IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education *2020, volume 9, issue 2*

INVESTIGATION OF METACOGNITION AWARENESS LEVELS AND PROBLEM SOLVING SKILLS OF MIDDLE SCHOOL STUDENTS

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Received: 25.04.2020 **Accepted:** 26.10.2020 **Published:** 31.12.2020

Abstract

The aim of this study was to analyze middle school students' metacognition awareness levels and problem solving skills. The research was carried out with a total of 1595 middle school students studying in the 5th, 6th, 7th, and 8th grades in a middle school in a city of the Central Anatolia Region. The metacognitive awareness scale (MAS) form B for children developed by Karakelle and Saraç (2007) and the problem solving inventory (PSI) for middle school level students developed by Serin and Saygılı (2010) were used as instruments. The research was developed in accordance with the survey model, which is one of the quantitative research methods. The SPSS program was used for analysis. Descriptive statistics, normality tests, correlation analysis, independent samples t test, and one-way variance analysis were run. For this study, the Cronbach Alpha value of the metacognitive awareness scale (MAS) for middle school students was found to be .84 and the problem-solving inventory (PSI) for children at the middle school level was found to be .65. Metacognition levels of females were higher than the males. Females and males were at the same level in the problem solving inventory. In the study, it was concluded that the metacognition awareness levels and problem solving skills were significantly different at different grade levels.

Keywords: Metacognition, middle school, problem solving skills.

INTRODUCTION

Thinking with knowledge is using related concepts but knowledge is not enough for thinking. Some educational institutions generally place that transfer of knowledge to students piece by piece, they do not encourage individuals to think and image adequately. The way to close this shortcoming is to include more mathematical thinking and more precisely problem solving activities. Students can develop different thinking skills through their experiences with problem solving. The skills gained with problem solving skills should be perceived in solving other problems, remembering a first solution, and being aware of all the mental activities. This process in problem solving steps reveals the importance of the concept of metacognition and its relationship.

The National Council of Teachers of Mathematics (NCTM) stated that the problem solving process should be extended to the entire mathematics education and the process should be shaped by teachers (NCTM, 1991). Metacognition skills begin to manifest in the preschool period and continue to develop throughout the learner's life. Metacognitive abilities further develop and differentiate with richness of life as an individual matures. However, the effect of teaching on the acquisition of metacognitive skills is more than maturation (Gage and Berliner, 1988; cited in Subaşı, 1999). In this process, the teacher should present problems that will give students' different expressions, considering their cognitive development. However, students' negative past experiences, or beliefs can negatively affect this process. Such negative thoughts can also negatively affect success.

Problem Solving

Mathematics is a special and general language that has a unique alphabet, contains symbols and shapes, uses letters for known and unknown expressions, and includes unique words and phrases (Umay, 2002). This language not only teaches its formulas but also provides skills, such as going beyond rules and exploring connections. Mathematical problems, on the other hand, help the individual to get into this thinking process. Unlike exercises that require repetition in a certain order, problems enable students to reach a result by thinking, researching, and discussing. Mathematical problems provide skills such as understanding connections within a problem, revealing operations to resolve the connections, making decisions, and implementing the process. NCTM expresses the main rationale for studying mathematics as problem solving (NCTM, 1977). Similarly, the NCTM stated that the problem-solving process should be extended to the entire teaching of mathematics and the process should be shaped by teachers (NCTM, 1991).

The most common problem types in the literature are unusual (non-routine) and ordinary (routine) problem types. An unusual problem type is defined as a predictable, well-studied approach or no-path problems for unusual problem solutions. In contrast, ordinary problems are those that one can solve by learning familiar methods that were previously familiar to them and follow step by step (Woodward, Beckmann, Driscoll, and Franke, 2012). Ordinary problems' solutions can be realized with four operations. The problem can be solved by following a well-known example that does not create innovation, which is step by step is an ordinary problem. One will not have the opportunity to use their own judgment or creative abilities (Polya, 2017). Solutions of extraordinary problems require higher levels of skills, such as seeing relationships, classifying, and organizing data beyond the four processing skills (Souviney, 1989). Mathematical problem solving is the process of eliminating a problem by using the necessary knowledge and passing the steps to reach an existing goal that mathematics must have in an abstract structure (Altun, 1995).

The process of solving the problem is not different from the scientific process. The ways to access information are experiences, knowledge of another person (consensus), knowledge of an expert person (authority), logic, and science (Büyüköztürk, Çakmak, Akgün, and Demirel, 2016). While solving a problem in the scientific method, one uses the problem solving process as support. It is a process, which includes the following steps in the scientific method: identifying a problem or problems, describing it, collecting data, analyzing it, and interpreting the reached conclusion (Fraenkel and Wallen, 2006).

Problem solving steps were defined by Polya (1944, p.5) as follows:

> "First, we need to understand the problem, and see clearly what the problem wants. As a second step, we need to see how the various elements are connected to each other, how the unknown is connected to the data to create an idea of the solution and ultimately create a solution plan. Third, we implement our plan. Fourth, we go back to the completed solution, review, and discuss the solution." (p. 5).

Whatever the problem is, it is necessary to decide on the solution and develop a strategy. Metacognition, on the other hand, has been stated as the main component of the problem solving process in many studies. Problem solving is an important element of learner's mental behavior (Schoenfeld, 1985).

Metacognition

According to Flawell (1985), who was the first to use the concept of metacognition, said metacognition is that the student is aware of the repetitive cognitive steps progressing in a certain order and time. Depending on the studies on the subject, different definitions have emerged over time. In some definitions, metacognition is considered as "high-level cognition" according to cognition within the hierarchical order of consciousness (Schunk and Pajares, 2001). Selçuk (2000) expressed it as the knowledge and awareness of individuals about their cognitive process. There are definitions that address behavior and reaction in the face of certain situations and problems as a process of changing them (Huitt, 1997). When considered within the boundaries of modeling, it is explained as a mesh divided into the three parts of metacognitive control, metacognitive monitoring, and metacognitive knowledge (Dunlosky and Metcalfe, 2009). Metacognitive information is stored declarative information that allows us to overcome an existing problem situation (Flawell, 1979).

When considered in the solution process of a mathematics problem, it can be expressed as remembering and using previous ideas and experiences required for problem solving. Stored declarative information helps us understand the problem. Metacognitive monitoring provides information about students' own cognitive status (Schwartz and Perfect, 2002). The condition of the appropriateness of the ideas obtained for the solution of a problem or the right solution strategy shows a cognitive monitoring status. However, metacognitive control expresses existing information with conscious or unconscious choices while activity is going on (Dunlosky and Metcalfe, 2009). The metacognitive control stage corresponds to looking back after solving a mathematical problem and reviewing the solution steps repeatedly. It provides consolidation of knowledge and the development of problem solving ability.

Problem Solving and Metacognition

Knowing the basic concepts and the rules for their use and knowing the steps to solve the problem in mathematics also brings methods that ensure achieving the correct result. While solving a problem, it may be necessary to use strategies such as organizing the data, deliberately estimating and checking, animation, logical reasoning, pattern finding, metacognitive monitoring, and drawing (Posamentier and Krulick, 2016). In addition to these skills, another required skill is metacognition (Victor, 2004). Students use metacognitive strategies in planning the problem, choosing for complex situations, associating these choices with previous knowledge, adapting new information to other situations, and monitoring how efficient the process is (Clark, 1998).

There are studies in the literature that suggest that there is a relationship between metacognitive knowledge and problem solving skills (Hollingworth and McLoughlin, 2001). There is a significant relationship between problem solving achievement and metacognition skills. Teaching skills increases student's achievement in problem solving. Thus, these skills organize the mental processes of students more actively and effectively (Schoenfeld, 1985). Karakelle (2012) stated that metacognition awareness levels and problem solving perceptions were interrelated structures. According to Aşık and Erktin (2019), there was a statistically low relationship between students' metacognition knowledge and problem solving skills.

The aim of this study was to analyze middle school students' metacognition awareness levels and problem solving skills in terms of different variables. The research problems were:

1. Is there a significant mean difference between metacognition awareness levels and problem solving skills in terms of gender?
2. Is there a significant relationship between metacognition awareness levels and problem solving skills?
3. Is there a significant mean difference in the level of metacognition awareness and problem-solving skills in terms of grade levels?

METHOD

Research Model

Surveys aiming to determine the expectations, behaviors, attitudes, opinions, beliefs, and characteristics of individuals on certain topics. These studies are called survey studies (Gürbüz and Şahin, 2017). The most ideal method of collecting information about different middle school student groups and their characteristics is survey models (Robson, 2017). Explaining the results and patterns in the survey models leads us to descriptive interpretation. In accordance with the data obtained, it was aimed to examine the metacognition awareness levels and problem solving skills of middle school students from various aspects. Research and publication ethics were followed in the article.

Sample of the Study

Non-probabilistic techniques that are not possible are easier to apply to study but their power to represent the research population is weak. Especially if the characteristics (demographic characteristics, attitudes, and experiences, etc.) of the elements that make up the research population are similar or homogeneous in the research population, the use of non-probabilistic techniques is often not a problem (Gürbüz and Şahin, 2017). In this study, the sampling was chosen by convenient sampling. The sample of the study was 779 female (48.8%) and 816 male (51.2%) students studying in a public middle school in Kocasinan, Kayseri. The distribution of students by gender is given in Table 1. The sample shows a balanced distribution in terms of gender.

Table 1. Gender distribution of the sample

Gender	f	%
Male	816	51.2
Female	779	48.8
Total	1595	100

Instruments

Metacognitive awareness scale (MAS) for children

The metacognitive awareness scale (MAS) form B for children was developed by Karakelle and Saraç (2007). The Cronbach Alpha value was found to be .64 by Karakelle and Saraç (2007). The scale includes 18 items with 5-point-Likert-type questions. The answer options are "1 - I Never Behave Like This, 2 - I Rarely Behave Like This, 3 - I Behave Like This Every Time, 4 - I Behave Like This Frequently, 5 - I Always Behave Like This". In this study, the reliability coefficient value for the metacognition awareness scale was found to be .84 as given in Table 2. According to Özdamar (2018), a Cronbach Alpha reliability coefficient of the scale between .90 < a <1.00 is highly reliable, .60 < a < .90 is reliable, .40 < a < .60 is low reliable, and .00 < a < .40 is not reliable. It is in the reliable range of metacognition awareness scale for children.

Problem solving inventory for elementary school children (PSI)

Problem solving skills were used for the problem solving inventory (PSI) for primary school children, which was developed by Serin, Serin, and Saygılı (2010). The Cronbach Alpha reliability coefficient was found as .80 by Serin, Serin, and Saygılı (2010). The scale consists of 24 items with 5-point-Likert type options. Answer options are “1 – Never, 2 – Rarely, 3 – Sometimes, 4 – Often, and 5 - Always”. As given in the problem solving inventory reliability analysis in Table 2, the problem solving reliability statistics value is .65 for the problem solving inventory. According to Özdamar (2018), a Cronbach Alpha reliability coefficient of the scale between .90 < a <1.00 is highly reliable, .60 < a < .90 is reliable, .40 < a < .60 is low reliable, and .00 < a < .40 is not reliable. The problem solving inventory for children in primary school is in the low-reliable range.

Table 2. Problem solving inventory and metacognition awareness scale reliability analysis

Scale	Cronbach Alpha	Total item number
Problem solving	.65	24
Metacognition	.84	18

Data Analysis

The analysis of the data collected from the metacognitive awareness scale (MAS) and problem solving inventory (PSI) for children was done with SPSS 25. In this context, descriptive statistics, normality tests, Levene test, correlation analysis, independent samples t-test, and one-way analysis of variance (ANOVA) were performed. The probability value for the analysis is determined as .05 level (95% confidence level) and .01 (99% confidence level).

Research Ethics

The ethical considerations of the data collection tools used in this research was carried out by the Social and Humanities Ethics Committee of Erciyes University in their meeting on 25 February 2020 and permission was given in the ethical committee review report number 62 on 28 April 2020. Research permission was obtained from the National Education Directorate of Kayseri with permission number 94025929-605.02-E.8819332.

RESULTS

In this section, the answers to the research questions, the analyses of the data collected from the metacognitive awareness scale (MAS) and the problem solving inventory (PSI), and the findings obtained from these analyses are included.

Central tendency measurements were used to define a single value that best expresses the distribution. The most common way is to calculate the means (Robson, 2017). In Table 3, descriptive statistics for the middle school students are given with central tendency of the MAS and problem solving inventory. When the descriptive statistics given in Table 3 are examined, the mean, median, and mode values related to problem solving and metacognition values are close to each other.

Table 3. Descriptive statistics of the scales

Scale	n	M	Median	Mode	Skewness	Kurtosis
Problem solving	1595	71.552	71	68	.192	.726
Metacognition	1595	69.156	71	72	-.531	.058

The normal distribution is the theoretical distribution of the scores seen after calculating the mean and standard deviation (Tabachnick and Fidell, 2013). Another way to test normal distribution is to look at the skewness and kurtosis coefficients. Since the descriptive statistics are between +1.5 and -1.5 in Table 3, problem solving inventory and metacognition awareness scale shows normal distribution (Tabachnick and Fidell, 2013). In samples with a normal distribution, the Levene homogeneity of the variances results are shown in Table 4.

Table 4. Homogeneity of variances Levene variance equation

Scale	F	df	p
Problem solving	.466	1593	.495
Metacognition	4.285	1593	.039

The homogeneity of the variance test is the first assumption of the independent samples t test. The Levene test result of problem solving is [$F_{(1593)}$ = .466, p=.49>.05] and the Levene test result of the metacognition awareness level is [$F_{(1593)}$=4.285, p=.039>.01]. Homogeneity of variances was satisfied.

Investigation of Metacognition Awareness Levels and Problem Solving Skills by Gender

After providing the homogeneity of variances assumption, it was examined whether there was a statistically significant mean difference between metacognition awareness levels and problem solving skills of female and male students attending middle school. Table 5 shows the independent sample t-test results regarding the gender variable.

Table 5. Independent sample t test results regarding gender

Scale	Gender	n	M	SD	t	p
Problem Solving	Female	816	71.693	9.267	.633	.527
	Male	779	71.404	8.971		
Metacognition	Female	816	68.550	10.770	2.23	.020
	Male	779	69.792	10.500		

Independent samples t-test results are given in Table 5 at the significance level of .05 for whether there is a significant mean difference in the problem solving skills and the metacognition awareness scores between female and male middle school students for problem solving skills [$t_{(1595)}$=.633, p=.527] and for metacognition awareness [$t_{(1595)}$=2.23, p=.020]. Since problem solving skills [$t_{(1595)}$=.633, p=.527>.05], there is no statistically significant mean difference between the means of male and female students attending middle school. As the metacognition awareness level is [$t_{(1595)}$=2.23, p=.02<.05], there is a statistically significant mean difference between the scores of males and females attending middle school. The metacognition awareness levels showed a significant mean difference in favor of male students (M=68.550) compared to female students (M=69.792).

IOJPE
ISSN: 1300 – 915X
www.iojpe.org
International Online Journal of Primary Education
2020, volume 9, issue 2

Examining the Relationship between Metacognition Awareness Levels and Problem Solving Skills

Correlation analysis, which means relationship, is an analysis method that confirms the relationship between two or more variables in studies (Taşpınar, 2017). Correlation analysis was conducted to examine the relationship between the problem solving skills and metacognition awareness means of students attending middle school. Since the data showed normal distribution, Pearson correlation analysis was performed. Problem solving skills and metacognition awareness levels are significant at a .05 level (r =.287, p =.000>.05) and is given in Table 6. Students' metacognition awareness levels have a positive and significant relationship in problem solving skills.

Table 6. Pearson correlations between metacognition and problem solving

Scale		Metacognition
Problem solving	Pearson Correlation	.287
	p	.000
	n	1595

Investigation of Metacognition Awareness Levels and Problem Solving Skills According to Grade Levels

Problem solving skills and metacognition awareness levels were examined at the grade levels. ANOVA was applied for more than two groups. This method of analysis can also be used to compare the means between independent samples, as well as to compare the means of three different periods for a sample that is not considered interdependent (Çimen, 2015). It was investigated whether there is a statistically significant mean difference between the problem solving skills and metacognition awareness levels of the students attending middle school at varying grade levels. Table 7 shows the normality test results of the grade levels.

Table 7. Normality test results of grade levels

Grade Level	n	Skewness	Kurtosis
5	250	.154	.307
6	492	.110	.220
7	356	.129	.258
8	497	.110	.219

The Levene Test was performed to test whether the homogeneity of the variance of the groups is one of the conditions of one-way analysis of variance for independent samples. The homogeneity test results of problem solving skills and metacognition awareness total scores are given in Table 8.

Table 8. Homogeneity of variances

Scale	Levene Statistics	df1	df2	p
Problem Solving	1.299	3	1591	.273
Metacognition	1.447	3	1591	.227

According to the Levene Test, there is no statistically significant difference between the variances of the groups since the problem solving skill group's significance is p=.2273>.05 and the metacognitive awareness level's significance is p=.222>.05. Therefore, the variances of the groups can be considered equal. Descriptive statistics of the problem solving and metacognition scales with respect to grade levels are given in Table 9.

Table 9. Descriptive statistics of scales with respect to grade levels

Scale	Grade Level	n	M	SD	Std. Error	Minimum	Maximum
Problem Solving	5	261	69.0843	8.13779	.50372	41	91
	6	523	71.7228	8.80339	.38495	46	108
	7	339	72.4985	8.90893	.48387	41	99
	8	346	72.5694	9.23899	.49669	42	104
	Total	1469	71.6324	8.89714	.23213	41	108
Metacognition	5	261	71.8621	10.00366	.61921	41	90
	6	523	69.5296	10.33188	.45178	21	90
	7	339	69.7640	10.21270	.55468	39	90
	8	346	66.8613	10.73169	.57694	34	90
	Total	1469	69.3696	10.45922	.27289	21	90

According to the mean differences between the grade levels in Table 10, the metacognitive awareness levels of the students attending middle school between grade levels, has a statistically significant mean difference in grade levels [$F_{(3,1591)}$=13.174, p=.000<.05]. Similarly, the total points of problem solving skills of the students attending middle school are between the grade levels, there is a statistically significant mean difference in grade levels [$F_{(3,1591)}$=7.777, p=.00<.05]. There is a significant mean difference between at least two of the four grade levels.

Table 10. Differences between groups

Scale		Sum of Squares	df	Mean of Squares	F	p
Metacognition	Between groups	4386.027	3	1462.009	13.174	.00
	Within groups	176558.788	1591	110.973		
	Total	180944.815	1594			
Problem Solving	Between groups	1917.156	3	639.052	7.777	.00
	Within groups	130737.222	1591	82.173		
	Total	132654.379	1594			

*p<.05

Multiple comparison tests were carried out to understand which grade levels of students attending middle school are different. If homogeneity of variances is satisfied (Equal Variances Assumed), the most used Post-Hoc test is the Tukey test (Kalaycı, 2014). Tukey test results for the differences between the mean of grade levels are given in Table 11.

Table 11. Differences between grade levels

Scale	(I) Grade Level	(J) Grade Level	Mean Differences	Standard Error	p
Problem Solving	5	6	-2.52117	0.81820	.011*
		7	-2.15025	0.86926	.064
		8	-4.92184	0.81681	.000*
	6	7	-0.37092	0.73299	.958
		8	-2.40067	0.66996	.002*
	7	8	-2.77160	0.73144	.001*
Metacognition	5	6	-2.67793	0.70407	.000*
		7	-3.32807	0.74801	.000*
		8	-2.93804	0.70287	.000*
	6	7	-0.65013	0.63075	.731
		8	-0.26010	0.57650	.969
	7	8	0.39003	0.62941	.926

*p<.05

When the mean difference between grade levels means is examined in Table 9, there is a significant mean difference in terms of problem solving skills among students studying at the sixth grade level among students studying in the sixth and eighth grades. There is no significant mean difference between students studying in the fifth grade and seventh grade since p=.064>.05 in terms of problem solving skills. There is no significant mean difference in terms of problem solving skills between students studying in the sixth grade and the seventh grade since p=.958>.05. There is a significant mean difference in terms of problem solving skills between students studying in the sixth grade and the eighth grade since p=.002<.05. There is a significant mean difference in problem solving skills between students studying in the seventh grade and in the eighth grade since p=.001<.05.

There is a significant mean difference in terms of metacognitive awareness levels between the students studying at the fifth grade level and in the sixth, seventh, and eighth grades as p=.00<.05. There is no significant mean difference in terms of metacognition awareness levels between the students studying at the sixth grade level and the metacognition awareness level of those in the seventh grade is p=.731>.05. There is no significant mean difference in terms of metacognition awareness levels between the students who study at the sixth grade level and in the eighth grade because p=.996 >.05. There is no significant mean difference between the metacognition awareness level of the students studying in the seventh grade level and in the eighth grade as p=.926>.05.

DISCUSSION and CONCLUSIONS

In this study, the level of metacognition awareness levels, problem-solving skills of middle school students, mean difference between female and male, the relationship between metacognition awareness level and problem solving skills, and mean difference between grade levels were examined.

According to the findings of the study, the problem solving skills of the students do not show a significant mean difference in terms of the gender of the students. In another study on the problem solving skills of teachers, there was no statistically significant mean difference in terms of problem solving skills of males and females (Demir and Baloğlu, 2020; Demirtaş and Dönmez, 2008). Problem solving skills of middle school teachers did not show a significant mean difference according to gender (İnan, 2015). Problems in the problem solving inventory are well-designed and non-routine problems. These problems were designed for gender bias so that both female and male students solve the problems in the problem solving inventory with similar abilities. These problems are from the daily life of both female and male students. The mean of metacognition awareness levels showed a significant mean difference according to gender. It is in favor of female student’s metacognition awareness levels. Similar findings were obtained in studies on metacognitive awareness level and gender (Evran and Yurdabakan, 2013). In a study conducted with metacognition awareness levels of middle school students, female metacognitive awareness levels were higher than male students (Öztürk and Kurtuluş, 2017). There are studies showing that metacognition awareness levels did not differ by gender (Balcı, 2007). The level of metacognition awareness in primary school students is an important variable in terms of gender (Topçu and Tüzün, 2009). The reasons why metacognition awareness levels are in favor of female students are stated to be that females are better than males in strategies such as planning, organizing, and evaluating (Bağçeci, Döş, and Sarıca, 2011). Female students are more concentrated due to developmental changes than male students are in middle grades. Female students use their metacognition abilities since they are more organized and planned than the male students in middle grades.

Students' metacognition awareness levels have a positive and significant relationship in problem solving skills. Similarly, in research conducted with middle school students, the finding that there was a positive and significant relationship between the student’s mathematical metacognition awareness and problem solving skill levels paralleled this finding (Kaplan, Duran, and Baş, 2016). In a study conducted with university students, individuals were clearly associated with the metacognitive actions used in solving problems in their daily lives, their self-perception of problem solving powers, and their metacognitive awareness levels (Karakelle, 2012). Effective problem solving abilities need the metacognition abilities of planning, organizing, and estimating. Metacognition awareness abilities are like the steps of problem solving and students use these abilities while defining variables in a problem and deciding which strategy they will use.

The problem solving skills and metacognition awareness levels of the students differed according to the grade levels for some of them. Problem solving skills differed at each grade level, while metacognition awareness levels differed in the lower grades. While metacognition awareness levels are expected to create a situation in favor of upper grades, this difference occurred in the lower grades. In another study conducted at the 6th, 7th, and 8th grade levels of middle school, there was a significant relationship between grade levels and metacognition awareness levels. As the grade levels increased, metacognition awareness levels increased (Temur, Kargın, Bayar, and Bayar, 2010).

Activities that will enable middle school students to be aware of and improve their metacognition levels should be included (Alan and Özsoy, 2019). It should be ensured that students can easily express what they know or do not know, their plans while solving a problem, and realize the inconsistencies or uncertainties within this plan. Environments in which students can evaluate themselves should be created, and the learning processes in different disciplines should be realized similarly to the student. The teacher should provide environments where students can express their thoughts comfortably, give feedback to the students about the awareness of metacognition levels, collect data, and guide them.

The study has same limitations. First limitation is that this study is a survey study. Metacognition abilities should be analyzed longitudinally and over years. Researchers only try to define the actual statements of the middle school students. Then, the surveys were administered in a big school to control the environmental factor. However, this was a limitation, future studies should be designed in a variety of schools for analyzing environmental factors.

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