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RESEARCH ARTICLE

ANALYSING MATHEMATICAL REASONING STRATEGY OF SECONDARY SCHOOL STUDENTS[i]

[1*]Menderes ÜNAL and [2]Abdullah GÖNÇ

[1]Assist. Prof. Dr., AhiEvran University, Faculty of Education, Kırsehir, Turkey
[2]Cacabey Secondary School, Kırsehir, Turkey

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ABSTRACT

This study aims to determine the use of reasoning strategy considering different variables which were consisted of students' problem solving skills and gender, location of schools and parents' income and education levels. Descriptive survey method was conducted in this research. The sample of the study was composed of eighth grade students from different six schools in both Kırşehir city centre and districts. In sample group, 64 girls (%54,4) and 52 boys (%45,6) were chosen randomly. For the purpose of identifying mathematical reasoning level of students, twenty open-ended questions from Eighth Grade National Curriculum were administered. "*Mathematical Communication and Reasoning Scale*", which was developed by Suzuki (1998) and adopted into Turkish by Taşdemir (2008), was conducted in the study. Reliability of the inventory used in the study has been retested and it has been calculated as 0,934. As a conclusion, the overall average of students' using reasoning strategy was found at intermediate level. In addition, a significant difference was seen in favour of girls in using reasoning strategy considering gender. In addition, there is a significant difference in favour of central districts with respect to towns and villages according to school location. Likewise, higher income levels of families and higher education status of parents were found significantly related to the reasoning levels of students.

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INTRODUCTION

Mathematics is an effective tool used in recognizing the environment and solving problems that people face. Throughout the history, people have applied to mathematics when they encountered a problem. Mathematics can be considered as a language that expresses abstract thoughts, uses symbols and reflects the idea of concepts. It is also a means of understanding and exploring real world by imagination. All of these aspects have made mathematics teaching a must. Due to this importance, math-related behaviours have become involved in all areas at all levels from pre-school education programs to higher education programs (Baykul, 2009). Current mathematics curriculum has been shaped by Studies in curriculum development and innovations in technology. So, teaching mathematics as other disciplines became one of the most important issue in societies. There are numerous factors in teaching mathematics (Taşdemir, 2015). Target competencies have been affected by students' individual characteristics, socio-economic levels of parents, teaching proficiency, content of educational programs, policies about education and back ground of teaching profession (Aytekin, Baltacı, Altunkaya, Kıymaz and Yıldız, 2016). After graduation, students have been expected to use cognitive, reflective and problem-solving skills whenever they face to overcome any problems by means of competencies gained from school (Büyükkurt, 1990; Semerci, 1999). In secondary school math curriculum, the necessity of gaining mathematical knowledge, skills and attitudes that a student may need throughout his or her life is emphasized. In the process of developing curriculum, conceptual learning, communicating (specific to mathematics), making mathematics more valuable in the eyes of everyone and developing students' problem solving skills are among the goals that come to the forefront. One of the most needed skills for the people among these is a problem solving (Baykul, 2009). As the students gain success in problem solving, feeling valued on their own solutions, their self-confidence on mathematics increases. Thus, students engage in more patient attitude in the process of problem solving (Toluk, 2003). As a part of this case problem solving holds an important place in secondary school curriculum. So, problem solving is considered as a basic skill expected to be developed (Ministry of National Education [MEB], 2013). Problem solving constructed on understanding new concepts and situations that lead to satisfactory results systematically by analysing.

Corresponding author: Menderes ÜNAL,
Assist. Prof. Dr., AhiEvran University, Faculty of Education, Kırsehir, Turkey.

Yeşilova (2013) argued problem solving and defined it as a process includes all affords to overcome difficulties or obstacles and reach goals. Another researcher Altun (2008) called problem solving as cognitive skills help to find new ways whenever someone faces unclear and problematic situations. The idea of taking problem solving as a means of learning has been becoming more important day by day. Students can reach a solution in problems that they face for the first time by using their existing knowledge. The development of reasoning skills as well as problem solving is required in addressing the challenges in daily life. Reasoning is the process of reaching a rational thinking by taking all the factors into account. Students' understanding of math and taking it valuable for themselves may be possible by the development of reasoning skills. Considering mathematics as a network of many related ideas is as a result of the emphasis on reasoning, as well as a basis for further reasoning (Umay and Kaf, 2005). Doğan (2013) explains reasoning in terms of matching, establish relation, social and cognitive solution, analysis, generalization and reduction. That is, reasoning is can be separated into deduction, induction and homothetic kinds. Students' reasoning levels can be determined by their comments on the situation or the diversity of strategy they used (Hines and McMahon, 2005).

In math education, students' problem solving strategies that require reasoning can be grouped into basic skills. In this context, the basic skills such as; the evaluation and interpretation of results; process, experimental and analytical verification of results; recognition of right and wrong process; development of special signs and words; identification of main elements of the problem; interpretation of the results in real-life context; determining the theme of the problem; providing clear evidence with heuristic analysis regarded as mathematical reasoning strategy (Suzuki, 1998). The aim of this study is to define students' level of mathematical reasoning strategy regarding secondary school students' problem solving skills. In this context, if there was a significant difference between mathematical reasoning strategy and students' gender, families' income status, the location of the school and educational background of the parents and problem solving skills were investigated.

Research Method (10pt)

Descriptive survey method was conducted in this research. Survey methods aim to define past or present states as they are. Descriptive survey could be separated into general survey model and case study. Relational survey model was conducted in the study because it was aimed to define changes and degrees among two or more variables (Karasar, 2006;Yazıcıoğlu and Erdoğan, 2007). The sample of the study was composed of eighth grade students from different six schools two of which are in Kırşehir, one in Mucur and Akpınar districts, and two schools in villages. In sample group, 64 girls (%54,4) and 52 boys (%45,6) were chosen randomly. Twenty open ended questions were prepared to define students' mathematical reasoning level. These questions were selected considering the eighth class mathematic curriculum. Content and language validity were confirmed by the opinions of four experts in mathematics and language. Besides, the questions that let students show their problem solving strategy with mathematical operations were selected. These questions were assumed suitable for revealing reasoning and self-sufficiency in problem solving.

Four of those open ended questions were conducted to four groups of students each week. To define students' mathematical reasoning level of "*Mathematical Communication and Reasoning Scale*" by Suzuki (1998) was used. This scale consists of five categories, concepts, process, reasoning, maturity and mathematical communication. The validity and reliability coefficient of Turkish translation version of the scale were done by Taşdemir (2008). Reliability of the adopted inventory, "*mathematical reasoning level*" which was used in the study, retested and calculated as 0,934. In an attempt to determine students mathematical reasoning strategy, the methods to solve the problems in worksheets during applications has been examined and classified as high (3), medium(2), low(1) and absence (0). The examples for the classification can be seen in the tables (see Appendix 1).

The data which were gathered from the students as well as information forms were entered into SPSS 16.0 software package and then necessary analysis were performed. Normal distribution Kolmogorov-Smirnov test results were calculated as $Z = 0.734$; $p>0.05$ and data was found to provide normal distribution (Büyüköztürk, 2003; Kalaycı, 2008). Frequency (f), percentage (%), arithmetic mean ($\overline{X}$), standard deviation (SD) from scientific research statistics, t- test, one-way ANOVA and Scheffe test were used to analyse the data

RESULTS AND ANALYSIS

The mean of reasoning strategy of the students is 2,52 out of 4. That is, the students' reasoning is at medium level. Strategy scores were compared to gender, residential area, family income, maternal and paternal education status of students and given in the following part with the comments.

Comparison of the genders of the students with reasoning strategy scores

Table 1.T-Test results for reasoning strategy scores according to the gender

Gender	n	$\overline{X}$	SD	df	t	p
Female	61	2,6639	,72319	112	2,377	,019
Male	53	2,3538	,66063			

p<.05

According to Table 1, comparing the female students' reasoning strategy scores ($\overline{X}$=2,66) to the male students' reasoning strategy scores ($\overline{X}$=2,35), there is a significant difference in favour of female students ($t_{(112)}$= 2,377; p< ,05). The difference can be explained by starting to maturate and abstract thinking earlier of females.

Comparison of the students' reasoning strategy scores to their residential areas

One-way ANOVA was employed to identify if there is a meaningful difference between students' reasoning strategy scores and the places that they reside. Findings are shown in Table 2

According to Table 2, there is a statistically significant difference between reasoning strategy scores of students and residential areas ($F_{(113)}$ = 35,008; p<, 01), Scheffe test analysis was implemented to identify the source of the difference in the scores of students who live in the city are compared to the students who live in the districts and the villages.

Table 2. ANOVA results of reasoning strategy scores and students' residential area

The source of the variance	SS	df	MS	F	p	Significant Difference
Between groups	21,971	2	10,986	35,008	,000	*City centre-District *City centre-Village
Within groups	34,832	111	,314			*District-Village
	56,803	113				

p<.01

There is a significant difference in favour of the students who live in the city centre. Likewise, the scores of the students live in the districts have a significant difference compared to the students who live in the villages. In other words, the development of the residential area and reasoning strategy scores increase linearly. The source of this difference can be correlated with limitations in accessing information and having number of educational problems.

Comparison of reasoning strategy scores to income of students' parents

One-way ANOVA was employed to identify whether there is a significant difference between reasoning strategy scores and students' families monthly income status. Findings are shown in Table 3.

Table 3. ANOVA results of reasoning strategy scores and income of students' parents

The source of the variance	SS	df	MS	F	p	Significant Difference
Between groups	15,432	3	5,144	13,678	,000	*3.000 TL and lower
Within groups	41,371	110	,376			*2.000 TL - 999 TL
	56,803	113				

p<.01

According to Table 3, there is a significant between reasoning strategy scores of students and monthly income status of parents ($F_{(113)} = 13,678$; p< ,01), To identify the source of the difference upon analysing the results of the multiple comparison tests were done via Scheffe test and a significant difference was found in favour of the students whose family income status 3000 TL and over. There is no significant difference in the students' families' monthly income status between 2000-2999 TL and 1000-1999 TL, but there is a significant difference between lower than 1000 TL income and 2000-2999 TL income level of parents. It says that parents' higher income supports school life and learning of students.

Comparison of the reasoning strategy scores of students to maternal education status

One-way ANOVA was employed to identify whether there is a significant difference between reasoning strategy scores of the students and maternal education status. Findings are shown in Table 4. According to Table 4, there is a significant difference when compared reasoning strategy scores to maternal education levels ($F_{(113)} = 16,476$; p<, 01). According to the results of the multiple comparison tests done via Scheffe test to identify the source, there is a significant difference between students whose mothers graduated from university & high school and primary school. Moreover, there is a significant difference between mothers who graduated from middle school and primary school. That is, maternal education levels directly related to reasoning strategy scores.

Difference in favour of high education levels of mothers might originate from the fact that they are more conscious about taking care of their children and their education.

Table 4. ANOVA results of reasoning strategy scores of students and maternal education status

The source of the variance	SS	df	MS	F	p	Significant Difference
Between groups	17,611	3	5,870	16,476	,000	* University-High school and Prim. School
Within groups	39,192	110	,356			* Middle School-Primary School
	56,803	113				

p<.01

Comparison of reasoning strategy scores with students' paternal education status

One-way ANOVA was employed to identify whether there exist a significant difference between reasoning scores and students' paternal education status. Findings are shown in Table 5

Table 5. ANOVA results of reasoning strategy scores and students' paternal education status.

The Source of the variance	SS	df	MS	F	p	Significant Difference
Between groups	17,164	3	5,721	15,877	,000	*University and High School-Middle and Primary School
Within groups	39,639	110	,360			
Total	56,803	113				

p<.01

According to Table 5, there is a significant difference when compared reasoning strategy to education status of students' parents ($F_{(113)} = 15,877$; p<,01), To identify the source of the difference, a multiple comparison tests done via Scheffe test and seen a significant difference in favour of fathers graduated from University /high schools comparing to primary/ middle schools. When students reasoning strategy scores examined according to paternal education status, it can be seen that higher education paternal status causes a significant difference. This situation can be explained as a positive effect of the conscious fathers about education and family structure.

Conclusion (10pt)

It was concluded that reasoning strategy change according to the students' genders. Significant difference regarding students' gender was seen in favour of girls, could be explained by girls' entering puberty and starting abstract thinking earlier. In a supporting study by Ünsal (2009) investigates whether proportional reasoning strategy varies according to the gender and concludes that female students are more successful than male ones in qualitative and quantitative reasoning problems. Students residing in the city centre were seen using reasoning strategy significantly higher than the students residing in rural areas comparing to the students residing in the districts or villages. The significant difference depending on the development of the settlement considering school residential can be connected to redundancy of physical

opportunities while educating students as well as fewness of general problems of schools. Colangelo, et al. (2003; Dağdelen and Ünal, 2017) concludes that the students residing in the rural areas are disadvantageous comparing to the students residing in the cities because of the differences in economic circumstances, a limited number of environmental stimuli and limited accessibility. Moreover, Tunalı (2007) shows in his post-graduate thesis, "*Examination of abstract thinking skills of gifted and normal intelligent children in the abstract operational stage*" that there is a significant difference between socio-economic level and reasoning skills and abstract thinking skills.

There is a direct relationship between students' family income levels and reasoning strategy. The significant difference in favour of higher income level was interpreted as leading students having the advantage of getting more supplements. Moreover, the education level of the parents has significant impact on increasing the reasoning strategy. According to Yenilmez, (2006) and Aytekin, et al. (2016), higher education level of parents caused a significant difference in students' using reasoning strategy leads a positive result of conscious family structure in terms of growing children. Ataman (2008) evaluated various socio-cultural and economical aspects and family environment structure and concluded that increase in the education level of the parents affects students' cognitive development.

At the end of statistical analysis, it was found out that students' average use of reasoning strategy level is moderate. This situation shows us the need of the reasoning strategy in school environment related to the strategy that can help to develop reasoning skills of the students. Tay (2007) supports this finding in his study focused on learning strategies, which foster the accomplishment of students. For this reason, to increase the students reasoning skills, there should be different kinds of questions that enable the use of different solution strategy in mathematics lessons and course books (Umay, 2003). In a study, Ünal (2017) besides strategies, suggests modern teaching methods and techniques to push up the success. Mathematics course books and the examples given by teachers must transcendence traditional problems and unleash the reasoning skills that the subject includes (Altun, 2008; Yıldız and Baltacı, 2016). Classroom environments in which students feel free to guess, discover different thinking skills and share their ideas with their friends should be established to strengthen students' mathematical reasoning and problem-solving skills (Yeşilova, 2013; Baş, 2015). Moreover, it is suggested that the school counselling services should help parents to become more aware and the difference in the income levels of the families should be diminished and infrastructure support at the school should be increased. In this context, creating awareness of families and subsidizing infrastructure support to schools by reducing the gap between income levels have been recommended.

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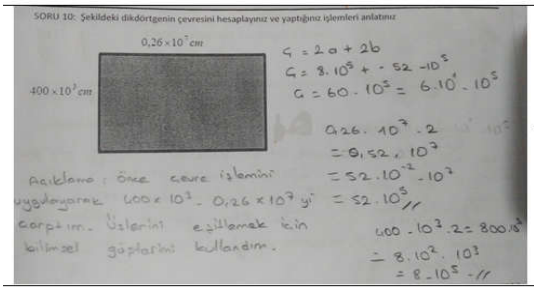
Appendix1:

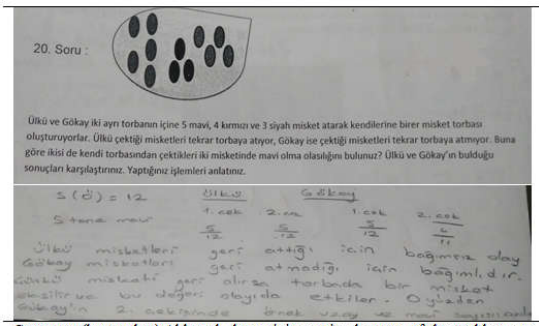
Figure 1. An example of high reasoning level



Question10: Calculate the circumference of the rectangle and explain the steps.
Explanation (by student): First, I multiply $400x10^3$ by $0,26x10^7$. For that, I equalize bases of numbers.

Comment (by teacher): Showed reasoning skill, chose proper strategy, evaluated result and process, interpret results. Therefore, s/he has high reasoning level.

Figure 2. An example of medium reasoning level

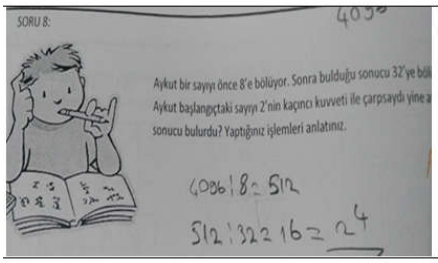


Question 20: Ülkü and Gökay put 5 blue, 4 red and 3 black marbles into 2 separate bags. They create a bag for themselves. Ülkü put marbles into bag, which she has already taken but Gökay does not put back. So, What is the possibility of getting Blue Marble for both? Compare the results and explain the procedure.

Comment (by teacher):Although determining main elements of the problem, no proof or interpretation about the process and results. Therefore, s/he has medium reasoning level.

Explanation (by student): Ülkü puts back the marbles into bag, so it is independent. However, Gökay does not put back, so it is dependent.

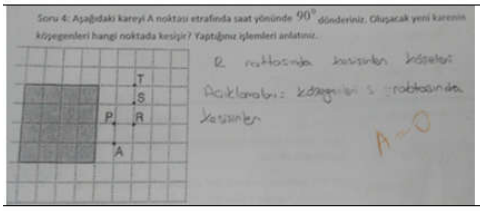
Figure 3. An example of low reasoning level



Question 8: Aykut divides any number by 8. And then, he divides the result by 32. To get the same result, what power of 2 (2^x) he had to multiply the original number.

Comment (by teacher):No supply clear evidence for problem solving and reasoning. Therefore, s/he has Low reasoning level.

Figure 4.An example of absence reasoning



Question 4: Spin around the square 90^0 from the fixed point A. Where does Diagonals of square meet? Explain the procedure.
Comment (by teacher):There is no strategy or reasoning to solve the problem. , s/he has no reasoning level

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