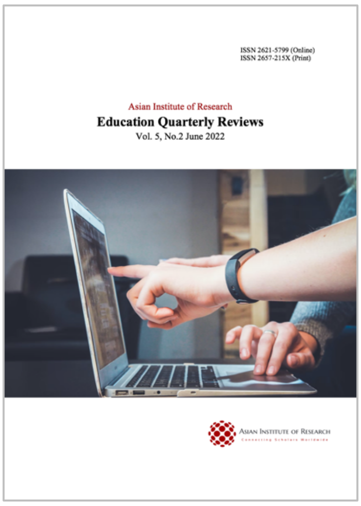

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Students' Skills In Solving Non-Routine Mathematical Problems

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Abstract
Mental skills are required for individuals to think quickly and make correct decisions. It can be said that mental skills, which play an important role in the acquisition of thinking and questioning skills, are only possible with creative, critical, and other high-level thinking skills. In this regard, the PISA exam, which reveals the mathematics achievement levels of countries, is important. Due to the absence of such an exam in the Turkish Republic of Northern Cyprus (TRNC), the descriptive scanning method, one of the quantitative research methods, was used in order to determine the effects on students' abilities in solving non-routine mathematical problems with the methods applied in the mathematics course. Based on this research conducted to determine the skills of 9th-grade high school students in solving non-routine mathematical problems, the mathematics achievement levels of the schools that accept students with special exams in the TRNC have been revealed.

Keywords: Non-Routine Problems, Problem-Solving Skills, Thinking Ability

1. Introduction

The Northern Cyprus Education system, which is implemented based on the Turkish Education system, is carried out as 6+3+4 in accordance with both the European Union (EU) and Turkey, with the addition of the 9th-grade application.

In the curricula prepared by the TRNC Ministry of Education, it is stated that high-level thinking skills in mathematics are important in problem-solving. It has been stated that these skills emerge as a resource for creative and critical thinking skills and therefore play an important role in the mental process (MEB, 2013).

As Polya (1957) stated, one of the most important factors in solving a problem is determining the appropriate strategy. When the studies in the literature are examined, it is seen that the most common problem-solving strategies include prediction and control, systematic list, finding correlations, drawing diagrams, writing equality or inequality, benefiting from solutions for similar easy problems, retrospective work, and reasoning by making a table (Ersoy and Güner, 2014).

In problem-solving, attention is drawn to the necessity of addressing cognitive, affective and motor skills, determining the most appropriate strategy when dealing with the stages of the problem, and collecting information about that problem (Tüysüz, 2013; Stevens, 1998). In addition, cognitive field theorists refer to the importance of the concept and its meaning in problem-solving and reveal that permanent learning is possible by using a combination of operational and conceptual information (Baki, 1998).

However, studies reveal that only the first three steps of the cognitive domain can be implemented in lessons where teaching is provided using traditional methods. The studies point out that analysis, synthesis, and evaluation that require high-level thinking skills were not done (Aydın and Yılmaz, 2010).

It is seen that the cognitive domain taxonomy, which has an important role in educational practices in many countries and was developed by Bloom et al. in 1956, is predominantly involved in learned attainment and behavior (Ornstein and Hunkins, 2014). In this regard, Bloom's Taxonomy particularly assists teachers with posing questions that will improve their thinking skills (Turgut, 1992). The steps determined for this taxonomy are knowledge, comprehension, application, analysis, synthesis and evaluation.

As the first step, the level of knowledge is related to the students' remembering what they have learned as well as the relationship between the related terms (Aykaç, 2014). The second step of comprehension is important to interpret the learned information and establish a cause-effect relationship (Reigeluth and Moore, 1999). In the application step, it is essential to base the acquired knowledge and skills on practical methods (Sönmez, 2012). In the analysis step, the aim is to make the relationship between these elements clearer by dividing the whole into separate elements (Omar et al., 2012). Individuals who can understand the information learned up to the analysis stage understand the relationship between the elements and separate the elements that constitute the whole in order to create a unique whole in the synthesis stage. In the evaluation step, considered as the last step, it is expected that learners will make inferences based on the previously stated conditions and issues (Reigeluth and Moore, 1999). Therefore, it is the most appropriate field for the tendency to measure skills related to the cognitive field consisting of six categories, especially in problems requiring high-level thinking skills in mathematics lessons, and it is thought that Bloom's taxonomy plays an important role in terms of solving problems.

The literature concluded that teachers did not include non-routine problems that allow learners to analyse problems in the classroom, engage in reasoning, and generate alternative ways of solving the problems (Işık and Kar, 2011). In order to solve non-routine problems, it is of particular importance that individuals have high-level thinking skills. This is not just a situation specific to non-routine problems, as it is accepted as the metacognitive levels expected by students as one of the important factors in teaching all problem-solving skills. In the context of higher-order thinking skills, it can be said that the acquisition of analysis, synthesis and evaluation steps determined by Bloom's Taxonomy can only be achieved by critical thinking, questioning, analysing and creative thinking, which is necessary for the effective use of information through mental processes. (Krathwohl, 2002). In this context, in order to gain high-level thinking skills, teachers should prepare course content that will facilitate the thinking process. In this direction, high-level, creative and critical thinking skills are discussed according to the purpose of this study. Teachers are expected to act as guides in teaching creative thinking skills and guide students to form different ideas through collaborative learning. The aim should be to develop methods that will improve creating thinking skills rather than the techniques used by teachers in the past.

Given that studies have revealed that individuals who can think creatively can look critically, it is accepted that critical thinking aims to improve the ability to analyse, evaluate and make inferences (Emir, 2001; Emir and Bahar, 2003). At the same time, critical thinking skills can activate higher-order thinking skills and play an important role in adapting to complexities in the continually evolving modern era (Torres and Cano, 1995). In recent times in particular, individuals have been increasingly required to have the mental skills that allow them to think quickly and make correct decisions (Parmaksız, 2015). Considering that mental skills also require thinking and questioning skills, it can be said that these are only possible with creative, critical and other high-level thinking skills.

This research aimed to determine the non-routine mathematical problem-solving skills of 9th-grade high school students in the secondary education department of the Turkish Republic of Northern Cyprus (TRNC) Ministry of National Education and Culture (MEB). For this purpose, answers to the following questions were sought:

1. Is there a significant difference in the basic math knowledge and concept test scores, non-routine mathematical problem-solving skills test scores and math achievement scores of 9th-grade high school students according to demographic variables?
2. Is there a significant relationship between the mathematics basic knowledge and concept test scores of the 9th-grade high school students and the total scores of the non-routine mathematical problem-solving skills test?

In addition to problem-solving, it is important to develop creativity and express different solutions with different thoughts in terms of non-routine problems. For this reason, determining the success levels of 9th-grade students in non-routine problems increases the importance of the study in this respect.

It is thought that determining the extent to which students can solve non-routine problems will the mathematics programs to be revised by taking these results into consideration.

2. Methodology

Descriptive review studies, which aim to identify opinions by applying a survey to certain groups from the sample representing the universe, are used in methods that aim to determine what events are and how they occur (Karasar, 2015).

2.1. Working group

The research study group consisted of 176 students since the survey was applied to readily available classes in six schools for which sampling permission was obtained by using stratified purposive sampling, one of the non-random sampling methods. The schools selected with this sampling technique were determined in a way that would enable a comparison of the characteristics of certain subgroups in accordance with the purpose of the research, based on the assumption that they would better represent the universe (Büyüköztürk and et al., 2017). Sample selection was determined by the values considered with 0.05 sampling error between universe sizes of 10,000 and 25,000 universe sizes (Yazıcıoğlu and Erdoğan, 2004). Since the application planned to be conducted in one of the schools coincided with a period close to the exam week and the teachers were required to give lessons, the school administrator did not provide the necessary permission, which caused the school not to be included in the research group.

Table 1: Distribution of Students by School Type and Gender

		n	f
School	S1	31	17.6
	S2	30	17.0
	S3	30	17.0
	S4	34	19.3
	S5	23	13.1
	S6	28	15.9
	Total	**176**	**100.0**
Gender	Female	108	61.4
	Male	68	38.6
	Total	**176**	**100.0**

Table 2: Distribution of Teachers by School Type and Gender

		n	f
School	S1	3	17.6
	S2	2	11.8
	S3	3	17.6
	S4	2	11.8
	S5	4	23.5
	S6	3	17.6
	Total	**17**	**100.0**
Gender	Female	13	76.5
	Male	4	23.5
	Total	**17**	**100.0**

2.2. Data Collection Tools

The data were collected through the "mathematics achievement test" developed by the researcher, which is designed to reveal students' performance in terms of mathematical concepts, knowledge skills and non-routine mathematical problem-solving skills. Expert opinion was sought after the researchers prepared the "mathematics achievement test" question pool from open-ended questions. The test, which was presented to three experts in the field for their opinion and comprised a final total of 11 open-ended questions, consists of two parts and the part that includes demographic information. Care was taken to determine the questions forming the first part in such a way that they would measure the level of basic mathematical knowledge and concepts that students should have by the 9th grade. Attention was paid to the fact that the questions in the second part were arranged in such a way to determine whether students could find a solution in case of a problem, that they consisted of problems that are not frequently included in the textbooks, that were different from the usual exam types, and that they required the use of creative and probabilistic thinking that require high-level thinking skills. Particular attention was paid to the preparation of the problems used in this study, which were applied in the second half of the 9th grade, to ensure that they were in line with the relevant curriculum. In addition, the questions used in this test, which are organized according to the Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation steps of Bloom's Taxonomy, are arranged as follows.

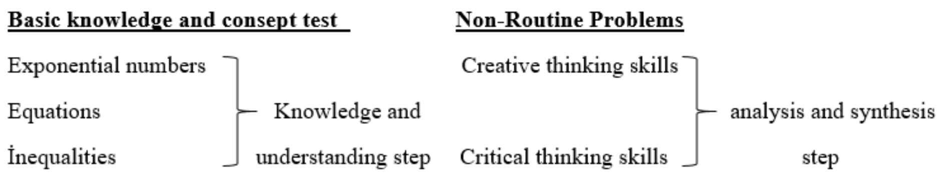

Figure: Relationship of math questions to bloom taxonomy digits

2.3. Data Collection

The data of the research were collected in the second half of the 2017-2018 academic year during a period of approximately 3 months.

2.4. Analysis and Analysis of Data

The quantitative data obtained as a result of the research were analysed using the SPSS 24.0 program. Since the data did not show normal distribution, non-parametric test techniques were used. The Mann-Whitney U test was used for two-factor variables, and the Kruskal-Wallis test was used for variables with more than two factors to determine significant differences between groups. Significance levels were accepted as $p<0.05$.

The construct validity of the mathematics test was determined by taking expert opinions, while the reliability was determined based on the correlation between the raters. While the validity of the Mathematics Test was determined by taking the opinions of two experts in the field, the decision was made to evaluate its reliability among three different raters. The raters in the study comprised three mathematics teachers who had graduated from the department of mathematics teaching. The teachers evaluated their scores based on the rubric rating key given to them. Popham (1997) and Kan (2007) stated in their studies that when scoring such tests with a rubric graded answer key, the number of raters should be between three and five people in order to save time, effort, and cost. Before scoring, the researcher interviewed each teacher and gave information about how the scoring should be and what should be paid attention to.

3. Findings

3.1. Demographic Information on Students

In order to determine the distribution of the demographic information of the students, frequency analysis was performed and the results are given in table form below.

Table 3: Demographic data of the students

		n	%
School report card	3	5	2.8
	4	9	5.1
	5	21	11.9
	6	36	20.5
	7	25	14.2
	8	34	19.3
	9	29	16.5
	10	17	9.7
	Total	**176**	**100.0**
Level of liking	Least	17	9.7
	Less	17	9.7
	Medium	52	29.5
	More	49	27.8
	Most	41	23.3
	Total	**176**	**100.0**
Taking a course	Yes	84	47.7
	No	92	52.3
	Total	**176**	**100.0**
Level of understanding	Never	2	1.1
	2	5	2.8
	3	2	1.1
	4	16	9.1
	5	15	8.5
	6	21	11.9
	7	27	15.3
	8	40	22.7
	9	28	15.9
	A Lot	20	11.4
	Total	**176**	**100.0**

According to the examination pass regulation system determined by the Ministry of National Education, grades of 5 and 6 were determined to be moderate, 7 and 8 were determined to be good, and 9 and 10 were determined to be very good. In this context, it can be said that those who have a grade of 7 or higher (59.7%) from the report card grades in the distribution have a good or very good grade in mathematics. The fact that 80% of the students with very poor grades (3) take private lessons shows that these students most likely attend these courses with the aim of passing their classes. It is seen that only 22% of the students with a report card grade of 4 go to private lessons, and 78% of them do not attend a private course because they pass the class due to their average grade, even though the grade is 4 according to the passing system. However, it is thought that 22% of them go to private lessons because they have an average grade problem. The rate of attending the course is around 40% for those with report card grades of 5, 6, 7, and 8, and it is thought that the purpose of taking private lessons may have been to ensure that the grades do not decrease as well to increase them as much as possible. Students with a grade of 3 may have aimed to raise their grade, while students with a grade of 9 may have aimed to raise their grade further. Similarly, the fact that those with a grade of 10 have a very high rate of 65% is thought to indicate that students who get grades of both 9 and 10 do not take private lessons for the purpose of passing the course but are likely to improve their learning. In general, around 50% of students take private lessons, which highlights the deficiencies in the education system. This situation reveals that both students who are weak in the course and students who are more advanced cannot sufficiently develop themselves in line with their own goals in their schools.

Table 4: Demographic data of the students (continued)

		Course taking status			
		Yes		**No**	
		n	**%**	**n**	**%**
School report card	**3**	4	80.0%	1	20.0%
	4	2	22.2%	7	77.8%
	5	10	47.6%	11	52.4%
	6	15	41.7%	21	58.3%
	7	6	24.0%	19	76.0%
	8	14	41.2%	20	58.8%
	9	22	75.9%	7	24.1%
	10	11	64.7%	6	35.3%

When we look at the proportion of students taking a course was examined, it was concluded that 47.7% of the students took a special course for mathematics, and 52.3% did not. Suppose the distribution of students' level of understanding of the mathematics lesson is examined. In that case, the increase in the number of students as the level of comprehension increases shows that the students in the research group can adequately understand what is explained in the mathematics lesson. In this direction, students who do not have problems in understanding mathematics are generally expected to develop a solution strategy to deal with the possible types of questions.

3.2. Distribution of Mathematics Achievement Test Scores by Gender Variable

On the other hand, when the distribution of students' mathematics achievement scores according to gender variable was examined, it was seen that the mathematics achievement scores did not differ significantly by gender ($p>0.05$). This situation shows that the mathematics achievement levels of male and female students are at the same level.

3.3. Distribution of Mathematics Achievement Scores by School Variable

Table 5: Distribution of Mathematics Achievement Test Scores by School Type Variable

		N	Average	Std. deviation	KW	p
Basic knowledge and conceptual skills	S1	31	12.4	2.5	47.509	0.000*
	S2	30	14.9	3.3		
	S3	30	11.0	2.5		
	S4	34	11.1	2.3		
	S5	23	12.2	3.5		
	S6	28	9.4	2.0		
	Total	176	11.8	3.1		
Non-routine	S1	31	12.7	2.1	15.423	0.009*
	S2	30	12.9	3.9		
	S3	30	12.6	2.4		
	S4	34	13.8	3.2		
	S5	23	13.4	2.5		
	S6	28	11.0	2.6		
	Total	176	12.8	3.0		
Total Points	S1	31	25.1	2.7	38.927	0.000*
	S2	30	27.8	5.4		
	S3	30	23.6	2.9		
	S4	34	24.9	4.5		
	S5	23	25.6	5.4		
	S6	28	20.4	3.5		
	Total	176	24.6	4.7		

*p<0.05

According to the results of the Kruskal-Wallis test, the basic knowledge and conceptual skills, non-routine and total scores differ significantly according to schools ($p<0.05$). According to the pairwise comparisons made in order to determine from which group the differences originate; For non-routine problems, it was observed that the mean of the S6 school was significantly lower than the mean of all other schools, and there was no significant difference between the other schools. In this context, it can be said that the students who constitute the study group, including those attending the S6 school, do not have sufficient skills to solve non-routine problems. In non-routine problems, although students from the S4 school achieved the highest success, there was no significant difference between the achievements of other schools, except for the students from the S6 school, who had the lowest success. For the total score, it was observed that the mean of the S6 school was significantly lower than the mean of all other schools. There was no significant difference between the other schools. In addition, it was seen that the average of the S2 school was significantly higher than the average of the S1, S3, S4, and S6 schools, but there was no difference with the average of the S5 school. This situation reveals that S2 school students have a higher mathematics achievement level than students from the other schools. As mentioned above for the S5 school, as mentioned above, it can be accepted that it is an Anatolian High School type of school and that GCSE programs are included in these schools, thus increasing the school's success. It is seen that the achievement scores of S6 school students are significantly lower than all other school students, considering similar reasons as well as in basic knowledge and concept skills and in solving non-routine problems.

It is expected that basic knowledge and skills will be acquired in the second phase of primary and secondary school education. Therefore, considering that the S2 school accepts students based on the results of an exam, it is thought that the students who continue from the middle level to the last level of high school are trying to gain the necessary knowledge and skills. However, it can be accepted that students from the S6 school, who have a different school culture and who are accepted with an exam at the high school level, do not gain sufficient basic knowledge and skills since they are educated with an exam-oriented system in order to enter these schools. The same can be considered valid for their performance in non-routine problems. It can be said that college students whose learning is not exam-oriented perform better because of their reasoning skills and the fact that they are educated through problems and GCSE-style interpretation questions.

3.4. Distribution of Mathematics Achievement Scores by Report Grade Variable

When the outcomes of the Kruskal-Wallis Test are examined for the distribution of mathematics achievement scores according to the report grade variable, it is seen that the relevant results are as follows:

Table 6: Distribution of Mathematics Achievement Test Scores by Report Grade Variable

		N	Average	Std. deviation	KW	p
Basic knowledge and conceptual skills	3	5	9.0	2.1	41.563	0.000*
	4	9	11.0	3.5		
	5	21	10.1	2.3		
	6	36	10.4	2.2		
	7	25	11.7	2.4		
	8	34	12.1	3.0		
	9	29	13.2	2.7		
	10	17	15.6	3.6		
	Total	176	11.8	3.1		
Non-routine	3	5	12.4	2.9	17.277	0.016*
	4	9	11.2	1.9		
	5	21	11.5	2.3		
	6	36	12.3	3.0		
	7	25	12.4	2.4		
	8	34	13.4	3.4		
	9	29	13.4	3.4		
	10	17	14.2	2.4		
	Total	176	12.8	3.0		
Total Points	3	5	21.4	2.7	43.437	0.000*
	4	9	22.2	4.8		
	5	21	21.6	3.4		
	6	36	22.8	3.5		
	7	25	24.2	3.3		
	8	34	25.4	4.4		
	9	29	26.6	5.0		
	10	17	29.8	4.6		
	Total	176	24.6	4.7		

*p<0.05

As can be seen from the table above, basic knowledge and conceptual skills differ significantly according to the non-routine and total score ($p<0.05$). The results of the pairwise comparisons (Mann-Whitney U test) conducted to determine from which the group difference originates are indicated in Table 6 below.

As can be seen from Table 5, when the total score is considered together with both basic knowledge and concept skills and non-routine scores, those with a grade of 10 are significantly different from the students with other grades; as previously explained, those with a grade of 10 are able to learn in greater depth about school lessons and on the same subjects. This differs significantly not only from those with grades 6, 5, 4, and 3, but also from grades 9, 8, and 7. It is also known that students with a grade of 10 are among the students who take the most courses after those with a grade of 3. Those with a grade of 9 differ from those with a grade of 3 in total points, those with a grade of 9 also engage in meaningful learning like those with a grade of 10, and those with a grade of 3 focus entirely on passing the class with private lessons. The fact that those with a grade of 9 were different from those with a grade of 7 may be due to the fact that those with a grade of 7 do not worry about failing in the classroom but are unlikely to increase their grades to 9 or 10, and those with a grade of 7 do not try to raise their position as they are not motivated to do so, meaning that they are comfortable instead of learning the subjects in greater depth. It is thought that those with a grade of 8 are not sufficiently different from those with grades of 7, 9, and 10, it is thought that those with 8 grades make an effort to increase their learning and are very close to those with grades of 7. However, there is no significant difference between those with a grade of 3, especially due to the high scores of basic knowledge and conceptual skills. Again, since those with a grade of 8 are in the middle, those with grades of 5 or 6 pass the grade, and those with a grade of 4 pass the grade probably due to their average grade, the total scores of these students based on their ability to solve non-routine problems of their basic knowledge and concept skills (grades 4, 5 and 6) differ significantly.

It has been previously stated why those with a grade of 7 did not differ from those with grades of 8, 9 and 10. However, it is seen that the students with a grade of 7 do not differ from those with grades of 3, 4 and 6, but only from students whose grades are at the limit (5) and who do not have a desire to increase their grade.

It can be accepted that these results show that students with higher grades increase their ability to solve non-routine problems as well as their basic knowledge and conceptual skills. It can be said that those who score high in basic knowledge and concept skills achieve higher scores in non-routine problem-solving skills.

3.5. Distribution of Mathematics Achievement Scores by Level of Liking

The changes in the mathematics achievement scores of the students according to the level of liking are shown in Table 6 below.

Table 7: Distribution of Mathematics Achievement Test Scores by the Variable of Level of Liking

		N	Average	Std. deviation	KW	p
Basic knowledge and conceptual skills	Less	17	10.0	1.9	18.441	0.001*
	2	17	11.5	2.9		
	3	52	11.0	3.0		
	4	49	12.2	3.0		
	More	41	13.3	3.3		
	Total	176	11.8	3.1		
Total Points	Less	17	20.9	2.9	21.191	0.000*
	2	17	23.9	3.9		
	3	52	23.8	4.5		
	4	49	25.2	4.8		
	More	41	26.7	4.6		
	Total	176	24.6	4.7		

*p<0.05

The basic knowledge and concept skills and the total score differ significantly according to the level of liking ($p<0.05$). The results of the Paired comparisons (Mann-Whitney U test) conducted to determine from which group the difference originates are given in Table 7 below.
ß
An examination of the table reveals that, for basic knowledge and concept skills, it is seen that the average of those who like maths at a very high level is significantly higher than the average of those who like it the least, and the average of those who like it the most is significantly higher than the average of those who like it least. Therefore, this situation shows that the success of students in basic mathematical knowledge and concept skills changes in direct proportion to their level of liking.

There was no difference in the scores of non-routine problem-solving skills between students who liked and did not like mathematics, and in fact, there was not a very high rate of doing so since students were not trained according to non-routine problems in schools. (Because the information will be transferred, and moreover, the types of questions that enable individuals to be creative and make judgments and which they are not accustomed to are not included).

On the other hand, in terms of basic knowledge and conceptual skills, it is seen that the high level of liking is different from those at the lower levels. Because those who like maths at a very high level most probably have increased their school grades with the special courses they have taken, there may be a significant difference between basic knowledge and conceptual skills due to the low grades of those who do not like it.

As can be seen, there is no effect on the scores of non-routine problem-solving skills in the total score, it differs not only from the very high level but also from the medium and low levels. Additionally, the highest level of liking differs from the lower and middle-lower levels, except for the higher level of liking, which is very much. This situation indicates that liking mathematics increases total mathematics achievement levels.

Table 8: Distribution of Mathematics Achievement Test Scores by the Variable of Courses Taken

Course Enrolment Status		N	Average	Std. deviation	U	P
Basic knowledge and conceptual skills	Yes	84	12.06	3.25	-0.941	0.347
	No	92	11.63	3.06		
Non-routine	Yes	84	12.83	2.75	-0.13	0.897
	No	92	12.67	3.15		
Total Points	Yes	84	24.89	4.49	-0.872	0.383
	No	92	24.30	4.84		

It was observed that mathematics achievement scores did not differ significantly according to courses taken ($p>0.05$). In other words, it can be said that the mathematics achievement levels of those who take the courses and those who do not are at the same level. This is because considering that the courses are school-oriented when the scale applied for research consists of questions that measure both basic knowledge and conceptual skills and non-routine problem skills, those taking these courses (such as 80% of those with a grade of 3) only did so to increase their grade. The fact that there are courses aimed at raising the school grade of students with a grade below 9 also shows that these private lessons do not develop the problem-solving skills targeted in mathematics programs.

3.6. Distribution of Students' Mathematics Achievement Scores by Understanding Levels

The distribution of students' mathematics achievement scores according to their understanding levels is shown in Table 8.

Table 9: Distribution of Mathematics Achievement Test Scores by Comprehension Level Variable

		N	Average	Std. Deviation	KW	p
Basic knowledge and conceptual skills	Never	2	8.00	1.41	5.828	0.000*
	2	5	9.20	2.17		
	3	2	10.00	1.41		
	4	16	10.50	2.58		
	5	15	11.47	3.29		
	6	21	10.14	1.82		
	7	27	11.78	3.33		
	8	40	11.43	2.66		
	9	28	13.50	2.69		
	More	20	14.75	3.37		
	Total	176	11.84	3.15		
	8	40	13.13	2.41		
	9	28	13.21	3.49		
	More	20	13.20	3.04		
	Total	176	12.75	2.96		
Total points	Never	2	17.50	0.71	5.076	0.000*
	2	5	21.40	2.51		
	3	2	19.50	3.54		
	4	16	22.56	3.92		
	5	15	22.67	4.10		
	6	21	22.19	3.60		
	7	27	25.56	4.80		
	8	40	24.55	4.03		
	9	28	26.71	4.85		
	A lot	20	27.95	4.36		
	Total	176	24.59	4.67		

*p<0.05

According to the Kruskal-Wallis analysis results shown in Table 9, the basic knowledge and concept skills and the total score differ significantly according to the level of comprehension ($p<0.05$), while the non-routine sub-dimension does not differ significantly according to the level of comprehension ($p>0.05$). The results of the Pairwise comparisons (Mann-Whitney U test) made in order to determine from which group the difference originates are indicated in Table 4.1.7.10 as follows.

As indicated in Table 4.1.7.10, it is thought that students who understand at the level of 7 for basic knowledge and concept skills are different from the intermediate students at levels 4 and 5, which are completely mediocre, because students who are at the lower level trying to raise themselves to the higher level. Those with grades of 9 and 10 are a group of students who virtually have a complete understanding, and it is thought that these students may have differed because they were also those who understood.

When we look at the non-routine problem-solving skill scores, it is seen that there is no significant difference between any level of understanding since school programs do not aim to develop problem-solving skills or to provide non-routine problem-solving skills, as mentioned above with regard to the level of liking. This, in turn, has an effect on the total scores and shows that the high-level understanding differs from the low-level understanding in total scores.

Those who understand at Level 10 differ from those who understand at Level 9 and 7. The fact that the students in this group (those with grades of 8) aim to increase their grades due to the course they have taken, as explained before, distinguishes them from the 9-10 group.

Students at level 9 are different from all others apart from those at level 10 and 7. Since 7 is the lowest level of understanding, it is thought that those who understand at this level try to improve themselves. Just as the 8 level is different from the 9 and 10 levels, it is seen that it differs only from those who do not understand at all and those who understand at 6 level. This is because while those who do not understand at all do not make a certain effort, it can be accepted that those who understand at level 6 are low due to the fact that they do not make any effort to maintain their position or to take it further. Level 7, on the other hand, does not differ from levels 8, 9 and 10 due to the aim of moving forward since it is at the lower limit of the upper comprehension level, and it is thought that those at level 3 differ from those at this level due to the courses they have taken even though they do not understand. However, it is seen that there is no difference among all levels other than this.

3.7. Relationships Between Math Scores

Correlation analysis was performed to determine the relationship between scores regarding mathematics scores, and the Spearman correlation coefficient was obtained.

Table 10: The Relationship Between Mathematics Test Achievement Scores

		Basic knowledge and conceptual skills	**non-routine**	**Total Points**
Basic knowledge and conceptual skills	r	1	.156*	.744**
	p		.038	.000
Non-routine	r	.156*	1	.748**
	p	.038		.000
Total Points	r	.744**	.748**	1
	p	.000	.000	

As can be seen from Table 10, there is a positive relationship of 15.6% between basic knowledge and concept skills and non-routine, and a positive relationship of 74.4% between basic knowledge and concept skills and the total score. On the other hand, there is a significant positive correlation at the level of 74.8% between non-routine and total scores.

In this direction, it can be concluded that the scores of the students in basic mathematics knowledge and concept skills affect the scores they obtain from non-routine problems, and in the same way, the scores of basic mathematics knowledge and concept skills affect their total scores. On the other hand, it can be said that the scores obtained from non-routine problems also affect the total scores. In summary, it can be accepted that non-routine problems affect the total score, which reveals the mathematics achievement score.

Approaches and measurements applied by schools in mathematics education are arranged in such a way that they are mainly at the level of knowledge and comprehension. Non-routine problems are rarely given enough space. Therefore, the correlation result between success scores in basic knowledge and concept skills and success scores in solving non-routine problems is a very low value of 0.15, which is an expected result according to the education system applied. In fact, if basic knowledge and conceptual skills were really gained, not because of memorization or special courses, and if they were familiarized with the questions in Bloom's Taxonomy in schools, the relationship between students' non-routine problem skills would be expected to be high. But the result here is quite natural. In addition, the relationships between the basic knowledge and conceptual skills and total score as well as the non-routine problem-solving skills and the total score were almost the same (0.74 - 0.75), and it is thought that there is another reason why there is a relationship between their skills.

4. Conclusion And Recommendations

4.1. Conclusion

The PISA exam, which reveals the mathematics achievement levels of countries, is important. However, it is not applied in our country. For this reason, the non-routine problem-solving skill test developed for research also emphasizes the importance of the research in this respect, as it will take its place as a new test in the field of mathematics. Based on this research conducted in this context, the mathematics achievement levels of the schools in our country that accept students based on examinations were determined.

When the literature is examined, similar to the results above, studies on whether students' passion for mathematics affects their academic achievement in different fields, the factors affecting mathematics achievement and its effect on mathematics self-efficacy (Özdemir, Bulut, and Ünal, 2018; Ergin and Ergin, 2017; Adal and Yavuz, 2017) were considered.

When the mathematics achievement score results in the study were examined, it was seen that the girls and boys were at the same level, and the findings did not differ according to the variable of taking the course.

When the dimensions revealing the mathematics achievement score were examined, it was seen that there were significant differences between schools. In terms of basic knowledge and concept skills, it was seen that S2 school students achieved the highest level of success, while the lowest level was achieved by S6 school students. Based on the examination of the non-routine problems, which is another dimension, it was concluded that while the S6 school still obtained the lowest score, there was no significant difference between the other schools. Similarly, the students of S6 school achieved a lower score than the students in all other schools in the last dimension, the total score, and lagged behind other schools. It can be said that the students of S6 school, who were ranked last as they obtained lower scores than the other schools in the general scoring, who have different secondary school cultures and admit students with a special exam, are not able to gain sufficient basic knowledge and skills because they are placed in the school with lower scores compared to those who attend the S5 school. On the other hand, considering that the S2 school accepts students with a special exam, it is natural that students who start from the middle level and continue until the last level of high school have a higher level of basic knowledge and conceptual skills when it is considered that they are placed with the highest scores.

Considering the non-routine problem-solving skills, it is thought that the reasoning skills of the college students are improved due to the fact that they are trained on GCSE-style questions, and they, therefore, achieve higher scores. In the study conducted by Özaşkın and Bacanak (2016), it was revealed that the necessity to conduct a structured program prevents the implementation of flexible teaching during the education period and that the exam-oriented system negatively affects the development of creativity.

Clean and Çimen (2017), when examining the problem-solving skills of 5th grade students, revealed that this is the first time such students encounter non-routine problems and that those with poor academic success have problems understanding and solving questions.

One of the other important results obtained in the research is that there is a significant difference between the change in the students' grades and their mathematics achievement and that the students whose grades increase in the basic knowledge and concept skills, as well as their success levels in non-routine problems, also increase.

Similarly, in Öz and Işık's (2018) study conducted with 174 primary and secondary school mathematics teaching undergraduate students, it was determined that the students whose mathematical reasoning skills were examined developed logical arguments for solutions and the rate of answering correctly in the dimensions of solving non-routine problems increased.

According to the variable of students' love of mathematics, it was observed that the total score and the basic knowledge and concept skill scores differed. It has been observed that the basic knowledge and conceptual skills of the students have changed in relation to the variable of liking mathematics, and the total mathematics achievement scores of those who love mathematics increased.

Bilgiç (2011) stated that students who develop a positive attitude towards the lesson ensure that they are suitable and prepared before coming to class, making them not only interested in the lesson, but also loving mathematics, whereas those who do not are less prepared and therefore less interested. For this reason, it has been revealed in the above-mentioned studies that students who prefer to sit in the back row will always require the help of others when trying to solve the problems that will arise in their lives, as emphasized in the studies above.

When the results obtained from the research are evaluated, it can be said that the fact that there is no difference in the non-routine problem-solving skill scores of the students who love and dislike mathematics is due to the fact that the students do not encounter such problems.

In this regard, Ulu, Tertemiz, and Peker's (2016) experimental studies on reading comprehension and problem-solving strategy education with control and experimental groups examined the effect on the non-routine problem-solving skills of 467 5^{th} grade primary school students. By giving 6 non-routine problems, it was discussed whether the students applied the strategies to solve the problems. The results revealed that the increase in mathematics achievement could be achieved by the students using their reading comprehension and problem-solving strategies of together and only by subjecting them to this type of education from an early age.

The results obtained from this study are similar those of the study by Işık and Kar (2011) that examined the non-routine problem-solving skills of 6th, 7th and 8th grade high school students. It was observed that students experience a number of problems arising from getting used to solving routine problems instead of non-routine problems that require high-level thinking skills.

When the mathematics achievement was evaluated, it was observed that there was not much difference between the students who took a special course from mathematics and those who did not, while significant differences were observed in the basic knowledge and concept skill score dimension and the total score dimension of the students whose mathematics understanding levels were examined. This situation reveals that school programs are not sufficiently effective to develop both problem-solving and non-routine problem-solving skills.

Similarly, Han, Hoon, Singh, Nasir, and Rasid (2019) selected 128 university lecturers in their study, and in line with the results of various reports, revealed that graduate students' problem-solving and communication skills are not sufficient in their business life. It has been revealed that they do not have sufficient reasoning skills to educate mathematical thinkers. While the data obtained show that the achievements of the instructors are below the average level, it also revealed that in order for individuals to gain mathematical thinking skills, they should primarily have concept knowledge and problem-solving skills. This study indicates that it is important for teachers to try to increase their problem-solving skills by choosing problems that will improve them and to work with difficult questions if necessary.

When the mathematics achievement scores of the students were compared, it was concluded that the solution of non-routine problems affected the total score, which revealed the mathematics achievement score. This is actually an expected result since not enough non-routine problems are included in schools.

Similarly, Saygılı (2017), who discussed how high school students' ability to solve non-routine problems and the strategies they use affect their success levels, revealed that students' non-routine problem-solving skills are not sufficient. Therefore, it has been observed that students who do not have sufficient knowledge of these subjects cannot effectively solve non-routine problems since the problems in question require conceptual and operational skills.

This situation also shows that in terms of the characteristics determined by the Ministry of National Education, the students have difficulty in identifying the problem, and they cannot establish the relevant connection or relationship.

Due to the fact that our education system does not have a regulation system for determining student achievement at the national level regarding the determination of the quality of education, comprehensive data were obtained on the perception, love, and understanding levels of the students in the schools, as well as their mathematical problem-solving skills, which the Ministry approved of National Education. Our education system, which is implemented in parallel with the education programs in Turkey, has been ranked at the bottom in exams in which the levels of students in Turkey are evaluated for years, and they remain below the average level (Kastberg, Chan and Murray, 2016). It is thought that this situation is due to the fact that many teachers in the education system continue to adopt the old understanding. When the PISA results in Turkey, which provides education with a content-based teaching method, are examined, it is seen that the top countries have adopted the student-centered education approach, and it is thought that this situation will only be improved if students can learn to conduct research based on a curriculum that is reorganized with technological developments.

4.2. Recommendations

In this section, some suggestions are given based on the data obtained in line with the research results. It can be noted that the questions prepared are based on learning and interpretation. At the same time, this situation can prevent rote-oriented education and support learning based on experimentation and observation rather than formula-based learning. In support of this, it is thought that the administrators in each school should encourage the use of such questions by providing the opportunity to compare the types used among teachers. For example, strengthening international ties, exchanging ideas on education systems, and entering the accreditation process can provide an advantage in terms of enhancing the national level of education. In addition, a national level measurement-evaluation and development centre can be established that will reveal the extent to which the desired outputs have been achieved in the education system. A wide range of diversity can be achieved by increasing the non-routine problem types determined for the mathematics achievement test designed to reveal the mathematics achievement scores.

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