used in the study were limited with the data collection tool and the scale used in the study.

The Study Group and Study Period

The author of the study made interviews with the students attending to Çanakkale Kepez Vocational and Technical Anatolian High School to introduce the study. Many of the students stated that they did not want to participate in the study because they did not have self-confidence. The author of the study chose 24 students by considering the success levels not the grades of the students. 6 of these students changed their minds when they saw the problems, or gave nearly fully empty papers, and were excluded from the study. 18 students participating in this research have been given the names S_1, S_2, …, S_{18}. Six of the students were 9^{th} Graders, eight of them were 10^{th} Graders, and four were 12^{th} Graders. Some of the 11^{th} Graders would travel abroad in a project, and the remaining students would be involved in intern work period, and therefore did not volunteer to participate in the study. Six of the students who participated in the study were at low success level, six of them were at the medium level, and another six of them were at high success level. The study was conducted by giving 60 minutes to the students during lunch break or in vacant classes when the students were available.

Data Collection Tool

The literature was reviewed, and a problem pool was formed with non-routine problems that were proper for high school level. Each problem was solved by the author of the study by using different strategies, and the strategies that might be used in solving the problems were noted. These solutions were also shown to the mathematics teachers at the same school, and it was discussed whether these problems had other solution ways. As a conclusion, 8 problems

were selected in which different strategies could be used to solve, and the non-routine problem test was formed. The Problem-Solving strategies that might be used in this test and brief explanations are as follows:

Making Systematic List (MSL): Organizing the data in lists.
Guess and Check (GC): Guessing the result, and cross-checking.
Making Model or Diagram (MD): Converting the problem into a scheme or a diagram in a way understood by the student.
Looking for Patterns (LP): Finding relations between the data.
Working Backwards (WB): Solving the problem towards the initial step from the latest.
Writing Equations (WE): Converting the data in the problem into an equation.
Making Tables (MT): Making tables with the data in the problem.
Eliminating Possible Situations (EPS): Eliminating the incorrect results by trying the possible results of the problem.
Simplifying the Problem (SP): Using the solution way of another similar problem that has smaller numbers than the present one.
Logical Reasoning (LR): Making deductions about the result and solution of the problem by considering the data given in it.

Table 1:
Classification of the different levels of conceptual understanding(CU)

Full Conceptual Understanding (Proficient)	**Partial Conceptual Understanding (Apprentice)**	**Lack of Conceptual Understanding (Novice)**
The student uses all relevant information to solve the problem.	The student extracts the "essence" of the problem, but is unable to use this information to solve the problem.	The student's solution is inconsistent or unrelated to the question.
The student is able to translate the problem into appropriate mathematical language.	The student is only partially able to make connections between/ among the concepts.	The student translates the problem into inappropriate mathematical concepts.
The student's answer is consistent with the question/problem.	The student's solution is not fully related to the question.	The student uses incorrect procedures without understanding the concepts related to the task.
	The student understands one portion of the task, but not the complete task.	

In assessing the problems and the strategies, the Oregon Problem-Solving Scale (Oregon Educational Faculty, 1991) was used. The sections and indicators of the Scale are given in Tables 1, 2 and 3. In this Scale, *conceptual understanding*, *using the operational knowledge* and *problem-solving skill* sections were assessed and scored by the author of the study and by another mathematics teacher by considering the *Master*, *Apprentice*, *Novice* level indicators. The scale and the use of it was explained to the second mathematics teachers who worked at the same school with the author of the study, and trials were made on several sample problems. After the author of the study made sure that the second mathematics teachers understood the

scale well, the assessment and scoring was started. The author of the study and the second mathematics teacher assessed the problems in accordance with the Scale, and the scores were then compared. Two scores that were different were compared and converted into one score. There were three scores, which were discussed like this, among the whole scores.

Table 2:
Classification of the use of procedural knowledge(UPK)

Full Use of Appropriate Procedures (Proficient)	Partial Use of Appropriate Procedures (Apprentice)	Lacks Use of Appropriate Procedures (Novice)
The student uses principles efficiently while justifying the solutions.	The student is not precise in using mathematical terms, principles, or procedures.	The student uses unsuitable methods or simple manipulation of data in his/her attempted solution.
The student uses appropriate mathematical terms and strategies.	The student is unable to carry out a procedure completely.	The student fails to eliminate unsuitable methods or solutions.
The student solves and verifies the problem.	The process the student uses to verify the solution is incorrect.	The student misuses principles or translates the problem into procedures.
The student uses mathematical principles and language precisely.		The student solution. fails to verify the solution.

The scoring system used in assessing the Problem-Solving performances of the students are as follows: Proficient 5 points; Apprentice 3 points; Novice 1 point. 2 points were used for the medium point of Novice and Apprentice sections, and 4 points were used for the medium point of Proficient and Apprentice section.

Table 3:
Classification of problem solving skills and strategies(PS)

Thorough/Insightful Use of Skills/Strategies (Proficient)	Partial Use of Skills/Strategies (Apprentice)	Limited Skills/Strategies (Novice)
The skills and strategies show some evidence of insightful thinking to explore the problem.	The skills and strategies have some focus, but clarity is limited.	The skills and strategies lack a central focus and the details are sketchy or nor present.
The student's work is clear and focused.	The student applies a strategy which is only partially useful.	The procedures are not recorded (ie. only the solution is present).
The skills/strategies are appropriate and demonstrate some insightful thinking.	The student starts the problem appropriately, but changes to an incorrect focus.	Strategies are random. The student does not fully explore the problem and look for concepts, patterns or relationships.
The student gives possible extensions or generalizations to the solution or the problem.	The student recognizes the pattern or relationship, but expands it incorrectly.	The student fails to see alternative solutions that the problem requires.

RESULTS AND DISCUSSION

The results of the study have been presented and discussed in three sections in accordance with the aims of the study. In the first section, examples have been given from the problem-solving styles of the students from different performance levels. These examples include different levels of conceptual understanding (CU), use of procedural knowledge(UPK) and problem-solving skills (PS). In the second section, all the performance assessments of all the students are given. In the last section, the strategies used by the students according to their success levels are explained and the relation between them are discussed.

Proficient Level at CU, UPK and PS

Being at Proficient level for CU is related with responding to the problem in full sense in a proper manner, explaining the problem statement in his/her own words, and using all the information in the problem. The solution of the problem by S_7 is given in Figure 1. The student firstly focused on the total time in which Sevgi was at the concert hall and then subtracted it from the end time of the concert. S_7 used the backward working strategy consciously and involved all the information in the problem. After finding the result, the student also did a crosscheck and understood that s/he had reached the definite result. For this reason, S_7 is at the Proficient level in terms of conceptual understanding in this problem.

Problem 1: Sevgi arrived at the concert hall 15 minutes before the concert started. However, the concert started 10 minutes later due to some technical problems, and the whole concert lasted for 2 hours 5 minutes. Sevgi left the concert hall at 22.30; so, what was the time when she arrived at the concert hall? Write clearly all of your thinking styles and the methods you use in solving this question.

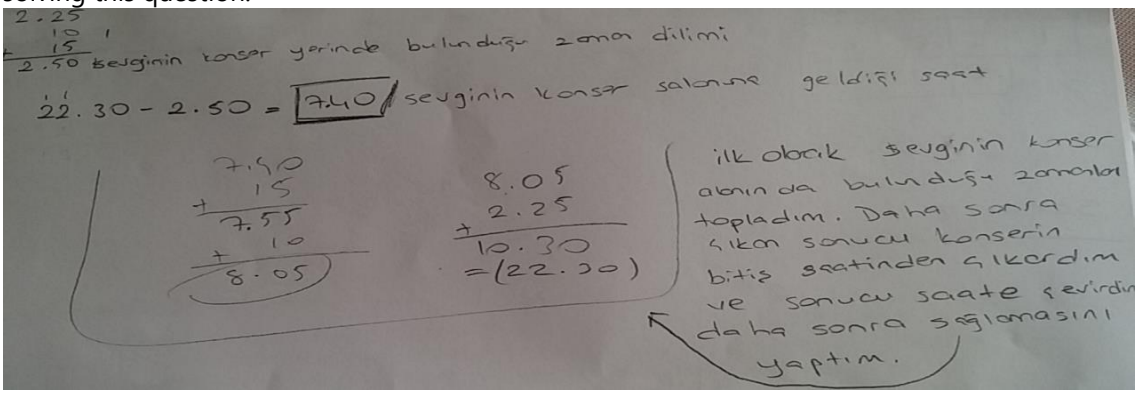

Figure 1: *The Solution of Problem 1 by S_7*

For UPK, being at Proficient level means realizing the procedures in agreement with the rules, using proper terms and strategies at the right time and place, understanding Mathematical language in an accurate manner, and reaching a perfect solution.

The solution of the problem by S_2 is given in Figure 2. In this solution, S_2 is at Proficient level for this problem in terms of procedural knowledge. The student drew a scheme and a shape and understood the core point of the problem, and then started to solve it. The student made accurate operations, and in the end, s/he made a cross check to be sure.

Problem 2: A cat is chasing a rabbit on a long road. There are 160 m difference between each other in initial status. When the cat runs for 9 meters, the rabbit jumps for 7 meters forward. Under these circumstances, how many meters must the cat run to catch the rabbit? Write clearly all of your thinking styles and the methods you use in solving this question.

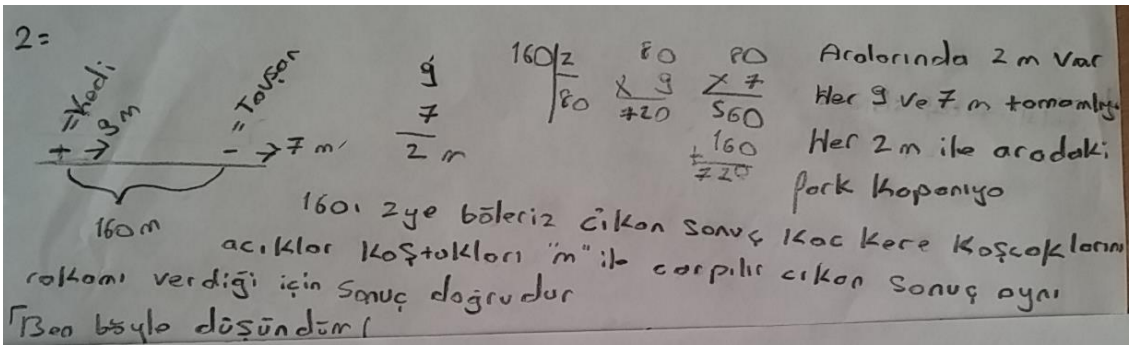

Figure 2: *The Solution of Problem 2 by S_2*

Being at Proficient level for PS involves finding the strategy to be used after analyzing the problem in detail, working in a manner focused on the result after understanding the problem, and generalizing the result. As it is seen in Figure 3 and 4, S_2 and S_{10} wrote all possible situations in a systematic manner. The methods they used show that students understood the problem fully. In addition, based on their solution methods, it is also clear that they may solve another similar problem because they wrote the solution of this one by matching, formulating or putting in order. Then, we can conclude that S_2 and S_{10} are at the Proficient level in Problem-Solving skills for this problem.

Problem 8: The result of a football match is 3-1. In this context, what can the score of the first half be? How many different routes can you use to reach 3-1, which is the result of the match? One of the routes may be as follows: 0-0, 1-0, 1-1, 2-1, 3-1. Write clearly all of your thinking styles and the methods you use in solving this question.

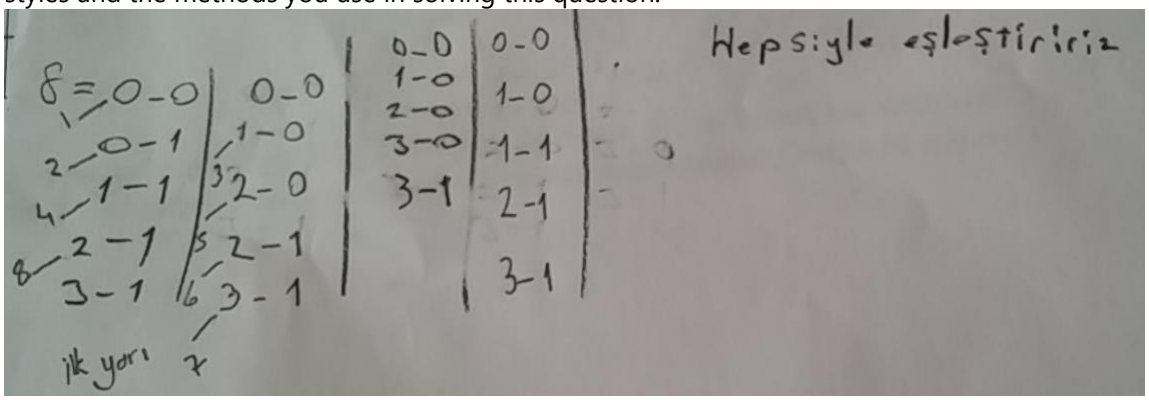

Figure3: *The Solution of Problem 8 by S_2*

Problem 4: The most favorite ingredients in a pizza store are mushroom, sausage, onion, pepper, cheese, and tomatoes. Write all the pizza types that may be baked with two ingredients. Solve the same question by examining the result for mushroom, sausage, pepper and cheese. Try to find a general rule by examining the results you find.

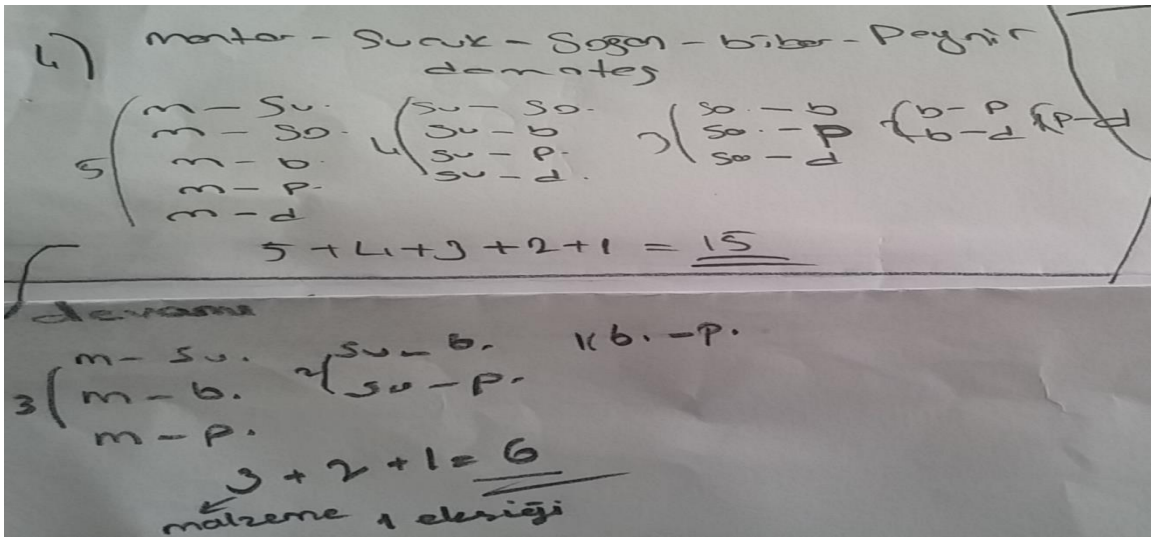

Figure 4: *The Solution of Problem 4 by S_{10}*

Apprentice level at KA, IB and PB

For CU, in the Apprentice level, a student understands the core of the problem, but cannot solve it, and partly establishes a connection between concepts. The answer is not related with the problem wholly, but related partly.

As it is seen in Figure 5, S_{15} showed the problem in a figure and with a drawing, and understood the initial data of it; however, s/he established an incorrect proportion. Although the solution may be made with proportion, using incorrect numbers shows that the students could not establish the relations between the concepts. Although the solution may be reached with proportion, using incorrect numbers show that the relations between the concepts are not established. For this reason, we may say that S_{15} is at Apprentice level in conceptual understanding for this problem.

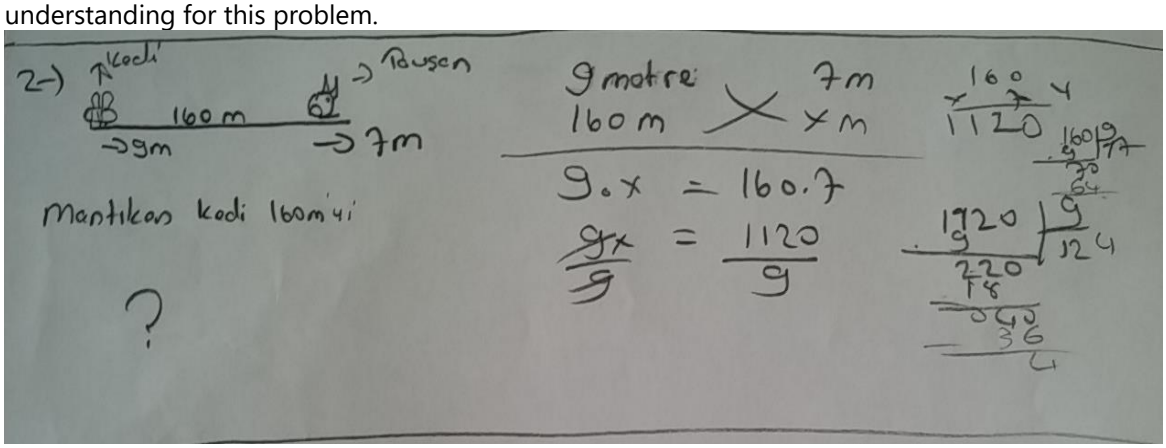

Figure 5: *The Solution of Problem 2 by S_{15}*

The Apprentice level for UPK is related with issues like the student being not imperfect in proceedings and strategies, being unable to make crosschecks, or doing it in an incorrect manner, and therefore, the result is not consistent with the problem.

As it is seen in Figure 6, S_6 found an incorrect result, and did not made counter check. In addition, the result seems inconsistent with the problem. For this reason, it may be claimed that S_6 is at Apprentice level for this problem in procedural knowledge.

Problem 3: A bacterium is placed in a jar at 14.00. It is known that this bacterium reproduces each 20-minute period. For example, 2 minutes later there will be 2 bacteria, and 4 bacteria after 40 minutes. In this context, by 18.00, how many bacteria will be in the jar? Write clearly all of your thinking styles and the methods you use in solving this question.

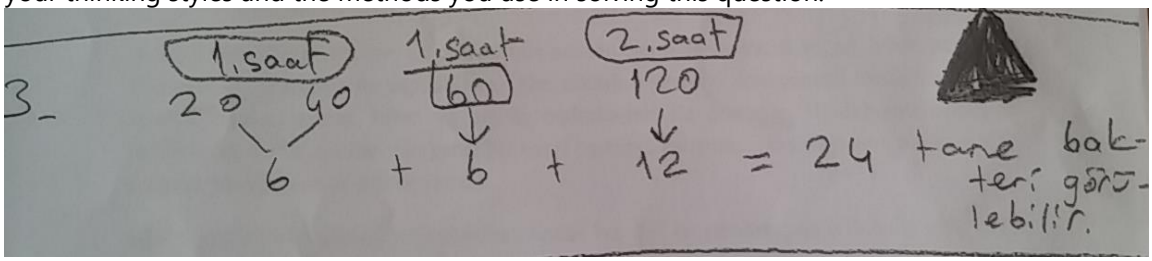

Figure 6: *The Solution of Problem 3 by S_6*

For PS, Apprentice level is checked with items such as the points on which the students are focused, and whether they understand the problem in a limited manner or not, the strategies they use for the solution of the problem in a partial manner, whether the student starts to solve the problem, but changes his/her focal point after some time, and makes mistakes, or the student has some incorrect attitudes in generalizing. In Figure 7, the solution of Problem 6 by S_5 is given. It seems that the student understood the core of the problem; however, s/he ignored the fact that one thirds was eliminated and two thirds was left. In this context, it is possible to claim that S_5 is at Apprentice level in Problem-Solving skills for this problem.

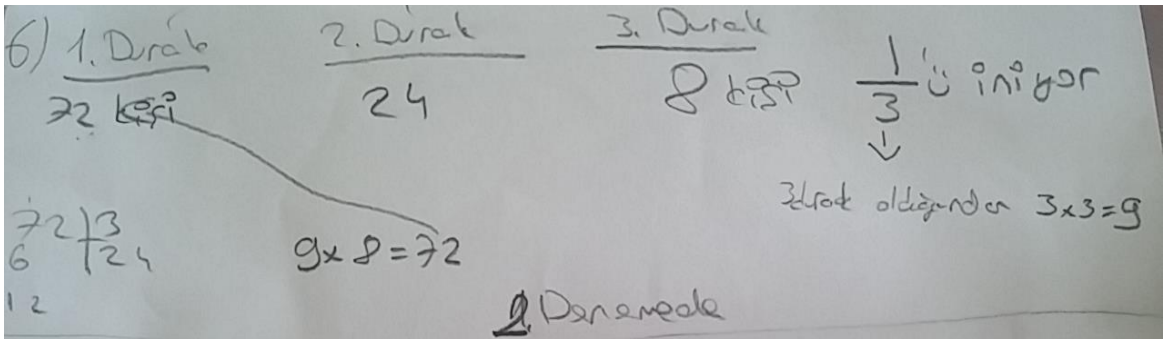

Figure 7: *The Solution of Problem 6 by S_5*

Novice Level at KA, IB and PB

The Novice level for CU is related with conflicting problem and answer, assessing the problem with incorrect concepts, incorrect results obtained with incorrect operations without understanding the content of the problem. In Figure 8, S_8 was focused on how to give the cookie with number 15, not in the number of the cookies being 15, and made a mistake. The problem and the answer was extremely inconsistent. This situation shows that S_8 is at the Novice Level at Problem-Solving skills for this problem.

Problem 5: Four people will share 15 cookies. However, since each of the participants will receive more cookies than the previous participant (except for the first participant). Under this circumstance, in how many different ways can they share the cookies?

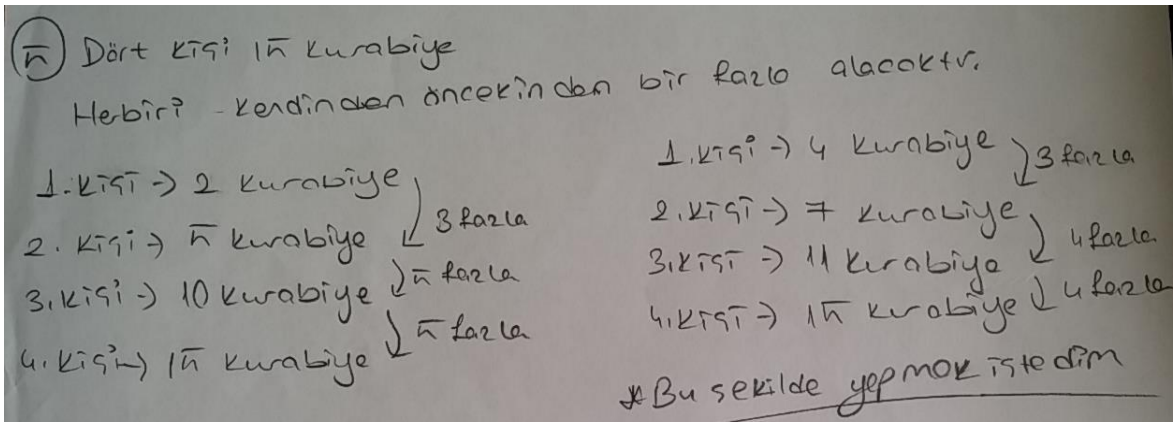

Figure 8: *The Solution of Problem 5 by S_8*

For UPL, the Novice level is checked with several items like using improper method and simple tricks, not being able to eliminate incorrect solutions and methods, and making incorrect operations. The solution of Problem 1 by S_{11} is given in Figure 9. It is not clear with which operation the student reached the existing result, the operations do not make sense and are incorrect. S_{11}, who did not notice his/her mistake, made incorrect operations for the solution of the problem from the very beginning to the end of his/her struggle. In this context, it may be claimed that S_{11} is at the Novice level in procedural knowledge for this problem.

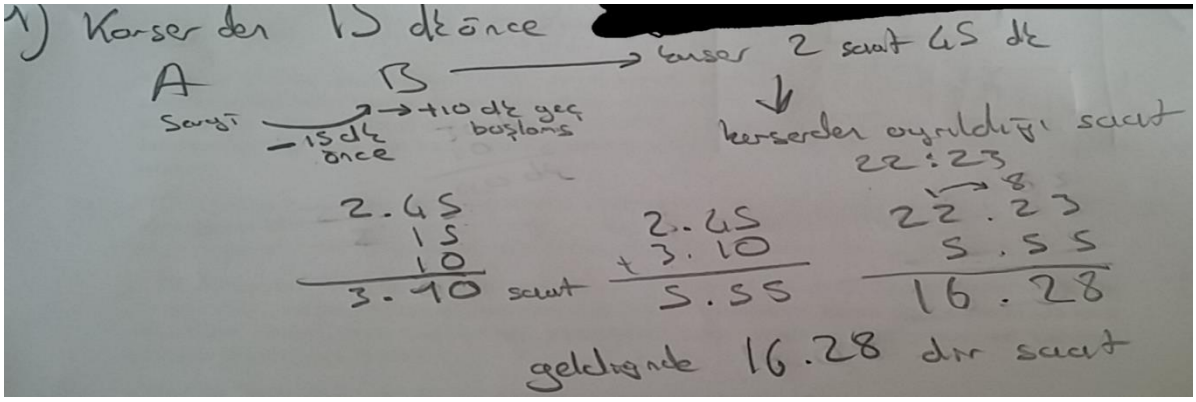

Figure 9: *The Solution of Problem 1 by S_{11}*

For PS, the Novice level is associated with using strategies, having superficial solution without clear ways to reach the solution, having incorrect focal points, and not being able to use alternative ways. In Figure 10, the solution of Problem 7 by S_{17} is given. The student wrote the numbers in boxes randomly without thinking, and then did not check whether they fit the rule or not. For this reason, it is possible to claim that S_{17} is at the Novice level in terms of Problem-Solving skill for this problem.

Problem 7: Place the numbers between zero and nine in the following figure in such a way that consecutive numbers do not exist in right-left-upper-lower-cross boxes following each other. State clearly with how many trials you solve this problem and write the methods you use.

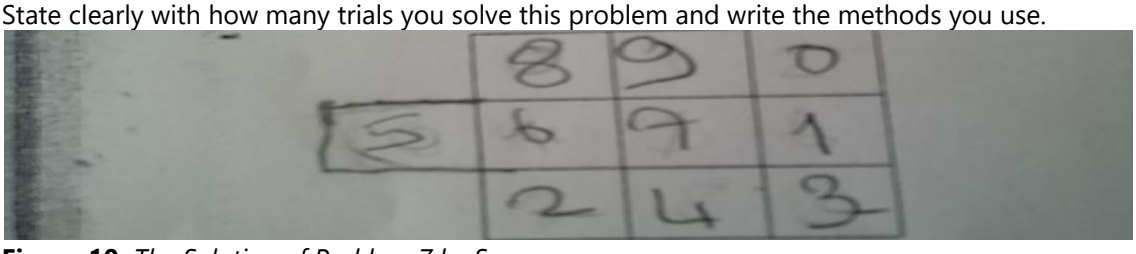

Figure 10: *The Solution of Problem 7 by S_{17}*

Comparison of Problem-Solving Performances

When Table 4 is considered, it is seen that only S_1 is at the Proficient level. The performance level of S_2, who is the closest, is Proficient/Apprentice. The difference between the scores of these two students is 0,38. These two students are in the 9th grade and are male. When the success level of S_1 in mathematics was asked to his/her teacher, it was understood that the average score of the students for first term was between 70-80 and the average score of the second term was between 80-90. It was also stated by the teacher that the scores of S_2 in Mathematics classes at school were between 50-60 in both terms. When the teacher assessed the two students in terms of their participation in classes, the teacher stated that S_1 was more successful, and S_2 did not love studying, but had some potential for being a better one.

Table : 4

Performance Assessment of All Students

	Components of Scale	Mean Score of Eight Problems	Average	Level of Performance
S_1	CU	4,500	4,54	Proficient
	UPK	4,625		
	PS	4,500		
S_2	CU	4,125	4,16	Proficient /Apprentice
	UPK	4,250		
	PS	4,125		
S_3	CU	3,250	3,29	Apprentice
	UPK	3,375		
	PS	3,250		
S_4	CU	3,125	3,08	Apprentice
	UPK	3,125		
	PS	3,000		
S_5	CU	2,875	2,92	Apprentice
	UPK	3,250		
	PS	2,625		
S_6	CU	2,750	2,83	Apprentice
	UPK	3,000		
	PS	2,750		
S_7	CU	2,625	2,71	Apprentice
	UPK	2,750		
	PS	2,750		
S_8	CU	2,875	2,67	Apprentice
	UPK	2,750		
	PS	2,375		
S_9	CU	2,625	2,5	Apprentice/Novice
	UPK	2,500		
	PS	2,375		
S_{10}	CU	2,625	2,41	Apprentice/Novice
	UPK	2,375		
	PS	2,250		
S_{11}	CU	2,500	2,38	Apprentice/Novice
	UPK	2,375		
	PS	2,250		
S_{12}	CU	2,125	2,2	Apprentice/Novice
	UPK	2,250		
	PS	2,125		
S_{13}	CU	2,125	2,04	Apprentice/Novice
	UPK	2,125		
	PS	1,875		
S_{14}	CU	2,125	2,04	Apprentice/Novice
	UPK	2,000		
	PS	2,000		
S_{15}	CU	2,125	1,96	Apprentice/Novice
	IB	1,875		
	PS	1,875		
S_{16}	CU	1,375	1,42	Novice
	UPK	1,500		
	PS	1,375		
S_{17}	CU	1,125	1,08	Novice
	UPK	1,000		
	PS	1,125		
S_{18}	CU	1,000	1,00	Novice
	IB	1,000		
	PS	1,000		

Scale: 4.2 5.0 Proficient 3.4 4.1 Proficient/Apprentice 2.6 3.3 Apprentice
1.8 2.5 Apprentice/Novice 1.0 1.7 Novice

When Table 4 is assessed, it is seen that Students S_3, S_4, S_5, S_6, S_7 and S_8 are at Apprentice level. The student with the highest average point is S_3. The teacher stated that S_3 is not interested in the lessons and is an unsuccessful student. When the student was asked about the reasons for failure, s/he stated that s/he was sent to high school upon the decision of the family, and added that s/he did not want to further education, and said that it was not necessary to be a university graduate to earn money. S_4 is the second student with the highest averages, and in terms of the mathematics classes at school, s/he is at the medium level. The student stated that s/he failed because the Mathematics teacher was assigned to another post in 10^{th} Grade, and had mathematics scores between 80-90 in 9^{th} grade. When the present teacher was interviewed, the teacher stated that the scores of the student in 10^{th} grade were between 50-60. When the grades of S_5, S_6 and S_8 in mathematics are considered, it is seen that S_8 has grades between 70-80, S_5 has grades between 60-70 and S_6 and S_7 has grades between 50-60.

When the students who are at Apprentice/Novice performance level are considered it is seen that the students with the highest average score was S_9 and the student with the lowest score was S_{15}. When the mathematics success levels of the 7 students at this level are assessed, it is seen that the scores intensify between 50-60. Only S_9 increased his grades to around 70 in the second Term and became more successful than the other students.

When Table 4 is assessed, it is seen that the students, whose performance levels are Novice, are Students S_{16}, S_{17}, and S_{18}. When the success levels of these students at Mathematics classes at school are assessed, it is seen that student S_{16} and S_{18} are unsuccessful, and S_{17} has grades between 40-50.

It is possible to claim that in general, the Problem-Solving performances of the students at school are parallel. When the fact that the school type being Vocational High School considered, it may be expected that the general performance levels are at medium level, because the students who will attend Vocational High School receive extremely lower scores than those who will attend other high schools. For example, the base score of Vahit Tuna Anatolian High School in Çanakkale was 453 in 2016; however, the base score of Kepez Vocational and Technical Anatolian High School was 132 in 2016. Table 5 supports this result. The general average scores of 18 students from Çanakkale Kepez Vocational and Technical Anatolian High School, who were selected randomly without considering grades at school, were found to be at Apprentice/Novice. 7 of the students are at this level. 6 Students were at Apprentice level, 3 students were at Novice level. Only one student being at Proficient and Proficient /Apprentice level is consistent with the levels of the students who attend the school.

Table 5:

Frequency of Problem Solving Performance Level of Students

Average of Eighteen Students	Performance Level	Number of Students
2,51(Apprentice/Novice)	Proficient	1
	Proficient/Apprentice	1
	Apprentice	6
	Apprentice/Novice	7
	Novice	3

When the average scores of the students received in *conceptual understanding* in all problems were analyzed, the situation given in Table 5 was obtained. In this context, it was determined that only one of the eighteen students were at Master level, and one was at Master/Apprentice level. It was determined that thirteen of the students were either at Apprentice or Apprentice/Novice level. In this respect, it is possible to claim that the students conceptualized non-routine problems at a medium level.

Table 6:

Classification of the different levels of conceptual understanding(CU)

	Students
Full Conceptual Understanding (Proficient)	n= 1 (S_1)
Full or Partial Conceptual Understanding (Proficient/	n= 1 (S_2)
Partial Conceptual Understanding (Apprentice)	n=8 (S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10})
Partial or Lack of Conceptual Understanding	n= 5 (S_{11}, S_{12}, S_{13}, S_{14}, S_{15})
Lack of Conceptual Understanding (Novice)	n= 3 (S_{16}, S_{17}, S_{18})

When Table 6 is analyzed, it is observed that there are two students who are at Master level in *operational knowledge*. Again, it is observed that thirteen students are either at Apprentice or at Apprentice/Novice level. Based on this, it is possible to claim that the *operational knowledge* of the students is at medium level, which is also the case in *conceptual understanding*. Since the *conceptual understanding* and *operational knowledge* of the students were not adequate, they might have not been able to solve the problems in an efficient manner. The same students' being at Novice level in *conceptual understanding* and *operational knowledge* supports this result. However, while S_9 and S_{10} were at Apprentice level in *conceptual understanding*, they were at Apprentice/Novice level in *operational knowledge*.

Table 7:

Classification of the different levels of procedural knowledge(UPK)

	Students
Full Conceptual Understanding (Proficient)	n= 2 (S_1, S_2)
Partial Conceptual Understanding (Apprentice)	n=6 (S_3, S_4, S_5, S_6, S_7, S_8)
Partial or Lack of Conceptual Understanding	n= 7 (S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15})
Lack of Conceptual Understanding (Novice)	n= 3 (S_{16}, S_{17}, S_{18})

When Table 7 is analyzed in the light of these data, it is observed that S_9 and S_{10} are at Apprentice/Novice level in problem-solving skills. In this respect, although these students are at medium level in conceptualizing the problems, their problem-solving skills are at Apprentice/Novice level because their *operational knowledge* is inadequate. It is also observed that sixteen of the students are below the Master/Apprentice level and eleven of them are below the Apprentice level. This situation shows that the problem-solving skills of the students in non-routine problems are at not an adequate level.

Table 8:

Classification of the different levels of problem solving skills and strategies(PS)

	Students
Full Conceptual Understanding (Proficient)	n= 1 (S_1)
Full or Partial Conceptual Understanding (Proficient/	n= 1 (S_2)
Partial Conceptual Understanding (Apprentice)	n=5 (S_3, S_4, S_5, S_6, S_7)
Partial or Lack of Conceptual Understanding	n= 8 (S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15})
Lack of Conceptual Understanding (Novice)	n= 3 (S_{16}, S_{17}, S_{18})

Comparison of Students' Performance Levels and Employed Strategies

When Table 8 is assessed, it is seen that S_1, whose performance level is Proficient, used 7 different strategies. It is also seen that the students, whose performance levels are Proficient/Apprentice, used 5 different strategies. When the strategies preferred by the students for questions are assessed, it is seen that almost all the preferences are the same except for 2nd and 3rd problems; however, it is also possible to claim that S_1 preferred Writing Equation Strategy and caused the difference. In addition, S_2 did not use a certain strategy in Problem 6, and could not solve the problem. The most distinctive characteristics of these two students is the fact that they used generally more than one strategy to solve the problem. This finding is

consistent with the finding of Koedinger and Tabahneck (1994) claiming that "Students with high Problem-Solving success levels can choose the correct strategy, or may change the strategy when it does not take them to the result". In addition, Schoenfeld (1999) said that choosing a strategy that is proper for the problem is like finding the right key from among many keys to open a door, which also supports our findings.

Table 9:

Strategy Preferences for the Two Most Successful Students

Problem No	Students/Strategy Preferences	
	S_1	S_2
1	WB/LR	WB/LR
2	WE	MD/GC
3	MSL/LP	LP/LR
4	MSL/LP/LR	MSL/LP/LR
5	GC/LR	MSL/GC
6	WE	---
7	GC/EPS	GC
8	GC/LR	GC/MSL

When Table 9 is assessed, it is seen that students generally used 1 strategy. The students who used the least strategies were S_{11}, S_{13} and S_{14} with 4 strategies. The strategies preferred by students at this performance level were generally like each other. The only difference was the fact that some students used more than one strategy in the same problem. The most frequently preferred strategies were backwards working, drawing shapes and making systematic lists.

Table 10:

Strategy Preferences of Apprentice / Novice Level Students

Problem No	Students/Strategy Preferences						
	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}
1	WB	WB/LR	WB	WB	WB	WB	WB
2	MD	MD	MD	---	MD	MD	MD/WE
3	MSL/LP	MSL	MD/MSL	MSL	MSL	MSL	MSL
4	MSL	MSL/LP	MD	---	MSL	---	WE
5	---	MD	---	---	MD	---	MD
6	WE	---	---	WE/LR	MD	---	---
7	GC	GC	GC	GC	---	GC	GC
8	LR	---	SL	GC	GC	GC	---

When Table 8 is assessed, it is seen that Students S_{16}, S_{17} and S_{18} are at Novice level and the other students are at Apprentice level. The students at Novice level used 3 or 4 strategies. The strategies they preferred were backwards working, logical reasoning, making systematic lists, drawing schemes-shapes, and guessing-checking. They generally preferred the same strategy in problems, and could not use a clear strategy at last in 3 questions. When the preference of the students whose performance levels were at Apprentice level were considered, it is seen that they used 5 or 6 strategies. In 3rd, 4th, 7th and 8th problems, most of the students used the same strategy.

Table 11:
Strategy Preferences of Apprentice / Novice Level Students

	Students/Strategy Preferences								
Prob.	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**	**S_8**	**S_{16}**	**S_{17}**	**S_{18}**
P1	WB/ LR	WB/ MSL	WB/LR	WB	WB	MSL/WB	WB/ MSL	WB	WB
P2	LR	MD/WE	LR/WE	MD	MD	MD/WE	MD	LR	MD
P3	MSL	MSL/ LP	MSL/L P	MSL/LP	---	MSL	MSL	---	---
P4	MSL	---	SL	---	MSL/LP	LP/MSL	---	---	---
P5	MSL/ GC	MD/SL	SL/TK	---	---	GC/MSL	MD	MD	---
P6	WB	WE	MT/WE	MT/WB	---	---	---	---	MSL
P7	GC	GC/LR	GC	GC	GC	GC	GC	GC	GC
P8	GC/ MSL/	---	GC	GC	GC/LR	GC	---	---	GC

CONCULISION

As a conclusion, each problem was solved by using at last 3 different strategies. The problems selected in the study may be solved by using 10 different strategies. The students did not choose only one of these strategies, which is simplifying the problem. Some problems were solved by using 2 or 3 strategies. The most frequently used strategies were making systematic lists, looking for patterns, logical reasoning, and drawing shapes-schemes. These findings show that non-routine problems may be solved with more than one way, and overlap with the findings of Mabilangan, Limjap & Belecina (2011).

After evaluating the students' problem-solving skills using the Oregon Mathematics Problem Solving Rubric, results showed that of the eighteen students, one was a proficient level, one was a proficient/apprentice level, six were an apprentice level, seven were apprentice/novice level and three were novice level of performance. Those who performed well were also proficient in the use of solution strategies.

In addition, solving non-routine problems require several mental skills like detecting the relations between the given data, making analyses and syntheses, thinking in abstract and deductive manner, considering the problem situation as well as the ability to make several consecutive operations (Altun, 2005). This situation is supported with the results of the present study.

According to the results of the study, the Problem-Solving skills of the students who attend to Vocational High Schools are at medium level in general; however, when given proper opportunities, the Problem-Solving skills may develop. In the present study, the students did not prior instruction on strategies, and moreover, they tried to solve the non-routine problems that did not encounter in their school lives by using different strategies. For this reason, if students are taught strategies on Problem-Solving and are given more non-routine problems, their success levels at Mathematics and their Problem-Solving skills may be improved.

According to another result of our study, there is a relation between Mathematics success levels of the students and their strategies they used. The students whose Problem-Solving skill was at Proficient level used seven different strategies, and generally, solved the

problems with more than one strategy. The students whose Problem-Solving skill was at Novice level used only four strategies and could not solve four problems.

The results of this study show similarities with the results of the studies conducted by Mabilangan, Limjap & Belecina (2011). The most distinctive difference between this present study and the one conducted by Mabilangan et al. (2011) is the selection of the Study Group. This study was conducted with 6 students at 3 different success levels; however, there were 5 successful students at the study conducted by Mabilangan et al. (2011). However, the results show great similarities, and support each other.

RECOMMENDATIONS

The scope of the study may be extended, and a comparison may be made between students attending different high school types. Similarly, a similar study may be conducted with students from different grades.

Non-routine problems being included more in the educational process is important in that students prepare themselves better for their future lives, and become a good problem solver. The effects of non-routine problems may be investigated with long-term studies in which the educational programs that have these kinds of problems as their focal points.

Studies that aim to develop the non-routine Problem-Solving skills of students by teaching strategies or studies that investigate the readiness of high school students for such problems may be conducted by considering the scope of the non-routine problems mentioned in the new secondary school curriculum planned for the 2017-2018 Academic year in Turkey.

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Lise Öğrencilerinin Rutin Olmayan Problemleri Çözme Becerilerinin ve Kullandıkları Stratejilerin İncelenmesi

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Özet

Bu araştırmanın amacı lise öğrencilerinin rutin olmayan problem çözme beceri düzeylerinin ve kullandıkları stratejilerin başarı durumlarına göre dağılımını saptamak amaçlanmaktadır. Bu amaç doğrultusunda öğrencilerin kavramsal anlama, işlemsel bilg düzeyleri ve problem çözme becerileri incelenmiştir. Durum çalışması deseninin kullanıldığı bu araştırma 18 öğrenci ile yürütülmüştür. Araştırma sonuçları her bir öğrenci en az üç farklı problem çözme stratejisi kullandığını göstermektedir. Araştırmadaki rutin olmayan sekiz problemde kullanılması muhtemel olan on stratejiden dokuzunu öğrenciler en az bir kez kullandıkları görülmüştür. En çok birlikte kullanılan stratejiler sistematik liste yapma, örüntü-bağıntı bulma, mantıksal düşünme, şema çizmedir. Problem çözme becerisi usta düzeyinde olan öğrencilerin stratejileri etkin bir şekilde kullandıkları görülmüştür.

Keywords: *Matematik eğitimi, Rutin olmayan problem, Problem çözme stratejisi*

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GENİŞLETİLMİŞ ÖZET

Problem: Problem çözme süreci; birçok becerinin bir arada bulunmasını gerektiren karmaşık bir süreç olarak ifade edilmektedir. Problem çözmenin birincil aşaması okuduğunu anlamadır ve bu süreç gerçekleşmediğinde bireylerin problemdeki sayıları rasgele kullanarak anlamsız sonuçlara ulaşacakları düşünülmektedir (Artzt ve Thomas, 1992; Goos, Galbraith ve Renshaw, 2000; Polya,1997). Literatür tarandığında iki çeşit problem türü ile karşılaşılmaktadır: Rutin (Sıradan) problemler ve rutin olmayan problemler (Altun; 2005). Matematik eğitimcileri problem çözümü öğretiminde rutin problemler kadar rutin olmayan problemlerin öğretiminin de önemli olduğu konusunda anlaşırlar. Literatürde rutin olmayan problemlerin genellikle, problem çözme becerisini ve bu becerilerin gerçek yaşamda kullanım becerisini geliştirdiği belirtilmektedir (Polya, 1957; Schoenfeld, 1992; Cai, 2003; London, 2007). Rutin olmayan problemler, sonucunun önceden kestirilemediği problemlerdir. Bilinen bir yöntemle ya da formülle çözülemez. Çözümü için analiz, sentez, deneme-yanılma ve yaratıcı bir girişim gerekir (Tarım ve Artut, 2009; Woodward, Beckmann, Driscoll, Franke, Herzig, Jitendra, Koedinger, & Ogbuehi, 2012). Bu tür problemlerin çözümünde üst düzey düşünme becerisi ve muhakeme önemlidir. Ayrıca işlemsel becerilerde de ustalık gerekmektedir. Öğrencilerin rutin olmayan problemleri anlama düzeyleri Oregon Eğitim Fakültesi tarafından (1991) üç maddeye dayandırılarak tanımlanmıştır bunlar; kavramsal anlama, işlemsel bilgiyi kullanma, problem çözme becerisi ve stratejiler. Bunlardan kavramsal bilgi öğrencilerin matematiksel bilgiler arasındaki ilişkileri ve bağlantıları fark etmesidir. Öğrencinin sadece yöntemi hatırlamaları genellikle yanlış sonuç bulmalarına yol açarken kavramsal anlamaları yöntemi bilmeseler de farklı yollardan doğru sonuca ulaşmalarını sağlar. Devlin (2007) kavramsal bilgi edininin matematik eğitiminin en önemli parçası olduğunu belirtmiştir. Kavramsal anlamaya ulaşmak için ilk önce öğrencilerin kuralı-yöntemi uygulayarak çalışmaları gerekmektedir (Devlin, 2007). Bu araştırma tek bir lise ile sınırlı olsa da öğrencilerin matematik ve problem çözme başarıları hakkında bir fikir verebilir. Türkiye' de Rutin olmayan problemler ile ilgili ortaöğretim dönemi ile yapılan araştırma sayısı oldukça sınırlıdır. Meslek lisesi öğrencileri ile yapılan bu araştırma ilköğretimden ortaöğretime geçişte akranlarından daha başarısız olan öğrencilerin problem çözme becerisi hakkında bir fikir vermesi açısından araştırma önemli gözükmektedir. Bu araştırmanın amacı lise öğrencilerinin rutin olmayan problem çözme beceri düzeylerinin ve kullandıkları stratejilerin başarı durumlarına göre dağılımını saptamak amaçlanmaktadır.

Yöntem: Lise öğrencilerinin rutin olmayan problem çözme beceri düzeylerinin ve kullandıkları stratejilerin başarı durumlarına göre dağılımını saptamayı amaçlayan bu çalışma doğası gereği betimsel niteliktedir. Betimsel araştırmalar nicel veya nitel olabildiğinden çalışma nitel araştırma yöntemlerinden durum çalışmasına uygun olarak yapılmıştır. Çalışmada, nitel araştırma yaklaşımı benimsenmiştir. Nitel araştırmalar, üzerinde araştırma yapan kişilerin sahip oldukları deneyimlerden yararlanma, duygu ve düşüncelerini anlayabilme bakımından tercih edilen bir araştırma yaklaşımıdır (Ekiz, 2009). Bu yaklaşıma dayalı olan, durum çalışması, bir veya birkaç durumu ya da olayı sınırlı sayıda örneklem ile her yönüyle derinlemesine inceleme olanağı sunmaktadır (Çepni, 2012). Bu çalışmada öğrencilerin hem kavramsal bilgileri hem işlemsel bilgileri hem de problem çözme becerileri detaylı olarak incelendiğinden bu yöntem tercih edilmiştir. Çalışmada her bir öğrenci kendi içinde değerlendirildiğinden ve sonra tüm öğrenciler birbirleriyle karşılaştırıldığından bütüncül çoklu durum deseni kullanılmıştır.

Bulgular ve Tartışma: Öğrencilerin okuldaki başarıları ile problem çözme performanslarının genel olarak paralel olduğu söylenebilir. Çanakkale Kepez Mesleki ve Teknik Anadolu lisesinden sınıf farkı gözetilmeksizin gönüllük esasına göre seçilmiş olan 18 öğrencinin genel ortalaması Çırak/Acemi düzeyinde bulunmuştur. Öğrencilerin 7'si bu düzeydedir. 6 öğrenci Çırak düzeyinde, 3 öğrenci ise Acemi düzeyindedir. Sadece birer öğrencinin Usta ve Usta/Çırak düzeyinde olması

okula gelen öğrenci düzeyi ile uyumlu bir sonuçtur. Onsekiz öğrenciden sadece biri kavramsal anlamada usta düzeyinde ve biri de usta/çırak düzeyindedir. Öğrencilerin on üçünün ya çırak ya da çırak/acemi düzeyinde olduğu görülmektedir. Buna göre öğrencilerin rutin olmayan problemleri orta düzeyde kavrayabildikleri söylenebilir. İşlemsel bilgide usta düzeyinde olan iki öğrenci olduğu görülmektedir. Yine on üç öğrenci ya çırak ya da çırak/acemi düzeyinde bulunmaktadır. Buradan öğrencilerin işlem bilgisinin de kavramsal anlamada olduğu gibi orta düzeyde olduğu söylenebilir. Öğrencilerin kavramsal anlamaları ve işlem bilgileri yeterli olmadığından problemleri etkin bir şekilde çözememiş olabilirler. Aynı öğrencilerin kavramsal anlama ve işlemsel bilgide acemi olduklarının görülmesi bu görüşü desteklemektedir. Öğrenciler problemleri orta düzeyde kavramalarına rağmen işlemsel bilgileri yetersiz kaldığından problem çözme becerileri de çırak/acemi düzeyinde olduğu söylenebilir. Öğrencilerin on altısının usta/çırak düzeyinin ve on birinin çırak düzeyinin altında olduğu görülmektedir. Bu durum öğrencilerin rutin olmayan problemleri çözme becerilerinin yeter düzeyde olmadığını göstermektedir.

Sonuç ve Öneriler: Sonuç olarak her problem en az üç farklı strateji kullanılarak çözülmüştür. Çalışmada seçilmiş olan problemler 10 farklı strateji kullanılarak çözülebilmektedir. Öğrenciler bunlardan sadece birini tercih etmemişlerdir; problemi basitleştirme. Bazı problemler iki veya üç strateji kullanılarak çözülmüştür. Bu araştırma sonuçları; Mabilangan, Limjap&Belecina (2011)' nin araştırma sonuçları ile benzerlik göstermektedir. Söz konusu araştırmanın bu araştırmadan en önemli farkı çalışma grubu seçimidir. Bu araştırma üç farklı başarı düzeyindeki altışar öğrenci ile yapılmıştır ancak Mabilangan ve diğerlerinin (2011) araştırması sadece başarılı beş öğrenci ile yapılmıştır. Buna rağmen sonuçlar büyük benzerlik göstermekte ve birbirini destekler niteliktedir. Araştırmanın kapsamı genişletilerek farklı lise türlerine devam eden öğrenciler arası bir karşılaştırma yapılabilir. Aynı şekilde farklı sınıflardaki öğrenciler ile benzer bir çalışma yapılabilir. Rutin olmayan problemlerin eğitim sürecinde daha fazla yer bulması öğrencilerin kendini hayata hazırlaması ve iyi birer problem çözücü olmaları açısından önemlidir. Bu tür problemleri merkeze alan öğretimlerin incelendiği uzun dönemli araştırmalar ile rutin olmayan problemlerin etkileri incelenebilir.