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The Investigation of the Relationship Between Mathematical Connection Skills and Self-Efficacy Beliefs*

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Abstract: In this study, it is aimed to examine the relationship between mathematical connection skills and mathematical connection self-efficacy beliefs. The study group consists of 33 students who are in the 11th grade of a public high school in Ordu. The study is a relational study and data collection tools are Mathematical Connection Skill Test developed by the researchers and the Mathematical Connection Self-efficacy Scale developed by Özgen and Bindak (2018). The study of Mumcu (2018) was used for the theoretical framework of the Mathematical Connection Skill Test. In the analysis of the data, descriptive statistics and correlation analysis were used. As a result of the study, it has been found that there is a positive and significant relationship between the students' connection skills and self-efficacy beliefs. In addition, when the relations between the sub-dimensions of data collection tools are examined, it is seen that there is a low relationship between skills of mathematical connection with real life and self-efficacy of connection with real life, skill of connecting mathematics with different disciplines and self-efficacy of connecting with different disciplines than expected. Suggestions were made for the nature of teaching environments and different studies that could be done about this subject in the light of the results obtained from the work.

Keywords: mathematical connection skills, mathematical connection self-efficacy, high school students.

INTRODUCTION

One of the general aims of teaching mathematics is to provide the mathematical knowledge that individuals need in their lives and the basic skills that enable them to use this knowledge in different areas of their life (Baki, 2014, p.34; Ministry of National Education [MoNE], 2013, p.1; National Council of Teachers of Mathematics [NCTM], 2000, p.4). In order to achieve this goal, students need to acquire basic mathematical skills such as being able to understand, interpret and

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use mathematical concepts and relationships among them, and to be able to connect mathematics with different fields and disciplines (Ball, 1990; Kinach, 2002; NCTM, 2000; Skemp, 1978; Vale, McAndrew & Krishnan, 2011; Van de Walle, 2013). In this context, skills of connection is clearly emphasized as one of the most important skills of learning and doing mathematics processes in current mathematics education program or standard documents (Chapman, 2012; MoNE, 2013).

Self-efficacy is a concept of judgments about how well individuals can perform the actions needed to cope with possible situations (Bandura, 1977). In many studies (Akbaş & Çelikkaleli, 2006, Cannon & Scharmann, 1996, Eggen & Kauchak, 1999, Gibson & Dembo, 1984, Guskey & Passaro, 1994; Riggs & Enochs, 1990, Savran and Çakıroğlu, 2001, Soodak & Podel, 1993; Woolfolk, Rosoff and Hoy, 1990), there is a positive relationship between self-efficacy beliefs and academic achievement. In case of connection skills, it is expected to be a positive relationship between self-efficacy beliefs of mathematical connection and the subject skills. From this point of view, it is aimed to investigate the relationship between the self-efficacy beliefs and the subject skills of the secondary school students in this study. The research questions of the study are as follows.

- What are the levels of students' mathematical connection skills?
- What are the levels of students' mathematical connection self-efficacy beliefs?
- Is there any significant relationship between students' connection skills and self-efficacy beliefs?
- Are there significant relationships between the subscales of connection skills and self-efficacy beliefs?

METHOD

This is a relational study and convenience sampling from purposeful sampling methods were used in the study. The grade levels which the *function* concept is included in the curriculum and the selected students should be volunteered for the study were considered for determining the study group.

Study Group

The characteristics of the study group

The study group consists of 33 secondary students who are in the 11th grade of a public school in Ordu. The number of girls and boys are 17 and 16 respectively.

Data Collection Tools

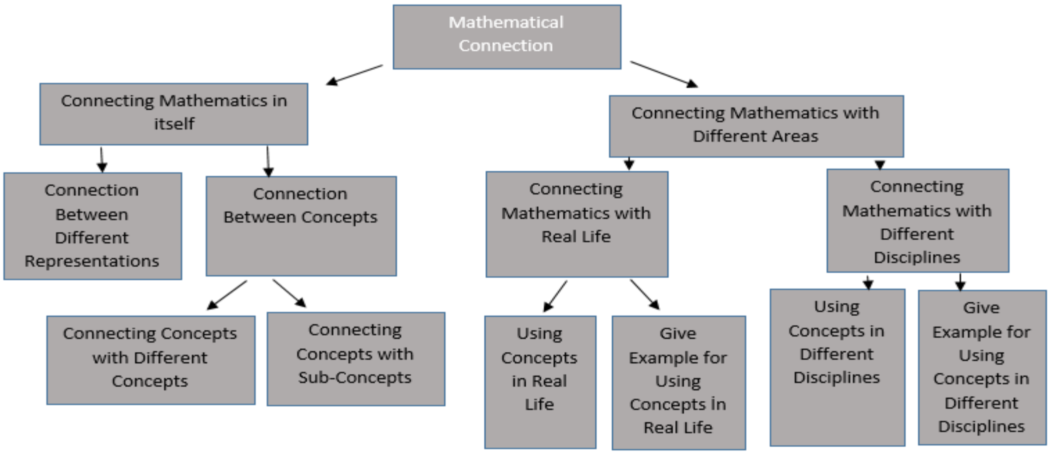
Mathematical Connection Skill Test (CST) developed by the researchers and the *Mathematical Connection Self-efficacy Scale* (CSB) developed by Özgen and Bindak (2018) were used as data collection tools.

Mathematical connection skill test (CST)

CST, developed by the researchers, consists of four sub-dimensions and 11 questions in total. In developing these questions, the concept of function was chosen in particular. This is because of the close relation of the function concept with real life and many other mathematical ideas. However, it is suggested that the concept of function is used as a unifying and integrative way of thinking in the field of mathematics education (NCTM, 1989, Altun, 1999; Brieske, 1973, Sajka, 2003, Selden and Selden, 1992).

The theoretical framework developed by Mumcu (2018) was used for the sub-dimensions of CST (Figure 1).

Figure 1: Sub-Dimensions of Mathematical Connection



According to this framework, sub-dimensions of mathematical connection skill are, *Connection Between Different Representation (CBDR)*, *Connection Between Concepts* (CBC), *Connection with Real Life (CwRL)* and *Connection with Different Disciplines (CwDD)*. In addition, the data in Table 1 are used in relation to the content of the questions in CST.

Table 1: Content of CST

Dimensions of CST	Sub-Dimensions of CST	Content/Aim of the Questions	Number of Questions	Total Number of Questions
CBDR		To be able to make connections between tables, diagrams, graphs and algebraic representations of functions.	3	**3**
CBC	Connecting with Sub-Conceps	Ability to select functions from given relationships To be able to relate composite operation with function concept.	2	**3**
	Connecting with Different Concepts	To be able to use the concept of function in relation to the concept of arithmetic mean.	1	
CwRL	Using Mathematical Concepts in Real Life Situations	To be able to use function concept in real life situations.	2	**3**
	Give Example for Using Mathematical Concepts in Real Life Situations	To be able to give example for using function concept in real life situations	1	
CwDD	Using Mathematical Concepts in Different Disciplines	To be able to use function concept in different disciplines	1	**2**
	Give Example for Using Mathematical Concepts in Different Disciplines	To be able to give example for using function concept in different disciplines	1	
General			11	**11**

Mathematical connection self-efficacy belief scale (CSB)

Developed by Ozgen and Bindak (2018), the CSB consists of five sub-dimensions and 22 items and is in the form of a five-point likert type scale. The sub-dimensions of the CSB can be expressed as *Difficulty* (D), *Using Mathematics* (UM), *Connecting Mathematics in Itself* (CII), *Connecting Mathematics with Real Life* (CwRL) and *Connecting Mathematics with Different Disciplines* (CwDD). Sub-dimensions include 6,5,5,3 and 3 items respectively.

Data Analysis

The data obtained from the CST were evaluated as 1/0 for true / false answers and the data from the CSB were evaluated *for all times-most of the times-sometimes-rarely-never* as 5-4-3-2-1 respectively. The arithmetic mean reference interval (Kan, 2009, p. 407) was used for CST and CSB levels (low-intermediate-high). Correlation values between CST and CSB and their sub-factor were calculated and interpreted in accordance with the sub-problems of the study.

For the validity of the CST, two experts were consulted, and some expressions of some questions were changed accordingly. Equivalent half-way method was used for the reliability of the CST and the Spearman Brown reliability coefficient was calculated as 0.53 for half of the test and 0.70 for the general. The Cronbach alpha internal consistency coefficient of the CSB is 0.85 in the original study; and was calculated as 0.75 in this study.

FINDINGS

Findings Obtained from CST

Findings obtained from CST are given in Table 2.

Table 2: Findings Obtained from CST

Sub-Dimensions of CST	Low		Intermediate		High	
	f	%	f	%	f	%
CBDR	8	24,24	15	45,45	10	30,30
CBC	23	69,69	9	27,27	1	3,03
CwRL	26	78,78	6	18,18	1	3,03
CwDD	21	63,63	9	27,27	3	9,09
CST General	21	63,63	12	36,36	-	-

According to Table 2, most of the students (about 70%) were found to be at a moderate level in the CBC, CwRL, CwDD sub-dimensions and in CST general, and near half of them in the CBDR dimension.

Findings Obtained from CSB

Findings obtained from CSB are given in Table 3.

Table 3: Findings Obtained from CSB

Sub-Dimensions of CSB	Low		Intermediate		High	
	f	%	f	%	f	%
D	2	6,06	21	63,63	10	30,30
UM	1	3,03	28	84,84	4	12,12
CII	3	9,09	24	72,72	6	18,18
CwRL	2	6,06	25	75,75	6	18,18
CwDD	4	12,12	27	81,81	2	6,06
CSB General	**2**	**6,06**	**25**	**75,75**	**6**	**18,18**

According to the data obtained from the CSB, most of the students were found to be moderately involved in the CSB and its sub-dimensions.

Findings on the Relationship Between CST and CSB

The results of the correlation analysis performed on the relationship between CST and CSB are given in Table 4.

Table 4: The Correlation Analysis Results Between CST and CSB

		BSB	CST
CSB	Pearson Correlation	1	.404*
	Sig. (2-tailed)		.020
	N	33	33
CST	Pearson Correlation	.404*	1
	Sig. (2-tailed)	.020	
	N	33	33
*Correlation is significant at the 0.05 level (2-tailed).			

According to the data in Table 4, there is a positive correlation between students' connection skills and self-efficacy beliefs ($r = 0.04^*$, $p < 0,05$). Accordingly, it can be said that the mathematical connection self-efficacy belief explains 16% of the subject performance.

Findings on the Relationship Between Sub-Dimensions

The results obtained from the correlation analysis between the sub-dimensions of CST and CSB were presented in Table 5.

Table 5: Coefficients of Correlation Between Sub-Dimensions of CSB and CSB

	D	UM	CII	CwRL	CwDD	CSB General
CBDR	0.058	0.252	0.348*	0.200	0.155	0.309
CBC	0.211	0.296	0.337	0.064	0.327	0.410*
CwRL	0.118	0.132	0.096	0.267	0.164	0.095
CwDD	0.294	0.117	0.197	0.387*	0.177	0.193
CST General	**0.103**	**0.324**	**0.402***	**0.406***	**0.331**	**0.404***

When the data in Table 5 were examined, positive and significant correlations were found between CBDR and CII self-efficacy, CwDD skill and CwRL self-efficacy, CST General and CII, CST General and CwRL, CST General and CSB General. On the other hand, there is a low relationship between skills of mathematical connection with real life and self-efficacy of connecting to real life, skills of connecting mathematics to different disciplines and self-efficacy of connecting to different disciplines than expected ($r < 0.30$).

DISCUSSION AND CONCLUSION

As a result of the study, it has been found that most of the students have difficulty using mathematical connection skills, especially in connecting the concept of function with different concepts and real life. This result is parallel to the results of different studies in the literature. The studies show that students and the prospective teachers have difficulties for using mathematical connection skills (Businskas, 2008; Dilberoğlu, 2015, Eli, 2009, Gülten, Ilgar and Gülten, 2009, Kızıloğlu and Konyalıoğlu, 2002, Leikin & Levav-Waynberg, 2007, Mumcu, 2018, Özgen, 2013a, 2013b; Taşdan, Uğurel and Koyunkaya, 2017).

However, it has been determined that students' conceptual knowledge about functions is restricted and they have misconceptions about this concept, which has a particularly important place in students' understanding of mathematics and relating with real life. In different studies, it is stated that students understand the concept of function very simply and primitively and have rooted misconceptions (Davis, 1984; Narlı and Başer, 2008; Tall & Vinner, 1981). For overcoming these difficulties, it is important the curriculum has content which provides and evaluates the ways of students' functional thinking. In addition, it is suggested that the teachers adapt the function concept in real life situations and related nature events to the teaching environments with appropriate mathematical models in order to ensure that the students understand the function concept. Moreover, it is suggested that teachers show not only the operational but also the structural side, and the connections between different representations (such as algebraic, graphical or tables) of the concept (Ural, 2006).

At the end of the study, results were obtained which support the hypothesis which is the basis for this study. Accordingly, there was a positive relationship between the mathematical connection skills and the mathematical connection self-efficacy beliefs of the 11th grade students. Parallel to this result, PISA (2003; 2012) results are the most comprehensive studies carried out on this subject. In these studies, there are high and mid-level relation between self-efficacy beliefs towards mathematics and mathematics literacy levels of students in Turkey. In addition, it was found that the mathematical self-efficacy beliefs have an effect on mathematical performances at the rate of 26% and 19% respectively (OECD, 2004, MoNE, 2015). Similarly, in different studies (Eshel, Yohanan, Kohavi & Revital, 2003, Desoete, 2001, Mayer, 1998, Bouffard-Bounchard, Parent & Larivee, 1991, Pajares & Graham, 1999, Malpass, O'Neil, Harold & Hocevar, 1999; Üredi and Üredi, 2005) it is concluded that there was a high correlation between mathematics self-efficacy and mathematical achievements.

In order to improve students' mathematical connection performances, firstly they must learn mathematics meaningfully. For this reason, in mathematics learning environments, teachers should focus on the conceptual meanings and try to make meaningful learnings by connecting concepts with real life and different disciplines besides mathematics. As a result of this study, mathematical connection self-efficacy belief was found to express 16% of the connection performance. It is suggested for different studies in this subject, it is necessary to investigate the other factors which are effective in this performance and to determine the elements to support the development of these factors.

REFERENCES

Akbaş, A., & Çelikkaleli, Ö. (2006). Sınıf öğretmeni adaylarının fen öğretimi özyeterlik inançlarının cinsiyet, öğrenim türü ve üniversitelerine göre incelenmesi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, *2*(1).

Altun, M. (1999). *Anadolu Üniversitesi Açıköğretim Fakültesi İlköğretim Öğretmenliği Lisans Tamamlama Programı Matematik Eğitimi.* A. Özdaş (Ed), 1, 2, 3, 4, 7, 8, 9, 10. Bölümler. Eskişehir: Açıköğretim Fakültesi Yayınları.

Baki, A. (2006). *Kuramdan uygulamaya matematik eğitimi*. Ankara: Harf Eğitim Yayıncılık.

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *Elementary School Journal*, *90*(4), 449–466.

Bandura, A. (1997). *Self-Efficacy: The exercise of control.* New York: W. H. Freeman and Company.

Bouffard-Bouchard, T., Parent, S., & Larivee, S. (1991). Influence of self-efficacy on self-regulation and performance among junior and senior high-school students. *International Journal of Behavioral Development,14*, 153–164.

Brieske, T. J. (1973). Functions, mappings, and mapping diagrams. *Mathematics Teacher, 66*(5), 463-468.

Businskas, A. M. (2008). *Conversations about connections: How secondary mathematics teachers conceptualize and contend with mathematical connections* (Unpublished PhD Thesis). Simon Fraser University.

Cannon, J. R., & Scharmann, L. C. (1996). Influence of a cooperative early field experience on preservice elementary teachers' science self-efficacy. *Science Education, 80*(4), 419-436.

Chapman, O. (2012). Challenges in mathematics teacher education. *Journal of Mathematics Teacher Education, 15*(4), 263-270.

Davis, R. B. (1984). *Learning mathematics: the cognitive science approach to mathematics education.* Norwood, NJ: Ablex.

Desoete, A. (2001). Metagognition and mathematical problem solving in grade 3. *Journal of Learning Disabilities, 34* (5), 435-449.

Dilberoğlu, M. (2015). *An investigation of pre-service middle school mathematics teachers' ability to connect the mathematics in content courses with the middle school mathematics* (Unpublished PhD Thesis). Middle East Technical University, Ankara.

Eggen, P., & Kauchak, D. (1999). *Educational psychology* (4th ed). Upper Saddle River, NJ: Merrill.

Eli, J. A. (2009). *An exploratory mixed methods study of prospective middle grades teachers' mathematical connections while completing investigative tasks in geometry* (Unpublished PhD Thesis). University of Kentucky.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 694-706.

Eshel, Y., & Kohavi, R. (2003). Perceived classroom control, self-regulated learning strategies, and academic achievement. *Educational psychology, 23*(3), 249-260.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569.

Guskey, T. R., & Passaro, P. D. (1994). Teacher efficacy: A study of construct dimensions. *American Educational Research Journal, 31*(3), 627-643.

Gülten, D. Ç., Ilgar, L., & Gülten, İ. (2009). Lise 1. sınıf öğrencilerinin matematik konularının günlük yaşamda kullanımı konusundaki fikirleri üzerine bir araştırma. *Hasan Ali Yücel Eğitim Fakültesi Dergisi, 6*(1), 51-62.

Kan, A. (2009). *Ölçme sonuçları üzerinde istatistiksel işlemler.* H. Atılgan (Ed.), Eğitimde ölçme ve değerlendirme (ss. 397-456). Anı Yayıncılık: Ankara.

Kızıloğlu, F. N. and Konyalıoğlu, A. C. (2002). Matematik öğretmenlerinin sınıf içi davranışları. *Kastamonu Eğitim Dergisi, 10*(1), 119-124.

Kinach, B. M. (2002). Understanding and learning-to-explain by representing mathematics: Epistemological dilemmas facing teacher educators in the secondary mathematics methods course. *Journal of Mathematics Teacher Education, 5*(2), 153-186.

Leikin, R., & Levav-Waynberg, A. (2007). Exploring mathematics teacher knowledge to explain the gap between theory-based recommendations and school practice in the use of connecting tasks. *Educational Studies in Mathematics, 66*(3), 349-371.

Malpass, J.R., O'Neil, J., Harold, F., & Hocevar, D. (1999). Self-regulation, goal orientation, self-efficacy, worry and high stakes math achievement for mathematically gifted high school students. *Roeper Review, 21*(4), 281-290.

Mayer, R. E. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional science, 26* (1-2), 49-63.

Ministry of National Education [MoNE] (2015). *PISA 2012 araştırması ulusal nihai rapor*. http://pisa.meb.gov.tr/?page_id=22 adresinden 25.01.2016 tarihinde indirilmiştir.

Ministry of National Education [MoNE] (2013). *Ortaöğretim matematik dersi öğretim programı.* Ankara: Milli Eğitim Bakanlığı, Talim ve Terbiye Kurulu Başkanlığı.

Mumcu, H. Y. Matematiksel İlişkilendirme Becerisinin Kuramsal Boyutta İncelenmesi: Türev Kavramı Örneği. *Turkish Journal of Computer and Mathematics Education (TURCOMAT),* 9(2), 211-248.

Narlı, S., & Baser, N. E. (2008). Küme, bağıntı, fonksiyon konularında bir başarı testi geliştirme ve bu test ile üniversite matematik bölümü 1. sınıf öğrencilerinin bu konulardaki hazırbulunuşluklarını betimleme üzerine nicel bir araştırma. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi,* 24.

National Council of Teachers of Mathematics [NCTM] (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: NCTM.

National Council of Teachers of Mathematics [NCTM] (2000). *Principles and standards for school mathematics.* Reston, VA: NCTM.

Organisation for Economic Co-operation and Development [OECD] (2004). *Learning for tomorrow's world-first results from PISA 2003.* Retrieved January 5, 2005, from <http://www.pisa.oecd.org/dataoecd/1/60/34002216.pdf>.

Özgen, K. (2013a). Self-efficacy beliefs in mathematical literacy and connections between mathematics and realworld: The case of high school students. *Journal of International Education Research, 9*(4), 305-316.

Özgen, K. (2013b). Problem çözme bağlamında matematiksel ilişkilendirme becerisi: Öğretmen adayları örneği. *E–Journal of New World Sciences Academy, 8*(3), 323-345.

Özgen, K., & Bindak, R. (2018). Development of Mathematical Connection Self-Efficacy Scale. *Kastamonu Education Journal, 26*(3), 913-924.

Pajares, F., & Graham, L., (1999). Self-efficacy, motivation constructs and mathematics performans of entering middle school students. *Contemporary Educational Psychology, 24*, 124-139.

Podell, D. M., & Soodak, L. C. (1993). Teacher efficacy and bias in special education referrals. *The Journal of Educational Research, 86*(4), 247-253.

Sajka, M. (2003). A secondary school student's understanding of the concept of function-A case study. *Educational Studies in Mathematics, 53*(3), 229-254.

Savran, A., & Çakiroğlu, J. (2001). Preserve biology teachers' perceived efficacy beliefs in teaching biology. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 21*(21).

Selden, A., & Selden, J. (1992). Research perspectives on conceptions of functions: Summary and overview. In G. Harel & E. Dubinsky (Eds.), *The concept of function: Aspects of epistemology and pedagogy* (pp. 1-16). Washington, DC: Mathematical Association of America.

Skemp, R. R. (1978). Faux amis. *The Arithmetic Teacher, 26*(3), 9-15.

Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. *Educational Studies in Mathematics, 12*(2), 151-169.

Tataroğlu Taşdan, B., Uğurel, I. and Yiğit Koyunkaya, M. (2017). *Matematik öğretmen adaylarının geliştirdikleri matematik öğrenme etkinliklerinin matematik içi ilişkilendirmeye ilişkin görüşleri kapsamında incelenmesi*. 3. Türk Bilgisayar ve Matematik Eğitimi Sempozyumu, 17-19 Mayıs 2017, Afyon, Bildiri Özetleri, ss.537-540.

Ural, A. (2006). Fonksiyon öğreniminde kavramsal zorluklar. *Ege Eğitim Dergisi, 7*(2), 75–94.

Üredi, I. (2005). *Algılanan anne baba tutumlarının ilköğretim 8. sınıf öğrencilerinin öz-düzenleyici öğrenme stratejileri ve motivasyonel inançları üzerindeki etkisi* (Unpublished Master Thesis). Yıldız Teknik Üniversitesi, İstanbul.

Vale, C., McAndrew, A., & Krishnan, S. (2011). Connecting with the horizon: Developing teachers‟ appreciation of mathematical structure. *Journal of Mathematics Teacher Education, 14*(3), 193-212.

Van de Walle, J. A. (2013). *Elementary and middle school mathematics: Teaching developmentally* (7th ed.). Boston: Allyn and Bacon.

Woolfolk, A. E., Rosoff, B., & Hoy, W. K. (1990). Teachers' sense of efficacy and their beliefs about managing students. *Teaching and Teacher Education, 6*, 137-148.

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Students Perspectives in Mathematics*

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Abstract: Mathematics is one of the important tools we use in solving the problems in our daily lives as much as we use in science (Baykul, 2000). There is no doubt that teachers play a significant role in mathematics teaching. Taking into account the importance of mathematics and mathematics education, the opinions of secondary school students on mathematics teachers and their attitudes in mathematics classes form the basis of this study. The aim of this research is to determine the relationship between secondary school students and mathematics teachers by examining the attitudes of secondary school students in mathematics lessons and their opinions about mathematics teachers. The study was carried out with a total of 60 students, 30 girls and 30 boys in Grade 7 and Grade 8 in a secondary school in Bafra District of Samsun Province during the first semester of the 2017-2018 academic year. This study is based on the case study, one of the quantitative research methods. During the study conducted for 8 weeks, "Teacher Evaluation Survey" published by MoNE (Ministry of National Education) and "Mathematical Attitude Scale" developed by Baykul (2006) was applied to the students. The obtained data were analyzed by IBM SPSS 15.0 package program. As a result of the analyses, it was determined that there was no significant difference regarding the opinions of students towards their teachers and the attitudes of students in mathematics in terms of gender and class variables. Moreover, it was found that there was no relation between the attitudes towards mathematics and the opinions about the teacher. Students expressed positive opinions about their teachers such as teachers are allowing different ideas, encouraging learning, providing effective mathematics teaching and establishing good communication.

Keywords: Attitude towards mathematics, teaching mathematics.

INTRODUCTION

The most important aim of teaching mathematics should be to make students understand the problems they may face in daily life and solve them in the shortest way (Baykul, 1997). Abstract concepts and principles making up the structure of mathematics are of great importance.

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Understanding these concepts and principles by students can only be realized through real experiences (Mathews, 1984). Students' attitudes towards mathematics are formed in the face of concrete experiences. This attitude will affect students' future experiences either positively or negatively.

Attitude is the tendency attributed to the individual that constitutes an individual's thoughts, feelings and behaviors about a psychological object in an orderly manner (Smith, 1968). Educators argue that individuals are indifferent in terms of the objects to which they show a negative attitude. Individuals state that the occupations to which they show a negative attitude are not suitable for them (Baykul, 2000). If we are to express this situation in terms of a mathematics lesson, the negative attitudes created by previous experiences will lead students to indifference and hence the failure. Students with a positive attitude will be more interested in mathematics and will make an effort to be successful.

According to Cüceloğlu (1991), there are two basic features on the basis of the attitude. The first of these; the attitude is long-term, that is, the mentioned tendency of the individual is observed for a long time. Accordingly, instantaneous and temporary tendencies are not seen as attitudes. In addition, it can be noted that attitudes are emotions that do not come with birth and are acquired later. The second characteristic is that the attitude is not just about feelings and thoughts, but also includes behaviors. It is expected that the individual will exhibit activities and behaviors that includes his or her feelings and beliefs towards something. We can give the continuous participation of a student, who loves mathematics, in the courses related to mathematics as an example.

Attitude is a concept that should be considered by all teachers. Attitude is much more important especially in mathematics lessons that are regarded as nightmares by students. Due to the previous experiences, a positive or negative attitude towards the mathematics lesson has occurred in secondary school students. The teacher cannot reach a successful result by ignoring students' positive or negative attitudes being acquired from their previous experiences. Life and experiences come to the fore in the formation of attitudes towards mathematics. In addition, teachers' attitudes towards mathematics affect the attitudes of students as well.

In the learning environment, positive or negative attitudes are formed by the students against the topic taught. It is known that positive attitudes lead to greater academic success, on the contrary, negative attitudes lead to a decrease in academic achievement (Tuncer, Berkant & Doğan, 2015). In an educational system where academic success is prioritized, the importance of having a positive attitude is of great importance.

Attitudes developed in a negative way towards mathematics are transformed into behaviors by being affected by some other reasons at the next stage and become obstacles in achieving success in mathematics education. Furthermore, it is possible to come across studies on fear, anxiety and negative attitudes towards mathematics (Baloğlu, 2001). In order to remove negative attitudes, different methods such as using visual elements in educational environments, providing information, supporting the information, attracting attention and direct attention, summarizing the topics, showing the relations between the cases or concepts, making complex issues that are difficult to visualize in the mind easier to comprehend can be used. Certainly, teachers have a major role in the formation or change of attitudes. Particularly, the attitudes of the 5th-grade students of secondary school towards the mathematics lesson should definitely be taken into consideration. Their trust in teachers should be increased by creating an atmosphere that will make them feel successful.

Mathematics should not be seen as a course only formed of numbers, rules, and forms coming together. Mathematics has its own particular order and a group of relationships in this order.

If the students have not absorbed this order and relationships, they will not have learned mathematics. In fact, mathematics is a different world where students discover and to which they attribute a meaning in their own minds. In this world, the more comfortable and unique the student is, the more successful they will be.

Another important factor for the success of a student in mathematics is the teacher. The main objective of education is to make an individual a harmonious member of the society in which he or she lives and the contemporary world that the society is bound to (Çelikten, Sanal and Yeni, 2005). The ability of students to adapt in a society is closely related to the process of solving the problems they encounter. Whether we are aware or not, we use mathematics in various areas in our daily lives. Although a lesson that is used in everyday life should be loved and well known by all students, it can be said that the mathematics course is one of the most frustrating courses for the students in our country (Yılmaz, 1995). In this case, the priority of mathematics teachers should be to remove the negative attitudes and fears students have.

It is a fact that secondary school students are much influenced by the environment they are in due to their age groups. They can get into different shapes by paying attention to the characters in a television series or sometimes by having interest in the heroes in a game they play. A student who spends about 8-9 hours a day at school can affect almost all students. It is not possible for teachers to remain indifferent in such situations. He or she can enter the minds of students by using a line from a TV series or saying a hero's name of a game. This situation will change the perspective of the students towards their teacher. In order to teach mathematics, it is not enough just to enter the classes but also necessary to access their minds.

Since mathematics is a way of thinking, the aim of mathematics teaching is not only to provide knowledge to the student; it should also contribute to the mental development of the student. Hence, the content and methods of mathematics education need to be regulated in such a way to improve the high-level skills of individuals and contribute to these skills (Pesen, 2003). Moreover, classroom management strategies used by the teachers and the level of relationship between students are among the factors of attitude against the course.

There are a number of factors that affect the success of students at school. Achievement motivation, anxiety, qualifications of the family, socio-economic characteristics, inadequate school and education conditions, general environmental characteristics, nutrition and healthcare conditions are among the main factors. Sometimes, some of these variables affect student achievement positively, whereas in some cases they can affect it negatively.

According to Bruner (1996), teachers should encourage their students to discover the principles on their own accord according to their interest. For this purpose, teachers and students should have an active dialogue. The duty of the teachers is to perform teaching according to the final state of the understanding level of the students and to transform the knowledge into a state that the student can easily access. The education program should be organized in a spiral way so that students can constantly add to their previous learning (Ocak, 2005). Teachers should organize the teaching and learning environment in such a way that it enables students to reach knowledge on the shortest path and to understand the knowledge on their own. Information can only be configured by an individual in a type of environment mentioned here (Cüce, 2012). Individuals, who have obtained the knowledge, will enjoy this process and they will form their next learning in this regard. One of the main aims of teachers should be to educate individuals who generate knowledge rather than memorizing it.

In order to be able to develop a positive attitude towards mathematics in students, the teacher should be influential on the student. The influential teacher is the person who has the ability to develop the intended learning objectives (Perrott,1982). In order to be able to make effective teaching, firstly it is necessary to set the objective. The success of a student is a coincidence unless there is a determined aim. Determination of an aim is the priority for an effective teaching, but it is not solely enough. The relationship between a teacher and a student is also very significant in terms of effective teaching.

Rapid developments in science and technology in recent years have also deeply influenced the aims of mathematics education. In these days, the fact that individuals can use mathematical rules and formulas excellently and that they have fast arithmetic processing skills in the field of mathematics is no longer regarded sufficient. In addition, individuals are expected to be able to think mathematically, express mathematically, value mathematics, and have good problem-solving skills. In order to realize these aims, firstly it is necessary that contemporary learning and teaching approaches are adopted and that the teacher's view of "teaching mathematics" and the student's view of "learning mathematics" change. Therefore, it is essential that the teachers should form the environment enabling them to build their own mathematical knowledge rather than presenting the mathematical knowledge to the students.

The Problem Statement

The problem statement of the study is how students determine their opinions regarding mathematics teachers and how this affects their attitudes towards mathematics. Moreover, what a mathematics teacher should pay attention to during the course in the eyes of students is another concern of the problem.

Research Questions

In order to broaden the scope of the study and to clarify the problem of the study and to examine it in detail, the problem of the study is divided into the following research questions:

1) Do teacher evaluation scores of secondary school students create a significant difference according to gender and class variables?

2) Do the attitude scale scores of secondary school students towards mathematics create a significant difference according to gender and class variables?

3) What is the relationship between the scores obtained from the teacher evaluation survey and mathematics attitude scale scores?

METHOD

Research Model

The study has been designed in the relational survey model included in the quantitative research paradigm. The relational survey is a method used for the description of a past or existing situation, estimation of the presence of the relationship between these variables and its dimension or predicting another variable with the help of some variables (Karasar, 1994; Mertens, 1998). Based on this model, the students' attitudes towards mathematics teachers and their attitudes towards mathematics have been examined in terms of gender and class variables. In addition, the relationship levels between the scores obtained from the teacher evaluation survey and the scores obtained from the mathematics attitude scale have been analyzed with the help of statistical procedures.

Sample

Characteristics of the sample

The sample consists of the students in 7/A and 8/F classes in a secondary school in Bafra District during the 2017-2018 academic year. The distribution of participants by gender and class levels was given in Table 1. A total of 60 students were included in the study. 30 of them were girls (50%) and 30 of them were boys (50%). 30 of the participants were studying in the 7th grade and (50%) 30 were in the 8th grade (50%).

Table 1: Demographic Characteristics of Participants

	Frequency (*f*)	Percentage (%)
Gender		
Girl	30	50
Boy	30	50
Class Level		
7/A	30	50
8/F	30	50

Data Collection

The genders of the students were taken into consideration in the selection of the participants for the study. Classes with an equal number of boys and girls were selected for the study. In addition, the fact that the total population in each class should be equal was considered. The success averages of the classes were not taken into account.

Teacher Evaluation Survey

In order to determine students' thoughts on mathematics teachers, "Teacher Evaluation Survey" published by MoNE (2006) was used. The survey consists of 17 Likert type items. The answers to these items are: "I do not agree (1), I am neutral (2) and I agree (3)". The highest score that can be obtained from this survey is 51 and the lowest score is 17. The increase in the score indicates that the students have a positive opinion about the teacher. Exploratory factor analysis was made for this survey and the total variance explained in the scale was determined to be 50.4%. It was observed that it was the only factor with an Eigenvalue higher than one in exploratory factor analysis. The reliability coefficient (Cronbach Alpha) in this study was calculated as 79.

Attitude Scale for Mathematics

In order to determine the students' attitudes towards mathematics "Mathematics Attitude Scale", developed by Baykul (2006) was used. The survey consists of 30 items Likert type items. The answers of these items were determined as "I definitely do not agree (1), I do not agree (2), I generally agree (3), and I totally agree (4)". The highest score that can be obtained from the scale is 120, the lowest score is 30. The increase in the score indicates that the positive attitude towards mathematics has increased. Exploratory factor analysis of this scale was made, and it was observed that it was the only factor with an Eigenvalue higher than 1 in exploratory factor analysis. In addition, the Cronbach Alpha reliability coefficient was calculated as 0.82.

Data Analysis

The data were transferred into the computer environment and analyzed using the IBM SPSS 15.0 package program. First, the data were controlled for the errors that could occur during entering them on the keyboard. The arithmetic average value was calculated for students' general attitudes towards mathematics and thoughts about their mathematics teachers through the IBM SPSS 15.0 package program. By analyzing the normality of the data, Mann-Whitney U test was applied according to gender and class variable about whether there is a significant difference between students' attitudes towards mathematics and opinions about their teachers' opinions. The level of significance was taken as $p<0.05$ and the results obtained were interpreted in this context.

FINDINGS

Findings regarding the first research question

The first finding of the study was for determining whether the scores of the secondary school students received from the teacher evaluation survey varied according to the gender and class. Firstly, it was examined whether the data obtained for this research question showed normal distribution.

Table 2: The normality test results of the data obtained from the teacher evaluation survey

	Kolmogorov-Simirnov		
	Statistics	**Sd**	**p**
Teacher Evaluation Survey	.158	60	.01*
Attitude Scale	.122	60	.028
*p<0.05			

When Table 2 was examined, it was observed that the data obtained from the teacher evaluation survey were not normally distributed ($p = .01 < .05$). As a result of this situation, Mann-Whitney U test from nonparametric tests was applied. Additionally, arithmetic averages were also calculated according to gender and class variables.

Table 3: Mann-Whitney U test results for class and gender variables of the data obtained from the teacher evaluation questionnaire

Variable	Average ($\bar{x}$)	Mann-Whitney U (p)
Gender		
Girl	49.18	0.73
Boy	48.69	0.73
Class Level		
7/A	49.70	0.22
8/F	48.55	0.22

According to Table-3, the arithmetic average of female students participating in the study was found to be 49.18 and the arithmetic average of male students was 48.69. The Mann-Whitney U test result was obtained as 0.73. Since the result obtained was greater than the significance value of 0.05, it was found that there was no significant difference between the scores obtained from the teacher evaluation survey and the gender variable. Also, the arithmetic average of 7th-grade students participating in the study was found as 49.7 and the arithmetic average of 8th-grade students was 48.55. The applied Mann-Whitney U test result was found to be as 0.22. Since the result obtained was greater than the significance value of 0.05, it was found that there was no significant difference between the scores obtained from the teacher evaluation survey and the grade variable.

Findings regarding the second research question

The second research problem of the study is to determine whether the scores obtained from the mathematics attitude scale of students vary according to the grades and genders. It was examined whether the data obtained for this research question showed normal distribution.

Table 4: Normality test of the data obtained from attitude scale towards mathematics

	Kolmogorov-Simirnov			Shapiro-Wilk		
	Statistics	**Sd**	**p**	**Statistics**	**Sd**	**p**
Teacher Evaluation Survey	.158	60	.01	.909	60	.01*
Attitude Scale	.122	60	.028	.952	60	.018
*p<0.05.						

When Table 4 was reviewed, it was also seen that attitude scale data were not distributed normally (p =.028 <.05). As a result of this situation, Mann-Whitney U test from nonparametric tests was applied.

Table 5: Mann-Whitney U test results for the class and gender variables of the data obtained from attitude scale towards mathematics

Gender	**Average ($\bar{x}$)**	**Mann-Whitney U (p)**
Girl	74.56	0.31
Boy	74.8	0.31
Class Level		
7/A	74.53	0.18
8/F	74.83	0.18

According to Table 5, the arithmetic average of female students participating in the study was found as 74.56 and the arithmetic average of male students was 74.8. The Mann-Whitney U test result was obtained as 0.31. Since the result obtained was greater than the significance value of 0.05, it was found that there was no significant difference between the scores obtained from the mathematics attitude scale and the gender variable. Also, the arithmetic average of 7th-grade students participating in the study was found as 74.53 and the arithmetic average of 8th-grade students was 74.83. The applied Mann-Whitney U test result was found to be as 0.18. Since the result obtained was greater than the significance value of 0.05, it was found that there was no significant difference between the scores obtained from the mathematics attitude scale and the grade variable.

Findings regarding the third research question

For the third research question of the study, it was tried to examine the relationship between the teacher evaluation survey and the data obtained from mathematics attitude scale. Correlation analysis was performed in line with this research question. The obtained results were shown in Table-6.

Table 6: Correlations between the data obtained from the scale of attitude towards mathematics and the data obtained from the teacher evaluation questionnaire

Measurements	n	r	p
Teacher Evaluation Survey	60	.20	.01
Attitude Scale	60	.20	.01

The Spearman coefficient was obtained as 0.20 (r= .20; p= .01). As a result, it was determined that the scores obtained from mathematics attitude scale and the teacher evaluation survey were related in a positive way but at a poor level.

DISCUSSION AND CONCLUSION

According to the findings obtained in the study, it has been found out that students have developed a positive attitude towards mathematics teachers in general. It can also be said that female students have more positive opinions compared to male students. Moreover, the students in class 7 / A have more positive views than the students in class 8 / F. It is possible to show the different subjects or test anxiety experienced in the 8th grade as the reason for this situation. According to the data, it can also be highlighted that the teacher does not perform any different behaviors in the classes and between boys and girls. Another reason for the high score average may be that students have responded with grade anxiety.

On the other hand, it was seen that the number of students who made positive comments was high. However, criticism has also been written about the use of technology. One of the important factors turning mathematics into a nightmare in the eyes of students is that it is abstract. At this point, technology helps the teacher. MoNE is trying to promote education and information network in schools. Secondary school students are using all the opportunities of the age they are in. They even outdistanced their parents and teachers in this regard. In particular, teachers need to pay a little more attention to this issue. Computers and tablets should be actively used in materializing mathematics. The studies conducted also support technology-supported mathematics learning is more permanent.

When the average scores of the mathematics attitudes scale of the students are taken into consideration, male students have more positive attitudes than female students. When evaluated on a class basis, the students in the class 8/F have more positive attitudes than the students in the class 7/A. In a general sense, it can be said that all the students who participated in the study have a positive attitude towards mathematics. However, there was no significant difference was found between the scores obtained as a result of the scale and gender and class variables. These results are consistent with the mathematics general performances and levels of interest of students in the age group of 15 in the results of the OECD-PISA project, conducted by the Ministry of National Education regarding the national research about Turkey. Also, the fact that mathematics is one of the main courses and plays a decisive role in most exams makes the approach of students similar without gender discrimination.

The fact that there is a positive relationship between the teacher evaluation survey and mathematics attitude scale scores is similar to other studies in the literature. However, the fact that this relationship is weak is an unexpected result. The relationship is stronger in the vast majority of other studies in the literature. The fact that the number of students is limited to 60 is one of the reasons for this situation. Moreover, grade anxiety is another reason for this situation although it was told to the students that the study to be performed would not be graded. The study can be repeated by reaching more students and the results can be compared. The studies performed in the same way as the study we have conducted below were also available.

According to Tuncer, Berkant & Yılmaz (2015), they worked with 225 secondary school students in a study called an evaluation of the opinions of secondary school students regarding their attitudes and concerns towards mathematics lesson. As a result of the survey conducted according to the survey model, there was no significant difference found between attitude and anxiety towards the attitude and anxiety belonging mathematics course in terms of gender. In the study, there was a significant difference determined between 6th and 7th, 7th and 8th and 6th and 8th-grade students in terms of classroom variable between both attitude and anxiety scores. In another study, Yücel and Koç (2011) found that the primary school second-grade students showed a positive attitude at a good level about mathematics course and that the achievements in mathematics were moderate. Furthermore, when gender differences were examined, it was found that there was no difference between male and female students in mathematics attitude and achievement. And, Avcı, Coşkuntuncel and İnandı (2011) conducted their study titled, attitudes of the twelfth-grade students in secondary education towards mathematics, with 835 grade students. While there was no significant difference found between students' attitudes toward mathematics and gender, a significant difference between the type of school they study and the mathematics attitude and between the type of field they study, and their mathematics attitudes have been seen. Akdemir (2006) worked with 715 students in his thesis titled as the attitudes towards mathematics and success motivation of the primary school students. As a result of the study, it was determined that the attitudes of elementary school students towards mathematics showed significant differences, however, they did not show significant differences according to gender in terms of the socio-economic situation of the school, education status of the parents and school type. These results support this study.

Students' previous experiences and environments also play an important role in the formation of their attitudes towards mathematics. The presence of people with negative attitudes, especially in family and friendship, will affect students in a negative way. In this case, the teacher has essential duties. First, such students should be identified and encouraged. Anxiety and fear can be reduced with questions appropriate to their level. While explaining mathematics lessons, direct instruction method should be abandoned, and the course should be taught using active learning methods. It should not be forgotten that each student has his or her own way of perception and level of understanding.

Teachers should be willing, energetic and compassionate in the classroom. They should pay attention to gestures and mimics and the language they use. They should shape the lessons according to the interests and needs of the students and give them tasks in which they will be successful (Baykul, 2004). In addition, the teacher should make eye contact during the course without disturbing the students and address them with their names. When the data obtained from the students in the study we have conducted are examined, comments such as "Our teacher is interested in our problems and values us. That is why I like him or her" are observed. In order to establish a good communication with students, first, it is necessary to listen to them. In order to develop a positive attitude towards the lesson, first students should like the teacher and trust him or her.

REFERENCES

Akdemir, Ö. (2006). *Attitudes of elementary school students towards mathematics lesson and success motivation.* Dokuz Eylül University Graduate School of Educational Sciences Educational Sciences Department of Educational Programs and Teaching Master Thesis.

Avcı, E.,Coşkuntuncel, O. & İnandı, Y. (2011). Attitudes of the Twelfth Grade Students in Secondary Education to Mathematics Lesson. *Mersin University Education Faculty Journal*, 7 (1), 50-58.

Baloğlu, M. (2010). An Investigation of the Validity and Reliability of the Adapted Mathematics Anxiety Rating Scale-Short Version (mars-sv) among Turkish Students. *European Journal of Psychological Education*, 25, 507-518.

Baykul, Y. (2000). *Teaching Mathematics in Primary Education 1-5. For Classes*. Ankara: Pegem Publishing.

Cüce, P.M., 2010. *Effects of Drama Based Instruction on Students' Achievement Levels and Attitudes Towards Mathematics*, XIV. World Congress of Comparative Education Societies, Boğaziçi Üniversitesi, 14–18 Haziran, İstanbul.

Cüceloğlu, D. (1991). *Human and behavior: Basic concepts of psychology*. İstanbul: Remzi Bookstore.

Çelikten, M., Şanal, M., & Yeni, Y. (2005). Teaching profession and its characteristics. *Erciyes University Journal of Social Sciences Institute*, 19 (2), 207-237.

Karasar, N. (1994). *Preparing Reports in Research*. Ankara:Nobel Publishing.

Ocak, G. (2005). The Effect of Invention Education on Learning to Stay. *Afyon Kocatepe University Journal of Social Sciences*, 7 (2), 289-297.

Olkun, S., Toluk, Z. (2003). *Activity-based mathematics teaching in primary education*. Ankara: Anı Publishing.

Pesen, C. (2003). *Mathematics Teaching*. Ankara: Nobel Publishing.

Smith, M. B. (1968). Attitude change. *International Encyclopedia of The Social Sciences*. Crowell and Mac Millan.

Tuncer, M., Berkant, H., Doğan, Y. (2015). Validity and reliability Study of Attitude Scale Towards English Course. *Journal of Research in Education and Teaching*, 4 (2), 260-266.

Yılmaz, A (1995). *The Impact of Active Method on Student Success in High School 2 nd Year Physics Course*. Dokuz Eylül University, Graduate School of Social Sciences Education Programs and Teaching Department Graduate Thesis, İzmir.

Yücel, Z. & Koç, M. (2011). The Relationship Between Gender and the Power of Predicting the Achievement Levels of Primary School Students Attitudes Towards Mathematics. *Primary Education Online Magazine*, 10(1), 133-143.

Conference Paper

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Self-Evaluations of High School Students Regarding Their Own Metacognitive Behaviours in Problem Solving*

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Abstract: The aim of the study is to ensure that high school students evaluate themselves in terms of metacognitive behaviours that they demonstrate during their problem solving process through their experiences of problem solving and to examine this process. The study was designed as a qualitative study and the obtained data were interpreted by descriptive analysis. The working group consists of a total of 94 students in 9th and 10th grade in a high school in a district of Yozgat in the academic year of 2015-2016. To collect data, students were first given two problems. Students are asked to clearly solve these problems and write down what they think. A questionnaire was applied to the students who solved these problems to evaluate the metacognitive behaviours in the problem solving process. When the data obtained from the questionnaire are analyzed, it can be considered that the majority of the students exhibit highly metacognitive behaviours without problem solving. However, the problem solutions of the students do not match these results very much; it is understood that the metacognitive behaviours that the students say they have shown and the metacognitive behaviours that emerged from examining the problem solutions are not generally parallel to each other.

Keywords: Metacognition, self-evaluations, high school students.

INTRODUCTION

The mathematics course in the school has goals such as transfer of mathematical knowledge, associating mathematics with everyday life, to develop a positive attitude towards mathematics, discovering the relationship of mathematics to other fields, to give value of mathematics, problem solving, to be aware of their own reasoning processes in the problem solving process and developing the ability to express these. Schools often give more emphasis to the transfer of knowledge. However, in education, it is more important to know how knowledge is learned and how cognitive

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processes progress in learning. In recent years, this issue has also become important. Today, the most distinctive features of good teaching are; how to effectively learn, how to remember (Çakıroğlu, 2007). The key role to teach these skills is "metacognition".

Metacognition means, in the shortest sense, that a person is aware of his own thinking processes and can control these processes (Beauford, 1996; Brown, 1978; Fager, 1979; Hacker and Dunlosky 2003; Huitt, 1997; Jager and Reezigt, 2005; Wellman, 1985; Transporter: Özsoy, 2007). More explicitly, metacognition includes things such as what one knows, how he knows, information about how a job is done, knowledge of which way he will go, which cognitive processes he or she is following when doing a job, self-control, and interpretation of output. This concept was first proposed by Flavell (1971) and continued to develop later. Since metacognition is a difficult concept to explain, it has been investigated by separating the various components (Brown, 1987; Flavell, 1987; Garofalo and Lester, 1985; Livingston, 2003).

In this study, the main components of metacognition are taken as metacognitive knowledge and metacognitive regulation:

1) Metacognitive Knowledge: The world knowledge that an individual gains about cognitive processes and the personal view of the individual's cognitive abilities of himself and others (Akin and Abacı, 2011). This includes declarative knowledge, procedural knowledge and conditional knowledge.

- Declarative Knowledge: It is information about what the person knows about the subject.
- Procedural Knowledge: It is knowledge about how to do the job of the person.
- Conditional Knowledge: It is information about knowing which information the person will use in which case.

2) Metacognitive Regulation: It is the ability to use metacognitive knowledge strategically to reach cognitive goals (Ozsoy 2008). In this study, planning, monitoring and evaluation were taken as sub-components.

- Planning: It contains all the cognitive preparations needed to do a job.
- Monitoring: It is being aware of the work done, continuous to control the work and himself.
- Evaluation: At the end of the work, the degree of achievement of objectives and the gains achieved are interpreted.

Like the definition of metacognition, it is mentioned that its measurement is difficult (Panaoura and Philippou, 2004). Nonetheless, behaviours that could be indicative of the metacognition were determined and worked to make measurements accordingly. When the investigations are examined, it is seen that the metric of the metacognition is sometimes made by considering the first person's own evaluations (Fotunato, Hecht, Title and Alvarez, 1991), and sometimes interpreting interviews, observations and work done by the researcher as an external person (Garofalo and Lester, 1985; Pugalee, 2001). Both methods have advantages and disadvantages. When a person is measured according to their own assessment, the person may not explain what they do not want, they may give different answers because they do not understand the terms in the question, they may tend to give the desired answers because they have anxiety. When the observations and comments of an external researcher are taken as a basis, it is impossible to determine all the operations in the mind of the person since the metacognition is more mental. Some processes may not appear as behaviour when applied in the mind, but may not be reflected to the second person.

21-item questionnaire was developed by Fortunato et al. (1991) for self-assessment of students' metacognitive and cognitive behaviours in the problem-solving process. This questionnaire was tested by applying 7th grade students after non-routine problems were solved. The same questionnaire was used by Biryukov (2004) to solve the perturbation-combination problems and then to simplify the relationship between metacognitive behaviours and problem solving success of mathematics teacher candidates and field teachers. Again, the same tool was used by Demircioğlu (2008) not to collect data but to allow mathematics teacher candidates to observe the problem-solving processes and give feedback to themselves.

In this study, the questionnaire developed by Fortunato et al. (1991) was used to investigate the self-evaluation of this experience after metacognition students solve the given problems. The aim of the study is to examine the situation arising from high school students' self-evaluations in terms of metacognitive behaviours they exhibit during the problem solving process by examining their problem-solving experiences.

METHOD

The researcher-teacher model was used in qualitative research methods in this study aimed at evaluating themselves in terms of metacognitive behaviours that high school students showed in problem solving process. The researcher-teacher model is the use of the action research model in educational sciences. The action research is aimed at solving the problem in the area and includes the stages of developing a general idea, exploration, planning, evaluation and other action steps (Aksoy, 2003). This study was mostly directed to the "exploration" phase of the action research. Prior to a study aimed at improving the metacognitive behaviours of high school students, it is desired to survey them based on the evaluations of the current state students through this study.

Study Group

The study group constitutes a total of 94 students in 9th and 10th grade in a high school located in Akdağmadeni province of Yozgat province in the first period of 2015-2016 education year. Two class (20 and 22 students) in the 9th grade and two class (27 and 25 students) in the 10th grade participated. The reason why the working group is selected this way is that the researcher is the mathematics teacher of these classes. The data of a randomly selected student (total 4 students) from each class were examined in more detail. Nicknames are used for these students. Aylin and Büşra are 9th grade students, Can and Doruk are 10th grade students.

Implementation and Collection of the Data

For the data collection tool used in this study, two problems were selected for the 9th and 10th grades related to the subjects that students were working during the semester (Ministry of National Education [Mne], 2015; Sahin, 2015). These problems are given in Table 1 with the class level they are using and their related topics.

Table 1: Problems in the Data Collection Tool

Grade	Topic	Problem
9	Sets	In a questionnaire conducted between a certain number of movie audiences, 196 of the audiences said "I like drams", 153 is "I love comedy", 88 is "I love science fiction", 59 is "drama and I liked comedy, 37 liked drama and science fiction, 32 liked comedy and science fiction, and 21 liked three movies. How many people have participated in the survey?
	Absolute Valuable Inequalities	Ahmet says Murat's age is probably 28. Murat also says that he made a correct prediction of Ahmet with a two-year error margin. Murat's real age is x. Accordingly, show the range of Murat's real age inequality.
10	Numeration	The restaurant "Korsikalı" offers the following options. Start: Soup or salad Main course: chicken breast, beef steak, fish Dessert: Pudding or cake How many different orders can be made at this restaurant?
	Probability	There are 3 black and 2 white balls in the black bag. There are 4 black and 3 white balls in the white bag. From a randomly selected bag, what is the probability that a ball shot randomly from bags is in the same color as the bag?

The questionnaire "How Do I Solve the Problems?" developed by Fortunato et al. in 1991 was used to evaluate students' metacognitive behaviours in the process of problem solving by overseeing problem solving processes. This questionnaire consists of 21 items and 4 parts. There are items related to the plans made before solving the problem in the first part, about what is done in the problem solving process in the second part, related to the control processes after solving the problem solving in the third part and related to strategies used in problem solving in the last part.

In each class the application was carried out in the same way. First, the data collection tool with the two problems given in Table 1 is distributed. Students are asked to clearly solve these problems and write down what they think. Two problems were made in about 30 minutes. Later, these papers were collected and a questionnaire was given to evaluate the process and students were asked to complete the questionnaire considering the problem-solving experience they had just experienced. These papers were collected after the survey was completed. The whole application lasted approximately 1 lesson (40 minutes).

Analysis of Data

For the analysis of the data, frequency analysis and descriptive analysis were generally performed. First of all, the responses of the 94 students to the questionnaire were all collected on a table and the frequencies and percentages of the answers given for each item were calculated. Then problem solving processes of students are examined and problem solving processes are described and interpreted together with the survey results. In doing so, problem solutions and questionnaire responses were obtained for 4 randomly selected students, one from each class.

FINDINGS

In this section, first of all, the questionnaire data is presented. The results obtained from the 94 students who participated in the survey are summarized in Table 2 as frequency and percentage. Table 2 gives the data for the entire study group with 9th and 10th grade levels.

Table 2. Group Findings of How to Solve Problems Questionnaire

		Yes				No				Maybe			
		9	**10**	**Tot.**	**%**	**9**	**10**	**Tot.**	**%**	**9**	**10**	**Tot.**	**%**
What did you do before you started to solve the problem?													
1	I've read the problem more than once.	33	36	**69**	**73,4**	4	9	**13**	**13,8**	5	7	**12**	**12,8**
2	"Do I understand what is being asked in the problem?" I asked myself.	18	30	**48**	**51,1**	10	11	**21**	**22,3**	13	11	**24**	**25,5**
3	I tried to express the problem with my own words.	28	38	**66**	**70,2**	6	8	**14**	**14,9**	8	5	**13**	**13,8**
4	I tried to remember that I solved a similar problem before.	26	33	**69**	**73,4**	10	2	**12**	**12,8**	6	7	**13**	**13,8**
5	I thought about what the information I need to solve this problem is	26	31	**57**	**60,6**	4	8	**12**	**12,8**	11	12	**23**	**24,5**
6	"Is there any information I do not need in this problem?" I asked myself.	14	14	**28**	**29,8**	17	25	**42**	**44,7**	11	13	**24**	**25,5**
What Have You Done When Solving the Problem?													
7	I thought about all the steps when solving the problem.	24	26	**50**	**53,2**	2	10	**12**	**12,8**	16	16	**32**	**34,0**
8	After taking a step, I looked at what you were doing backwards.	29	25	**54**	**57,4**	6	16	**22**	**23,4**	6	12	**18**	**19,1**
9	After finishing a step I stopped and thought again	32	28	**60**	**63,8**	5	17	**22**	**23,4**	5	6	**11**	**11,7**
10	When I solved the problem, I checked my work step by step.	24	27	**51**	**54,3**	5	10	**15**	**16,0**	13	14	**27**	**28,7**
11	I did my step again when I did something wrong.	26	25	**51**	**54,3**	7	14	**21**	**22,3**	9	14	**22**	**23,4**
What did you do after finishing the Problem Solving?													
12	I looked back to see if I did the right things.	32	36	**68**	**72,3**	3	9	**12**	**12,8**	7	7	**14**	**14,9**
13	I checked whether I did my calculations correctly.	34	38	**72**	**76,6**	1	4	**5**	**5,3**	7	10	**17**	**18,1**
14	I went back and checked my work again	28	33	**61**	**64,9**	4	12	**16**	**17,0**	10	7	**17**	**18,1**
15	I look at the probing again to see if my answer means anything.	30	31	**61**	**64,9**	6	10	**16**	**17,0**	6	11	**17**	**18,1**
16	I thought about a different way to solve the problem.	21	25	**46**	**48,9**	12	18	**30**	**31,9**	9	9	**18**	**19,1**
Have you used any of these routes while solving the problem?													
17	I have drawn a shape to help me understand the problem.	26	20	**46**	**48,9**	8	29	**37**	**39,4**	8	3	**11**	**11,7**
18	I used the "guess and control" method.	34	37	**71**	**75,5**	3	7	**10**	**10,6**	5	8	**13**	**13,8**
19	I selected the process I needed to solve this problem.	26	39	**65**	**69,1**	1	5	**6**	**6,4**	15	8	**23**	**24,5**
20	I have been feeling confused and I can not decide what to do.	13	18	**31**	**33,0**	13	21	**34**	**36,2**	16	13	**29**	**30,8**
21	I have noted important information.	12	9	**21**	**22,3**	24	36	**60**	**63,8**	6	7	**13**	**13,8**

When the survey data is examined, it is mostly answered as "yes", so it can be considered that students have a high level of metacognitive behaviours during problem solving.

In the first part (planning), it is seen that the majority of all the items out of the article "Is there any information I do not need in this problem? I asked myself." (6) respond positively. In the second part (monitoring), it is seen that students mostly responded to all the items (7-11) positively. In the third part (evaluation), it appears that the majority of students outside the item " I thought about a different way to solve the problem." (16) respond positively. In the last part (strategies), it seems that most of the students responded negatively or vaguely to the items (17, 20, 21) "I have drawn a shape to help me understand the problem", "I have been feeling confused and I can not decide what to do" and "I have noted important information". It is seen that students mostly respond positively to " I used the guess and control method." and "I selected the process I needed to solve this problem." (18, 19).

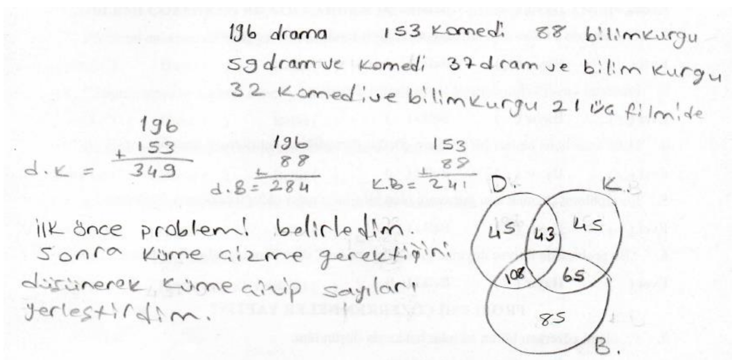
Although the data in the questionnaire are more related to the internal processes and it is not possible to check the truth directly from the problem solutions, it has wanted to compare the survey data and problem solutions. For this, the papers of 4 students, one from each branch, were randomly selected and examined. Table 3 shows the responses of these students to the items of the questionnaire using initials.

Table 3. Answers to the How to Solve Problems Questionnaire

	Yes	No	Maybe
What did you do before you started to solve the problem?			
1. I've read the problem more than once.	A-B-D	C	
2. "Do I understand what is being asked in the problem?" I asked myself.	B-C-D	A	
3. I tried to express the problem with my own words.	A-B-C-D		
4. I tried to remember that I solved a similar problem before.	A-B-C-D		
5. I thought about what the information I need to solve this problem is.	B-C-D	A	
6. "Is there any information I do not need in this problem?" I asked myself.	C-D	A-B	
What Have You Done When Solving the Problem?			
7. I thought about all the steps when solving the problem.	B	C	A-D
8. After taking a step, I looked at what you were doing backwards.	A-B-D	C	
9. After finishing a step I stopped and thought again.	A-B	C-D	
10. When I solved the problem, I checked my work step by step.	B-D	C	A
11. I did my step again when I did something wrong.	A-B-D	C	
What did you do after finishing the Problem Solving?			
12. I looked back to see if I did the right things.	A-B-D	C	
13. I checked whether I did my calculations correctly.	A-B-C-D		
14. I went back and checked my work again.	A-B-D	C	
15. I look at the probing again to see if my answer means anything.	B-D	C	A
16. I thought about a different way to solve the problem.	C	B-D	A
Have you used any of these routes while solving the problem?			
17. I have drawn a shape to help me understand the problem.	A-B	C-D	
18. I used the "guess and control" method.	A-B-C-D		
19. I selected the process I needed to solve this problem.	A-B-C-D		
20. I have been feeling confused and I can not decide what to do.	A-B	C-D	
21. I have noted important information.	B-D	A-C	

As seen in Table 3, students often tend to respond "yes" to the items in the survey. Only Can has given more "no" answers. In order to compare the students' survey findings with the problem solutions, the problem solutions of these 4 students were examined. The original solutions of students and the English of their written explanations were given together.

Figure 1: The Solution of Aylin's First Problem

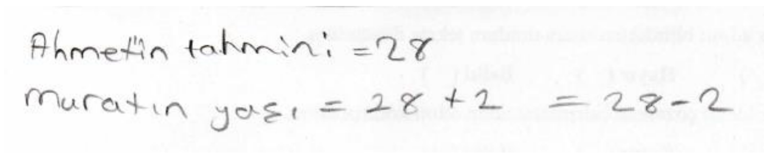


196 drams 153 comedy 88 science fiction. 59 drams and comedy, 37 drams and science fiction, 32 comedy and science fiction, 21 all three-movies.

First I identified the problem. Then thought that I had to draw a set and I set up the numbers.

Aylin first noted the important information given in the problem (planning). Then she sums up the element numbers of the three sets as two given in the problem. It is not known why she did this. She might have tried to solve similar problems about union of sets thinking (procedural knowledge). But she did not go on this path and did not reach a conclusion. She then showed the sets by way of a scheme (planning), but did not make an explanation as to how she placed the numbers placed in the sets. She finally tried to explain what he did (monitoring). She has not found a solution to the problem.

Figure 2: The Solution of Aylin's Second Problem



Ahmet's estimate= 28

Age of Murat= 28+2=28-2

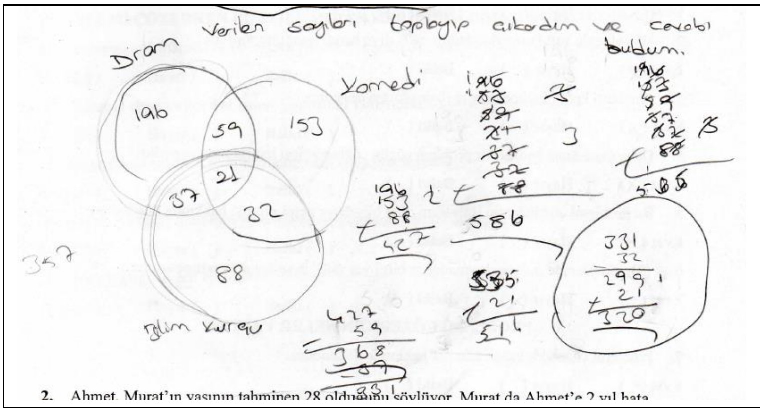
In the second problem, Aylin noted the basic knowledge given first (planning). Since she had interpreted the expression "2 years error margin" in the problem as 2 years more or 2 years less, she wrote two results as 28 + 2 and 28-2 for Murat's age. In fact, she has taken the right approach, but she has only taken the extreme points of the error share, not the interval. In this problem, Aylin did not explain.

Aylin seems to have read the two problems underlined, especially for important information. She may have read the problem more than once (1). She wrote information on the problem at the beginning. This may be the way to express her problem with her own words (3). Particularly in the first problem, it is seen that she tried the methods which are similar to the methods that are used at the lesson (4). In the second part of the questionnaire, the answers to the questions about self-monitoring were generally positive. Although this case can not be observed much in her solutions, it can be detected by in the first problem he tries to do it by drawing a schematic at first, not to go out of his way, and finally trying to explain how he thinks in the process. There are no errors in the calculations that she made. This can be a sign that she come back what she does at the end (12, 13, 14). In the first question, she drew the sets in a scheme (17). Although she did say that she used the method of guess and control in the questionnaire, this method has not been seen in her solutions. In the first problem, it is understood that her head has been confused because he can not fully determine the path he will follow and can not reach the result (20). Aylin responded "no" to items 2, 5, 6 and 21 in the survey. The answer, which does not note important information in item 21 between these items, does not correspond to his solutions. Because the important numerical information given in both problems is noted at the beginning.

In the second problem, Aylin noted the basic knowledge given first (planning). Since she had interpreted the expression "2 years error margin" in the problem as 2 years more or 2 years less, she wrote two results as 28 + 2 and 28-2 for Murat's age. In fact, she has taken the right approach, but she has only taken the extreme points of the error share, not the interval. In this problem, Aylin did not explain.

Aylin seems to have read the two problems underlined, especially for important information. She may have read the problem more than once (1). She wrote information on the problem at the beginning. This may be the way to express her problem with her own words (3). Particularly in the first problem, it is seen that she tried the methods which are similar to the methods that are used at the lesson (4). In the second part of the questionnaire, the answers to the questions about self-monitoring were generally positive. Although this case can not be observed much in her solutions, it can be detected by in the first problem he tries to do it by drawing a schematic at first, not to go out of his way, and finally trying to explain how he thinks in the process. There are no errors in the calculations that she made. This can be a sign that she come back what she does at the end (12, 13, 14). In the first question, she drew the sets in a scheme (17). Although she did say that she used the method of guess and control in the questionnaire, this method has not been seen in her solutions. In the first problem, it is understood that her head has been confused because he can not fully determine the path he will follow and can not reach the result (20). Aylin responded "no" to items 2, 5, 6 and 21 in the survey. The answer, which does not note important information in item 21 between these items, does not correspond to his solutions. Because the important numerical information given in both problems is noted at the beginning.

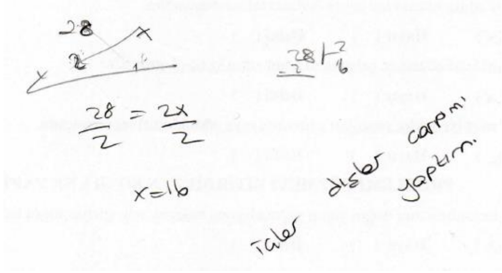
Figure 3: The Solution of Büşra's First Problem



I added up and subtracted the numbers given, and I found the answer.

Büşra first laid out the scheme of the sets given in the problem (planning). Then he placed the numbers given in the problem on this scheme. However, while she was doing the placement, she made a mistake either because she did not analyze the information given in the problem well, or because she could not learn how to solve these problems very well. For example, she thought the number of drama lovers in the problem is "the number of only drama lovers" and the number of drama and comedy lovers in the problem as "the number of drama and comedy lovers who do not like science fiction." On the other hand, she firstly added all numbers given in the problem. Since she may have thought that she could not reach a result here, this time he started by adding the element numbers of the three main sets given in the problem. Processes which she has made here show that while she was finding the union's number of elements of the three sets, she followed the correct steps. However, she found the right result to be less than 10 because she made a small process error in the first addition.

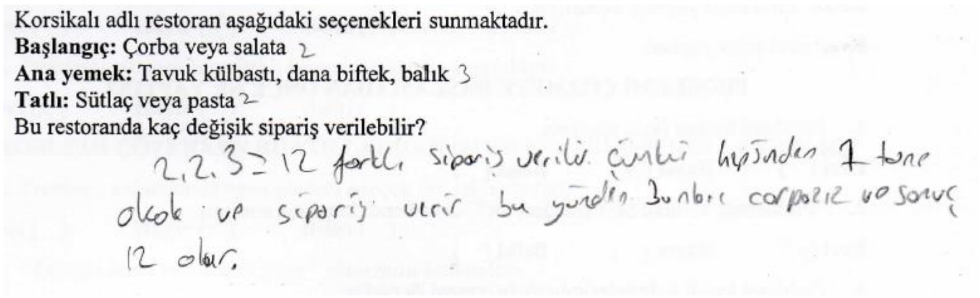
Figure 4: The Solution of Büşra's Second Problem

	*I did cross-multiplication.*

Büşra approached to second problem from a wrong way. This can be understood from that while the problem was related to the issue of "inequality", she was trying to solve by establishing ratios and equations. Büşra might have acted that way because she did not understand the problem or could not find a suitable solution. She has made a mistake in this wrong path that she has already gone. She wrote that she was benefiting from cross-multiplication (procedural knowledge).

Büşra underlined the two problems by highlighting important information. She may have read more than one (1). Büşra stated that she tried to express the problem with his own words in the questionnaire. However, there was no such written expression in her solutions. In the first problem, it is understood that she tried to remember that she had solved a similar problem earlier and thought about the information she needed (4, 5). In the second part of the questionnaire, Büşra gave positive responses to all of the items related to self-monitoring, which were made while solving the problem. This situation is not reflected in the solutions because she does not write much explanation. But that does not mean that Büşra does not exhibit the behaviour in the second part. Self-evaluation items in the third part of the questionnaire were generally answered as "yes". Although Büşra has stated that she controls her calculations in this section, it seems that there is a calculation error in both questions. Büşra may not have checked it, or she may have not noticed the error when she checked it. Although Büşra claims that probing looks again to see if the answer is meaningful, in the second problem, her attempt to find a definite value indicates that there is no meaning between the problem and the solution. In the first problem, she used the figure-drawing strategy (17). Although she stated that he used the method of guess and control on the questionnaire, it has not seen this method in her solutions. In the first problem, it is understood that her head is mixed (20). Because she tried to use different methods and tried to make an irrelevant solution to the second problem. Büşra stated that she notes important information in the survey. Despite this, she did not find notes on her paper. Büşra responded "no" to items 6 and 16 only. Although she said that she did not think about a different way to solve the problem in the number 16, it seems that she changed the method in the solution of the first problem.

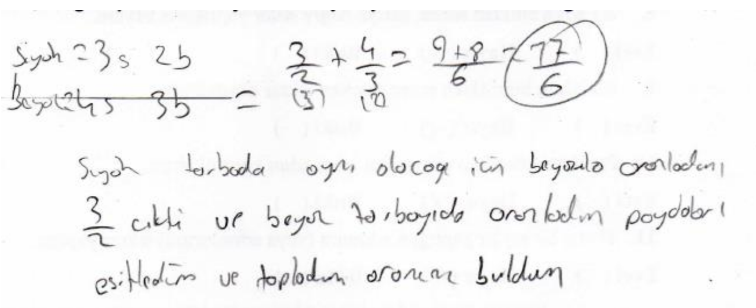
Figure 5: The Solution of Can's First Problem


Korsikalı adlı restoran aşağıdaki seçenekleri sunmaktadır.
Başlangıç: Çorba veya salata 2
Ana yemek: Tavuk külbastı, dana biftek, balık 3
Tatlı: Sütlaç veya pasta 2
Bu restoranda kaç değişik sipariş verilebilir?
2.2.3=12 farklı sipariş verilir. Çünkü hepsinden 1 tane olcak ve sipariş verir bu yüzden bunları çarparız ve sonuç 12 olur.

2.2.3=12 different orders are given. Because there will be one from each one and he gives order. So we multiply them and the result is 12.

It appears that Can has written the numbers of the meals alongside the information to summarize the information given in the first problem (procedural knowledge, planning). He multiplied these numbers and reached the right result. It is understood from his explanations that Can knew that one must be careful about the point of choosing one from each type of food and process to be done in such cases where a progressive selection is required.

Figure 6: The Solution of Can's Second Problem


Siyah = 3s 2b
Beyaz = 4s 3b = $\frac{3}{2} + \frac{4}{3} = \frac{9+8}{6} = \frac{17}{6}$
Siyah torbada aynı olacağı için beyazla oranladım, $\frac{3}{2}$ çıktı ve beyaz torbayıda oranladım paydaları eşitledim ve topladım oranı buldum

Black= 3b 2w

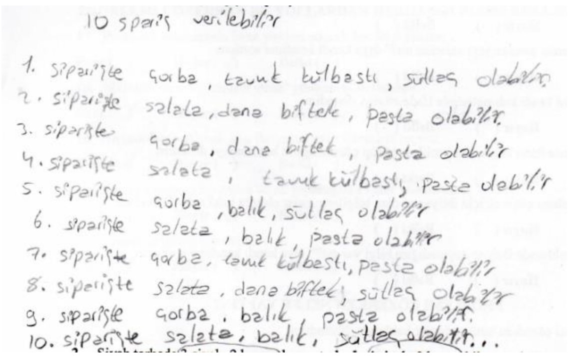
White= 4b 3w

Because the black bag is the same, I rate it with white. It was 3/2 and I also rated the white bag. I equalized the denominations, I added them up, I found the ratio.

Firstly Can summarized the information given in the question on the second problem (procedural knowledge, planning). By the time the solution, Can has taken the ratios of the number of black balls in each of the bags to the number of white balls and he added these ratios wrongly. He has also expressed the process he has done (monitoring). It may be thought that he does not understand the question of probability or the logic of such probabilities question about why he chooses such a solution.

Unlike the group, Can responded "yes" to 9 of the items in the survey and "no" to 12 of them. Since Can summarizes the information given in the problem, it can be considered that he tried to express the problem with his own words (3). Can's follow-up at the solution of the first problem may show that she thought about similar problems before (4). Can replied "no" to all of the items related to self-monitoring in the second part of the questionnaire (7-11). He did not reflect the behaviours mentioned in this section in his solutions. It can be considered that Can's solution checks whether he has made his calculations correctly since he did not encounter a transaction error (13). Although he states that he uses the "guess and control" method, this has not seen in his solutions. However, this does not mean that he is not using it anyway. He answered "no" in items 1, 12, 14, 15, 17, 20 and 21 except the second part of the questionnaire. When solving the problems Can did not draw any shape as mentioned before (17). He stated that he did not record important information. However, it appears that the problem solutions are noted as a summary of the information given at the beginning.

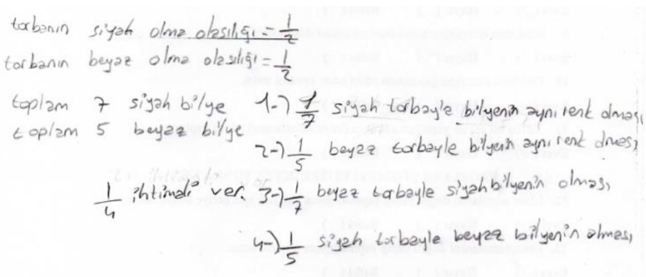
Figure 7: The Solution of Doruk's First Problem



10 orders can be placed.
In the 1st order soup, chicken breast, pudding can be.
In the 2nd order salad, beef steak, cake can be.
In the 3rd order soup, beef steak, cake can be.
In the 4th order salad, chicken breast, cake can be.
In the 5th order soup, fish, pudding can be.
In the 6th order salad, fish, cake can be.
In the 7th order soup, chicken breast, cake can be.
In the 8th order salad, beef steak, pudding can be.
In the 9th order soup, fish, cake can be.
In the 10th order salad, fish, pudding can be.

It seems that Doruk tried to solve the problem by listing the possible cases in the first problem. While listing, most cases have been written, but 2 cases have not been written because they may not have come to mind. It may be because the reason Doruk can not write all possible situations is that he does not go through a certain matching sequence.

Figure 8: The Solution of Doruk's Second Problem



The possibility of the bag being black = 1/2
The possibility of the bag being black = ½

Total 7 black ball, 5 white ball.

1) 1/7 the same color as the black bag and the ball.
2) 1/5 the same color as the white bag and the ball.
3) 1/7 the white bag and the black ball.
4) 1/5 the black bag and the white ball.

There's a 1/4 possibility.

In the second problem, Doruk correctly wrote the probabilities of selecting the bags. It is clear that Doruk first thought that bag selection should be made (procedural information). However, afterwards, he determined the numbers of the total black and yellow balls in the bags and made the selection situations on them. In fact, he was able to think and express all the situations (4 situations) that could be related to the bags and balls to be selected. He has made the wrong turn and has not reached the right conclusion.

It seems that Doruk read two problems carefully. Because he rounded and underlined important information. From here it can be thought that he may have read more than one to understand the problem (1). Even though he stated that he was trying to express himself with his own words, no such attempt was made in his solutions. Though he stated that he controlled his work step by step while solving the problem, it seems that some cases have been overlooked. Doruk responded to the majority of the items in the third part of the questionnaire with "yes". There are no reflections about this in his solution. He says that he used the "guess and control" method when solving problems, but it is not seen in their solutions. He said that he notes important information, but such notes were not found on his paper. It is seen that Doruk responded "no" to items 9, 16, 17 and 20. He did not figure in solving the problems (17).

DISCUSSION AND CONCLUSION

When the results of the questionnaire are examined, the following can be said:

- In the planning part of the problem solving process, it is seen that students mostly responded "yes" to the items. From here it can be said that most of the students have already thought about the operations that they have to do, they are trying to benefit from their previous experiences and they are trying to understand the problem and the desire first. In this section, it is seen that only a minority of those who responded "yes" to the question “Is there any information I do not need in this problem, I asked myself.” It can be considered here that students often have the belief that all given use should be used or that they can not distinguish what is given in the problem as necessary-unnecessary.
- In the process of problem solving, it was seen that the majority of the students gave the answer "yes" to the items. It can be said that the majority of the students are aware of what they are doing during problem solving, knowing what they are doing, checking the steps they are taking. However, although the majority of respondents gave the answer "yes", the rates were lower than in the previous section.
- The part of after solving the problem, students often responded "yes" to items at high rates. From this it can be said that the majority of the students think about the things which they do after solving the problems, that they control their estimates. In this section, it was seen that the ratio of those who answered "yes" to "I thought about a different way to solve the problem" was found to be low. It can be assumed from this that students often have the belief that the problems can be solved in one way or that they have the conclusion that the important thing is to conclude the problem and then there is not a need to try other ways.
- In the strategies used when solving the problem, students responded to "yes" at high rates to items which are related to using the method of “guess and control” and selecting the processes needed, while the rate of "yes" response to other items is low. It can be said that there are not many students who use the drawing strategy and students who distinguish important notes. Again, in this section, it was seen that the most "no" response was given to the article " I have been feeling confused and I can not decide what to do.". As a result, it can be assumed that the students are not very aware of the strategies they use.
- Generally, there is no significant difference between class levels.
- When the whole questionnaire is commented on, it can be considered that the majority of the students actually have higher metacognitive behaviours in problem solving. Normally, the level of metacognitive behaviour predicts success, but in this study while the level of metacognitive behaviour in the applied questionnaire is high, the problem solving success is low. However, when we compare the answers of the questionnaire and solutions of problems for 4 students, it seems that they do not quite match the results obtained from this table. In other words, metacognitive behaviours that students say they have shown and metacognitive behaviours that arise from examining problem solutions are not always parallel to each other. In addition, fewer metacognitive behaviours could be detected in problem solving of students. However, it should

be kept in mind that students do not write much about what they think when solving problems. Because the metacognition is an intrinsic process, it can be interpreted as much as the person transfers to the other side. When the transmission is low, it may not always be right to think that there is little or no metacognitive behaviour.

- In general, it has been observed that the students in the questionnaire responded “yes” to the majority of items. it seems that those who gave "no" or "maybe" answers in the items 6, 16, 17, 20 and 21 are more than those who gave "yes". This result is consistent with the results obtained by Fortunato et al. (1991). In their study, they also found that items 6, 16, 17, 18, 20 and 21 were generally answered "no". Unlike other studies, in this study the majority of students responded positively to item 18.

Suggestions for teachers and researchers can be given as a result of this study. In future studies, it will be useful to use different methods and techniques such as vocal thinking and interviewing instead of collecting data from written papers only if students want to reach self-assessment on metacognition. Rather than teaching teachers the shortest path to problem solving and teaching them to solve it automatically, teachers should give their students an opportunity to think about improving their metacognitive behaviours and to find out what their students are doing and find their way.

REFERENCES

Akın, A. and Abacı, R. (2011). *Metacognition*. Ankara: Nobel Publishing.

Aksoy, N. (2003). Action research: a method to be used to improve and change educational practices. *Journal of Theory and Practice in Education Management*, *9*(4), 474-489.

Biryukov, P.(2004). Metacognitive aspects of solving combinatorics problems. *International Journal for Mathematics Teaching and Learning* (01.07.2006) www.cimt.plymouth.ac.uk/journal/biryukov.pdf

Brown, A. L. (1978). Knowing when, where, and how to remember; a problem of metacognition. *Advances in Instructional Psychology*, *1*.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. *Metacognition, motivation, and understanding*, chapter 3, 65-116.

Çakıroğlu, A. (2007). Metacognition. *Turkey Social Research Journal,* 11 (2), 21-27.

Demircioğlu, H. (2008). *The influence of the educational situations designed for the development of metacognitive behavior of mathematics teacher candidates* (Doctoral Thesis). Gazi University, Ankara.

Doğan, A. (2013). Metacognition and metacognitive teaching. *Middle Eastern & African Journal of Educational Research*, (3), 6-20.

Flavell, J.H.(1979). Metacognition and cognitive monitoring. *American Psychologist,* 34 (10) 906-911, October 1979.

Fortunato, I, Hecht, D., Title, C. K and Alvarez, L. (1991). Metacognition and problem solving. *The Arithmetic Teacher,* Dec. 39(4) 38.

Garafalo J. and Lester, F. (1985) *Metacognition, cognitive monitoring and mathematical performance.* Journal for Research in Mathematics Education, 16, 163–175.

Livingston, J. A. (2003). Metacognition: An Overview. https://files.eric.ed.gov/fulltext/ED474273.pdf (15.04.2018)

Ministry of National Education (Mne) Commission (2015). *Secondary Mathematics Class 9 1st Book*, Mne Publications, Ankara. S.108, 198.

Özsoy, G. (2008). Metacognition. *Turkish Journal of Educational Sciences,* 6(4), 713-740.

Panaoura, A. and Philippou, G. (2005). The measurement of young pupils’ metacognitive ability in mathematics: The case of self-representation and self-evaluation. In *Proceedings of CERME* (Vol. 4).

Pugalee, D. K. (2001). Writing, mathematics, and metacognition: Looking for connections through students' work in mathematical problem solving. *School Science and Mathematics*, *101*(5), 236-245.

Şahin, M. (2015). *Mathematics 10*. Ankara: Palme Publishing, S.10, 97.

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Analysis of Defining and Drawing Skills of Secondary School Students: Parallelogram Example *

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Abstract: The aim of this study is to comparatively examine the students' ability to define and draw parallelogram for each class level. General survey model was chosen as the methodology of this study and the working group of the study consists of 120 middle school students from a state middle school in Turkey. Two open-ended questions were used to gather data. One of the questions was taken from the study of Fujita (2012) and the other question was prepared by researchers based on the relevant literature, mathematics curricula and textbooks. The document analysis method was used to analyze data. As a result of the research, it was seen that students at all class levels drawn prototype-parallelogram, and had difficulty in defining parallelograms. It has been determined that students at all grade levels cannot consider a rhombus as a special form of parallelogram, and do not prefer it in their drawings.

Keywords: parallelogram, define- and drawing skills, secondary school students

INTRODUCTION

Geometry is an important branch of mathematics to teach. The study of geometry contributes to helping students develop the skills of visualisation, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof (Jones, 2002). Despite the great importance placed on geometry education included in the mathematics curriculum, much research shows that geometry perception levels of students are not at the expected level (Clements & Battissa, 1992; Carroll, 1998). The topic of quadrilaterals, which holds an important place in primary and secondary school mathematics program, are able to develop some mathematical skills such as defining, classifying geometric shapes, drawing, relational understanding, logical deduction, deductive and inductive thinking (MEB, 2013; 2015). Despite this importance,when the literature is examined, it is seen that the students have some difficulties with the quadrilaterals.

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It has been revealed that students have problems in defining quadrilaterals (de Villiers, 1994; Fujita & Jones, 2006; 2007; Okazaki & Fujita, 2007; Ergün, 2010; Berkün, 2011; Aktaş & Aktaş, 2012; Fujita, 2012; Türnüklü, Alaylı & Akkaş, 2013; Aktaş, 2016; Karakuş & Erşen, 2016; Ayaz, 2016), drawing quadrilaterals Berkün, 2011; Erşen & Karakuş, 2013; Türnüklü, Alaylı & Akkaş, 2013), hierarchical classification of quadrilaterals (de Villiers, 1994; Fujita & Jones, 2006; Akuysal, 2007; Okazaki & Fujita, 2007; Berkün, 2011; Türnüklü, Alaylı & Akkaş, 2013; Karakuş & Erşen, 2016), and so on. In these studies, Fujita (2012) determined that students often recognize prototypes of quadrilaterals and that they are not aware of the hierarchical relationship between quadrilaterals. In his work, Fujita (2012) identified four developmental levels that revealed levels of understanding quadrilaterals:

“Level 0”: The student has no basic knowledge of parallelogram

"Prototype Level" where the student has limited parallelogram knowledge

"Partially Prototype Level" in which the student has expanded the limited knowledge of parallelogram, for example, the student accepts equilateral triangles as parallelogram, but can not fully explain the relation between them.

"Hierarchical Level" where the student can determine the relation between the parallelogram and some other special quadrilaterals and can explain the relation between them mathematically.

Aktas and Aktas (2012), who conducted a study based on Fujita's (2012) study, found that 9^{th} grade students were not at the expected level of achievement in defining a parallelogram, and that students who correctly defined them remembered parallelogram with its typical image. They also found no inferences that could reveal the hierarchical relationship between quadrilaterals. Berkün (2011) conducted his research on 5th and 7th grade students and found that students were unaware of the hierarchical relationship between the quadrilaterals. He claims also that students think that it is a uniform drawing belonging to each special quadrant, and those who have made more than one drawing have only changed the position or size of the drawing. In their work with 4th grade students under the NAEP (The National Assessment of Educational Progress) Walcott, Mohr and Kastberg (2009), found that students use a non-mathematical language when describing parallelogram and that students use names of “oblique rectangles or rectangles with oblique edge” instead of parallelogram names.

When the above explanations and studies are evaluated, it is important to find out how secondary school students define geometric concepts, how they draw shapes, how they classify geometric shapes and objects, and how they determine their relations with each other. In this context, it is thought that it is important to determine the conceptual learning of the geometric concepts of the secondary school students (5th, 6th, 7th, and 8th grade students). As a matter of fact, research is needed to determine whether students' polygonal perception, identification, and classification patterns change according to the class level. In this study, from special quadrangles only parallelograms are used, in order to gain in-depth knowledge of the students' conceptual learning in the field of geometry. Parallelograms contain the most hierarchical relationships within the family of special quadrilateral. As a matter of fact, rhombuses, rectangles and squares are also a parallelogram. In addition, the concept of parallelograms serves as a bridge to understanding other lower- and upper-level geometric concepts (Ulusoy & Çakıroğlu, 2017).

In this study, students from every grade level of secondary school are involved. The ability to define and drawing skills of students at all class levels has been examined. The study is also based on the evaluation framework of Fujita (2012). It can be said that the research from these directions is different from the other researches. In this research, it is aimed to comparatively examine the students' ability to describe and draw parallelogram for each class level. For these purposes, research questions are identified as follows:

1. What is the level of definition of the parallelogram of the secondary school students?
2. How are the parallelogram drawings of the secondary school students?

METHODOLOGY

In this study, it is aimed to comparatively examine the students' ability to describe and draw parallelogram for each class level. Therefore, a general survey model is conducted. Karasar (2008) describes the general screening models as; screening operations to reach some general judgments about a universe or a set of samples taken from the universe which compose of multitude of elements.

Study Group

The study group consists of 120 middle school students from a state middle school in Samsun. Since one of the researchers is a mathematics teacher in the middle school, the convenience sampling method is preferred. Convenience sampling method is practical and gives researchers time (Yıldırım & Şimşek, 2008). The demographic properties of working group is given in the following Table1.

Table1: Demographic properties of working group

Grade	5th	6th	7th	8th	Total
Number of students	30	30	28	32	120

Analysis of Data

The document analysis method is used to analyze data. Document analysis is a systematic procedure for reviewing or evaluating documents—both printed and electronic (computer-based and Internet-transmitted) material. Like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009). Students' written answers to two open-ended questions are considered as documents in this study.

For the analysis of students' answers to question 1, Fujita's (2012) assessment criteria are used. These criteria are given in the following Table 2 and Table 3.

Table 2: Students' level of understanding parallelogram (Fujita, 2012)

Level	Description
D-P-Hierarchical	Learners can accept squares, rectangles and rhombi are also parallelograms. 'The opposing direction inclusion relationship' of definitions and attributes is understood
D-P-Partial Prototypical	Learners have begun to extend their figural concepts. For example, they accept rhombi are also parallelograms but not squares and rectangles. Their judgement would be likely to be prototypical type 2
D-P-Prototypical	Learners who have their own limited personal figural concepts. Their judgement would be either prototypical type 1 or 2
Level 0	Learners do not have basic knowledge of parallelograms

Table 3: Evaluation criteria for question1

Question	D-P- Hierarchical	D-P-Partial Prototypical	D-PPrototypical	Level 0
Q 1	correct definition (rectangle with opposite edges parallel to each other)	writing different features of parallelogram	define according to external appearance of the parallelogram (oblique rectangle etc.)	empty or other misconceptions

In question 2 students were asked to draw three different parallelograms at the dotted partitions. The main purpose of using the dotted partition is to see exactly which quadrangle the students draw and to determine whether students are paying attention to critical features of parallelograms. In addition, the suggestions in the secondary school mathematics curriculum for the use of square or dotted paper on teaching basic geometric concepts have been taken into consideration (MEB, 2013).

The answers for each question are independently analyzed by two different researchers, and necessary subcategories were created. The obtained data are also checked by a third researcher. Discrepancies between them are reviewed again and data analysis is finalized. In these comparisons, the percentage of incompatibility that Miles and Huberman (1994) suggested, reliability (Reliability = Opinion Unity / (Opinion Unity + Opinion Separation)) is calculated for each category separately. The percentage of Question 1 is % 83 and Question 2 is % 94. All calculated percentages are higher than 70% and therefore analysis in the study can be considered as reliable (Miles & Huberman, 1994).

FINDINGS

The data in this study is investigated under the two following categories: “defining a parallelogram” and “parallelogram drawings”.

Defining a Parallelogram

In the first question, students are asked to describe the parallelogram. The level of definition of the parallelograms of the students is given in Table 4.

Table 4: Students’ level of definitions of a parallelogram

Grades	5th		6th		7th		8th	
Levels	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
D-P-Hierarchical	2	7	-	0	5	17.8	3	9.3
D-P-Partial Prototypical	4	13	1	3.3	6	21.4	5	15.6
D-P-Prototypical	4	13	18	60.0	4	14.3	10	31.3
Level 0	20	67	11	36.7	13	46.5	14	43.8

When Table 4 is examined, it can be seen that 6^{th} grade students can not define parallelograms, 7% of 5^{th} grade students, 17.8% of 7^{th} grade students and 9.3% of 8^{th} grade students can describe a parallelogram at hierarchical level. 13% of Grade 5 students, 3.3% of Grade 6 students, 21.4% of Grade 7 students, and 15.6% of Grade 8 students can define parallelograms at D-P-Partial

Prototypical level,that is in the definitions given by the students, they can list all the features of parallelograms. It can be seen that 13% of 5th grade students, 60% of 6th grade students, 14.3% of 7th grade students and 31.3% of 8th grade students can define parallelograms at D-P-Prototypical level, that is, students are more likely to describe parallelograms according to the external appearance of parallelograms. 67% of Grade 5 students, 36.7% of Grade 6 students, 46.5% of Grade 7 students, and 43.8% of Grade 8 students were assigned to level 0 because they did not correctly define the parallelograms.

Some examples of parallelogram definitions for each level are shown in Table 5 below.

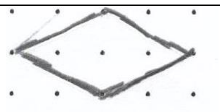
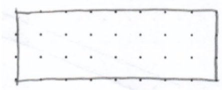
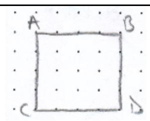
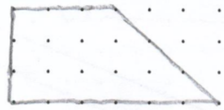
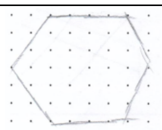
Table 5: Some examples from student answers

Levels	**Sample student answers**
D-P-Hierarchical	Karşılıklı kenarları paralel olan dörtgenlere paralel kenar denir. (Quadrangles with parallel sides are called parallelograms.)
D-P-Partial Prototypical	Karşılıklı kenarları eşit olan ve iç açıları toplamı 360 derece olan bir dörtgendir. Karşılıklı kenarları paralel ve uzunlukları eşittir. (A rectangle whose opposite sides are equal and whose sum of inner angles is 360 degrees. Opposite sides are parallel and equal in length.)
D-P-Prototypical	Kare veya dikdörtgenin vb. yana yatmış. (shapes such as squares or rectangles are tilted to the side)
Level 0	iki kenarın birbirine olan paralelliği (two sides parallel to each other)

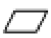
Drawings

In question 2 students were asked to draw three different parallelograms in dotted sections. As a result of the examination, two categories were determined as the correct drawing and the wrong drawing. Then the correct drawings are divided into subcategories as prototype parallelograms, non-prototype parallelograms, rhombus, rectangles, and squares. Wrong drawings are divided into subcategories, such as trapezoids, rectangles that are not parallel to each other's edges, and those that are empty or irrelevant. These findings are shown in Table6.

Table 6: Students' parallelogram drawing skills and some examples of drawings *

Categories	Subcategories	Example Drawings	5th grade		6thgrade		7th grade		8th grade	
			f	%	f	%	f	%	f	%
Correct Drawings	Prototype Parallelogram Drawings		9	30	54	80	15	54	29	91
	Non-Prototype Parallelogram Drawings		6	20	7	24	6	21	9	28
	Rhombus Drawings		2	6	4	13	1	3	3	9
	Rectangles Drawings		16	53	3	10	19	68	12	37
	Squares Drawings		4	13	2	7	12	43	13	40
Incorrect Drawings	Trapezoids drawings		9	30	4	13	5	18	5	15
	Rectangles drawings that are not parallel to each other's edges		12	40	11	37	10	36	5	15
	Empty or irrelevant drawings		4	13	4	13	1	3	2	6

*Since a student draws three different rectangles, the sum of the percentage of correct drawings and those who make the wrong drawings at each class level does not give 100%.

Table 6 shows that 30% of the 5th grade students, 80% of the 6th grade students, 54% of the 7th grade students and 91% of the 8th grade students draw a typical parallelogram (). It was determined that 20% of 5th grade students, 24% of 6th grade students, 21% of 7th grade students and

28% of 8th grade students were drawing unusual parallelograms. It was also found that 53% of 5th grade students draw a rectangle, 68% of 7th grade students draw a rectangle, 43% draw a square, and 37% of 8th grade students draw a rectangle and 40% square. 30% of 5th grade students, 13% of 6th grade students, 18% of 7th grade students and 15% of 8th grade students draw trapezoids. It is also seen that 40% of Grade 5 students, 37% of Grade 6 students, 36% of Grade 7 students and 15% of Grade 8 students draw quadrangles that are not parallel to each other's edges.

DISCUSSION AND CONCLUSION

When the parallelogram definitions were evaluated, it was found out that students' ability of defining the parallelograms at all class levels were inadequate in general. Especially, it has been determined that most 5th grade students can not define a parallelogram; and 6th grade students were more likely to define a parallelogram according to their external appearances of parallelogram. It was observed that 7th grade students were partially more successful than others in defining parallelogram. It is seen that there are fewer students (% 17.8) who are aware of the necessary and sufficient conditions for definition at the hierarchical level in 7th grade. When we look at the level of definition of the 8th grade, it is seen that there are students at all levels but most of them are at Prototype or Level 0. It can be said that 8th grade students are very inadequate in defining a parallelogram when class level is taken into consideration. This indicates that there is no significant increase in the ability of students to define a parallelogram, despite the increase of the class level. As a matter of fact, Özdemir, Erdoğan and Dur (2014) determined that the quadratic definitions of teacher candidates were at the prototype level, that is, the level of middle school students, in the study conducted by the university with the elementary mathematics teacher candidates in the fourth grade. This result supports the result of our research that the students' ability to define despite the increase of the class level has not changed. In addition, according to other studies, it has been revealed that it is difficult for students to define and it has been seen that the students try to make definitions according to the prototype they have created in their minds (De Villiers, 1998; Fujita & Jones, 2007; Aktaş & Aktaş, 2012; Fujita, 2012; Erşen & Karakuş, 2013; Türnüklü, Alaylı & Akkaş, 2013; Akkaş & Türnüklü, 2015).

In the second question, students are asked to draw three different parallelograms at the dotted sections. When we look at the results, it is seen that 5th grade students mostly draw prototype parallelograms and rectangles. This shows that 5th grade students generally draw typical parallelograms. 5th grade students draw a rectangle, which is a special parallelogram, more than the other quadrants. It is thought that this is so because the students likened the rectangle and the parallelogram formally to each other. As a matter of fact, 5th grade students do not prefer rhombus and square drawings very much, and this supports the previous result. In addition, in the study conducted with the mathematics teacher candidates, Türnüklü (2014) stated that the teacher candidates related rectangle to parallelogram, which supports the findings in our research. Most students in grades 6, 7, and 8 have drawn parallel the prototype of parallelogram (). This suggests that students prefer the typical parallelogram model they are accustomed to, even if the class level increases. Students often see the typical parallelogram in their lessons. Therefore, it can be said that they created this model as a concept image in their minds. As a matter of fact, studies have shown that teachers frequently use the typical parallelogram model in mathematics lessons (Akuysal, 2007; Ergün, 2010; Erşen & Karakuş, 2013; Türnüklü, Alaylı & Akkaş, 2013; Akkaş & Türnüklü, 2015). 5th and 7th graders' parallelogram drawing preferences are close together. In the mathematics program of the 5th and 7th grades, while the quadrangles are processed in the lessons, the rectangles and parallelograms are given at the same time. Moreover, according to the students, these two rectangles are very similar to each other. Because of these reasons, it can be said that at both grade levels, students mostly drawn rectangles instead of parallelograms. When the secondary school mathematics program is examined; in the 5th grade, other special squares are trained outside the trapezoid (square, rectangular, rhombus, and parallelogram). In the 6th grade, only the concepts of the height of the parallelogram and the domain relation are discussed. For the 7th class, all special quadrangles (square, rectangle, rhombus, parallax and trapezoid) are handled together. In the 8th grade, no special quadrants are included.

As a result of the research, it was seen that students at all class levels drawn prototype-parallelograms, and students at all class levels had difficulty in defining a parallelogram. It has been determined that students at all grade levels cannot consider the rhombus as a special form of a parallelogram, and do not prefer it in their drawings. As a matter of fact, Aktaş and Aktaş (2012) stated that 8th grade students could not establish a relation between rhombus and parallelogram, and similarly, in his work with students in the 9-13 age group, Nakahara (1995) stated that it is more difficult for students to establish a parallelogram-rhombus relationship. In general, it was determined that the 7th grade was more successful and the 6th grade was more unsuccessful in all the questions.

As a result of our research it can be said that students do not prefer non-prototype parallelogram drawings, and that the prototypes were drawn by students only by changing the size and stance. It has been seen that students draw trapezoids and polygons with two edges parallel to each other such as hexagons and pentagons instead of parallelograms. It can be said that the students perceive geometrical shapes, with two edges parallel to each other as parallelograms and that they draw such geometric shapes. As a matter of fact, Ulusoy and Çakıroğlu (2017) in their study with 7th grade students reached the conclusion that the students focused on the concept of "parallel edges" from the concept of "parallelograms" by taking the direction of this syntactical similarity and seeing parallel shapes as parallelograms.

From these results, it may be advisable to include special prototype images as well as special forms in lessons in the teaching of the parallelogram. Instead of giving the definitions directly, students should be offered opportunities to explore them. In teaching quadrangles, suitable learning environments should be provided by considering van Hiele geometry thinking levels. Activities such as concept maps can be prepared to reveal the hierarchical relationships of the parallelogram with some other special quadrilaterals. Special teaching methods such as realistic mathematics education or problem based learning, can be applied for better understanding the quadrants. In addition, concrete materials (geometry strips, geometry boards, etc.), dynamic geometry software (Geoegebra, Cabri etc.) and origami (paper folding) activities can provide a better understanding of the parallelograms of students. It should also be emphasized that the concepts of parallelogram and parallel edges are not the same for students and it will be appropriate to include examples of this difference.

REFERENCES

Akkaş, E. N., & Türnüklü, E. (2015). Ortaokul Matematik Öğretmenlerinin Dörtgenler Konusunda Pedagojik Alan Bilgilerinin Öğrenci Bilgisi Bileşeninde İncelenmesi [Middle School Mathematics Teachers' Pedagogical Content Knowledge Regarding Student Knowledge about Quadrilaterals]. *İlköğretim Online, 14*(2), 744-756.

Aktaş, M. C. (2016). Turkish High School Students' Definitions for Parallelograms: Appropriate or Inappropriate? *International Journal of Mathematical Education in Science and Technology, 47*(4), 583-596.

Aktaş, M. C., & Aktaş, D. Y. (2012). Öğrencilerin Dörtgenleri Anlamaları: Paralelkenar Örneği [Students' Understanding of Quadrilaterals: The Sample of Parallelogram]. *Eğitim ve Öğretim Araştırmaları Dergisi, 1*(2), 319–329.

Akuysal, N. (2007). İlköğretim 7. Sınıf Öğrencilerinin 7. Sınıf Ünitelerindeki Geometrik Kavramlardaki Yanılgıları [Seventh Grade Students' Misconceptions about Geometrical Concepts]. Yüksek Lisans Tezi, Selçuk Üniversitesi, Eğitim Bilimleri Enstitüsü, Konya.

Ayaz, Ü. B. (2016). Ortaokul Öğrencilerinin Dörtgenlere İlişkin Kavram İmajları [Middle School Students' Concept Images related to Quadrilaterals]. Yüksek Lisans Tezi, Necmettin Erbakan Üniversitesi, Eğitim Bilimleri Enstitüsü, Konya.

Berkün, M. (2011). İlköğretim 5 ve 7. Sınıf Öğrencilerinin Çokgenler Üzerindeki İmgeleri ve Sınıflandırma Stratejileri [The Images of Polygons and Classification Strategies for the Primary School Students of 5th and 7th Grades]. Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir.

Clements, D. H., & Battista, M. T. (1992). Geometry and spatial understanding. Handbook of research mathematics teaching and learning. (Edt: D. A. Grouws). New York: McMillan Publishing Company. pp. 420-465.

De Villiers, M. (1994). The role and function of a hierarchical classification of quadrilaterals. *For the Learning of Mathematics, 14*(1), 11-18.

Ergün, S. (2010). İlköğretim 7. Sınıf Öğrencilerinin Çokgenleri Algılama, Tanımlama ve Sınıflama Biçimleri [7th Grade Students' Perception, Definition and Classification of the Polygons]. Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü, İzmir.

Erşen, Z. B., & Karakuş, F. (2013). Sınıf öğretmeni adaylarının dörtgenlere yönelik kavram imajlarının değerlendirilmesi [Evaluation of preservice elementary teachers' concept images for quadrilaterals]. *Turkish Journal of Computer and Mathematics Education, 4*(2), 124-146.

Fujita, T., & Jones, K. (2006). Primary trainee teachers' understanding of basic geometrical figures in scotland. In J. Novotana, H. Moraova, K. Magdelena & N. Stehlikova (Eds.), Proceedings of The 30th Conference of the International Group for the Psychology of Mathematics Education, 3, 14-21.

Fujita, T., & Jones, K. (2007). Learners' understanding of the definitions and hierarchical classification of quadrilaterals: Towards a theoretical framing. *Research in Mathematics Education, 9*(1&2), 3-20.

Fujita, T. (2012). Learners' level of understanding of inclusion relations of quadrilaterals and prototype phenomenon. *The Journal of Mathematical Behavior, 31*, 60-72.

Jones, K. (2002). Issues in the Teaching and Learning of Geometry. In: Linda Haggarty (Ed), Aspects of Teaching Secondary Mathematics: perspectives on practice. London: RoutledgeFalmer. Chapter 8, pp 121-139. ISBN: 0-415-26641-6).

Karasar, N. (2008). *Bilimsel araştırma yöntemi: kavramlar-ilkeler-teknikler* [*Scientific research method: concepts-principles-techniques*]. Ankara: Nobel Yayın Dağıtım.

Karakuş, F., & Erşen, Z.B. (2016). Sınıf öğretmeni adaylarının bazı dörtgenlere yönelik tanımlama ve sınıflamalarının incelenmesi [Examining pre-service primary school teachers' definitions and classifications towards quadrilaterals]. *Karaelmas Journal of Educational Sciences, 4*, 38-49.

MEB. (2013). İlkokul matematik dersi 1-4. Sınıflar öğretim programı [Primary school mathematics curriculum (grades 1-4)].Ankara: MEB Talim ve Terbiye Kurulu Başkanlığı.

MEB. (2015). Ortaokul matematik dersi 5-8. Sınıflar öğretim programı [Secondary school mathematics curriculum (grades 5-8)]. Ankara: MEB Talim ve Terbiye Kurulu Başkanlığı.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publication.

Nakahara, T. (1995). Children's construction process of the concepts of basic quadrilaterals in Japan. In A. Oliver & K. Newstead (Eds.), *Proceedings of the 19th Conference of the International Group for the Psychology of Mathematics Education, 3,* 27-34.

Okazaki, M., & Fujita,T. (2007). Prototype phenomena and common cognitive paths in the understanding of the ınclusion relations between quadrilaterals in Japan and Scotland. In H. Woo, K. Park & D. Seo (Eds.), Proceedings of The 31st Conference of the Internatıonal Group for the Psychology of Mathematics Education, 4, 41-48.

Türnüklü, E., Alaylı, F.G., & Akkaş, E.N. (2013). İlköğretim matematik öğretmen adaylarının dörtgenlere ilişkin algıları ve imgelerinin incelenmesi [Investigation of prospective primary mathematics teachers' perceptions and images for quadrilaterals]. *Kuram ve Uygulamada Eğitim Bilimleri, 13*(2), 1213-1232.

Walcott, C., Mohr, D., & Kastberg, S.E. (2009). Making sense of shape: An analysis of children‟s written responses, *Journal of Mathematical Behavior, 28*, 30-40.

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The Investigation of Algorithmic Thinking Skills of Fifth and Sixth Graders at a Theoretical Dimension*

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Abstract: Besides algorithmic thinking is a basic mathematical skill that places on the centre of mathematical processes such as problem solving, programming and coding, it is seen that studies related to algorithmic thinking in the literature are very limited. In this context, this study aims to investigate the algorithmic thinking skills of secondary school students at a theoretical dimension. This is a case study and the study group consists of 138 students in total studying at fifth and sixth grades of different public secondary schools in the province of Ordu. Roughly, fifty-four and forty-five percents of the study group consist of female and male and fifty and forty-nine percent of them consist of fifth and sixth graders respectively. Criteria sampling method of objective sampling methods was used in determining the study group and *Algorithmic Thinking Test* developed by the author as a data collection tool was administered to the students in the study group. As a result of the study, the algorithmic thinking skills of the students were assessed considering the sub-dimensions of these skills and students in the study group had 43% of the achievement averages in using algorithmic thinking skills at the end of the study. It is seen that *algorithmic tasks* are the most successful questions for the students, and the *logic* is the most unsuccessful. Some recommendations were presented for relevant studies that can be carried out about the subject in the future.

Keywords: algorithmic thinking, fifth and sixth graders, theoretical study.

INTRODUCTION

Informally, computational thinking describes the mental activity in formulating a problem to admit a computational solution. The solution can be carried out by a human or machine, or more generally, by a combination of humans and machines (Wing, 2006). Though the idea of computational thinking was first introduced by Seymour Papert (1980), the discussions with regard to the teaching of this concept became widespread with the notion of Wing (2006) suggesting that every student should be taught computational thinking as one of the fundamental areas such as reading, writing and arithmetic. International Society for Technology in Education [ISTE] (2015)

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indicates that computational thinking skill is an expression of creative thinking, algorithmic thinking, critical thinking, problem solving, cooperative learning and communication skills and underlines that it cannot be described independently of these skills.

Being an important component of computational thinking skill, algorithmic thinking is defined by Brown (2015) as the ability to understand, implement, assess and design algorithms to solve a range of problems. As for Futschek (2006), it is an ability that is necessary at any stage of problem solving process whereas Olsen (2000) indicates that this ability is one of the most important abilities that students should develop in educational environments. As algorithmic thinking is a component of computer thinking, it is seen that the studies on the subject are generally based on computer thinking (Grover and Pea, 2013; Korkmaz, Çakır, Özden, Oluk and Sarıoğlu, 2015; Korkmaz, Çakır and Özden, 2017; Oluk, Korkmaz and Oluk, 2018; Yünkül, Durak, Çankaya and Mısırlı, 2017) and the scope of these studies is limited. From these studies, Grover and Pea (2013), Oluk, Korkmaz and Oluk (2018) and Durak, Çankaya and Mısırlı (2017) examined the effect of scratch programme on the learners' computational and algorithmic thinking skills. Korkmaz, Çakır and Özden (2017) developed a computational thinking scale and Korkmaz, Çakır, Özden, Oluk and Sarıoğlu (2015) evaluated the students' computational thinking skills in terms of school type, department, class level / graduation status, gender and age variables by using this scale.

In particular, studies specially on algorithmic thinking skills are quite limited and these studies (Burton, 2010; Futschek, 2006; Hromkovič, Kohn, Komm and Serafini, 2016; Zsakó and Szlávi, 2012) have generally theoretical structure. From these studies, Burton (2010) examined the ways of encouraging algorithmic thinking without a computer by using a pen and-paper like multiple choice questions and three stage tasks. Futschek (2006) said in his study that algorithmic thinking is a key ability in informatics that can be developed independently from learning programming, and he put forward some problems and claimed a proper visualization of these problems can help to understand the basic concepts connected with algorithms: correctness, termination, efficiency, determinism, parallelism, etc. The study of Hromkovič, Kohn, Komm and Serafini (2016) developed three examples that illustrate how general aspects of algorithmic thinking can be incorporated into programming classes and investigated the algorithmic thinking skills of secondary school students at a theoretical dimension. Zsakó and Szlávi (2012) aimed at dealing with algorithmic thinking's depths and made the specifications and levels of algorithmic thinking competence. Therefore, in this study, apart from the mentioned studies, the algorithmic thinking skills were handled practically and the ways in which the students used this skill were investigated. The aim of the study is to investigate the algorithmic thinking skills of secondary school students at a theoretical dimension.

METHOD

The survey method was used in this study. Survey studies aims to collect data for determining specific characteristics of a group (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz and Demirel, 2018). In this study, it is preferred to use this method since it has been studied by taking a special mathematical competence, together with its sub-dimensions.

Study Group

The study group consists of a total of 138 students in fifth and sixth grade levels in different state secondary schools in Ordu. Criteria sampling method of objective sampling methods was used for determining the study group (Patton, 1990). For determining the schools that would take part in the study, the TEOG (Transition from Primary to Secondary Education) exam results carried out in 2017 were taken into account, in line with the consensus of mathematics teachers and school principals across the province. In this regard, the students studying at schools that ranked in the middle group according to success rating participated in the study. The students who have been attending fifth and sixth grades and also volunteer for the study were selected. The demographic information of these students is as follows.

Table 1: The distribution of study group according to the independent variables

	Gender		**Grade Level**	
	Girl	Boy	5	6
N	75	63	70	68
%	54.34	45.65	50.72	49.27

Data Collection Tools

Algorithmic Thinking Test (ATT) developed by the researchers and consisting of 12 open-ended questions was used as data collection tool in the study. The theoretical structure of Burton (2010) was used for developing the questions in the test. Accordingly, the test consists of four sub-dimensions: *Algorithmic Tasks, Tracing Tasks, Logic Tasks* and *Analysis Tasks.* Besides, online data sources (Kalelioğlu, 2017) were utilized in the determination of the questions in ATT. Information on the scope of the questions in each sub-dimension of ATT is given below.

Algorithmic tasks

In these questions, the students use a given algorithm according to the rule of a problem or develop an algorithm to solve a given problem.

Tracing tasks

In these questions, the students use the steps of a given algorithm in accordance with the current situation / problem situation or predict the result of an algorithm given in the problem.

Logic Tasks

In these questions, the students use the reasoning skills effectively for determining and using the appropriate algorithms for the problem situations.

Analysis tasks

In these questions, students are asked about the correctness / effectiveness of the algorithms used in the given problems. Students can also determine the inappropriate step of an algorithm or determine the sequence of the steps of an algorithm that best suits for the expected solution.

The ATT consists of eight questions in total, having 3, 2, 2 and 1 questions for each dimension respectively. For the validity of ATT, the difficulty and discriminatory indices of the items were examined and the expert opinions were used for the reliability of the test. As a result of the examination, four problems were removed from the test because of the discrimination values were below 0.20. The average strength of the test was calculated as 0.44. Accordingly, it can be said that the difficulties of the questions in the test are moderate. Finally, the Spearman Brow coefficient for internal consistency was calculated as 0.75 for the test.

Data Analysis

The responses of students in the study were interpreted by expressing the percentage and frequency values for each sub-dimension of the ATT.

FINDINGS

General Findings Obtained from ATT

Findings obtained from ATT are given in Table 2.

Table 2: Findings Obtained from ATT

Dimensions of ATT	Number of	N	x	ss
Algorithmic	3	138	**0.53**	.31
Tracing	2		**0.46**	.77
Logic	2		**0.32**	.34
Analysis	1		**0.34**	.47
Total	8		**0.43**	.24

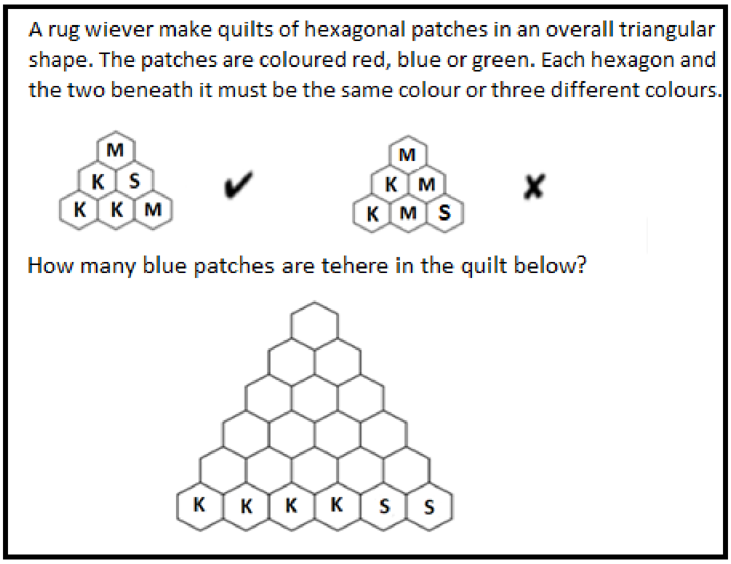
According to Table 2, it can be said that the students in the study group had 43% of the achievement averages for using algorithmic thinking skills. This value for each sub-dimensions of ATT were calculated as 0.53, 0.46, 0.32 and 0.34 for algorithmic, tracing, logic and analyses tasks respectively. According to these values, it is seen that the most successful dimension for the students is *algorithmic tasks* and the most unsuccessful is *logic tasks* of ATT. So, it can be said that the students are more successful in using given algorithms according to the rule of a problem or developing an algorithm to solve a given problem while they have difficulties for using reasoning skills effectively for determining and using the appropriate algorithms for the problem situations.

Findings Obtained from Sub-Dimensions of ATT

In this section, examples of the questions in the sub-factors of ATT and the achievement averages of the students in the relevant questions are given.

Algorithmic tasks

Figure 1: Sample question placed in *Algorithmic Tasks* of ATT.



It is necessary to use the rules (steps) of the given algorithm in this problem. For this reason, it placed in the dimension of *algorithmic tasks*. 53.62% of the students answered this question correctly. The right and wrong student solutions for this question are exemplified below.

Figure 2: The true answer of S_{28}.

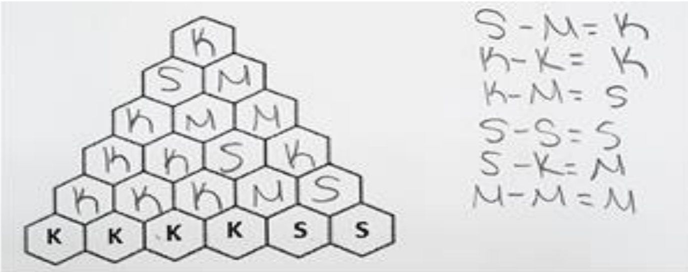
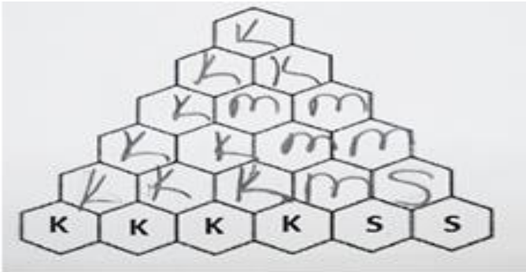


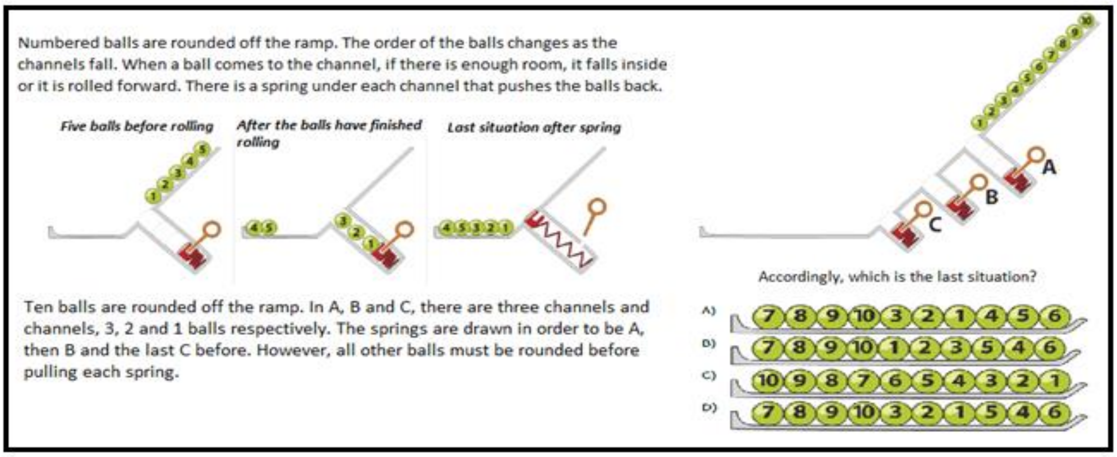
Figure 3: The wrong answer of S_{42}.



In Figure 2, it is seen that the student can determine the steps according to the given rule of algorithm. In Figure 3, the student had difficulty to create the appropriate steps for the given algorithm.

Tracing tasks

Figure 4: Sample question placed in *Tracing Tasks* of ATT.



It is necessary to guess the result of the algorithm given in this question. For this reason, it placed in the dimension of tracing tasks. 32.60% of the students answered this question correctly. The right and wrong student solutions for this question are exemplified below.

Figure 5: The true answer of S_{37}.

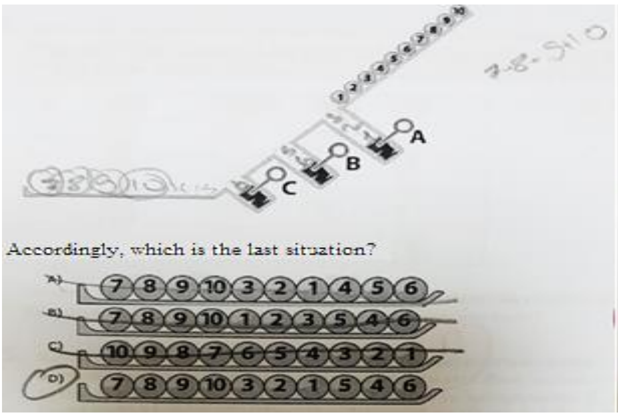
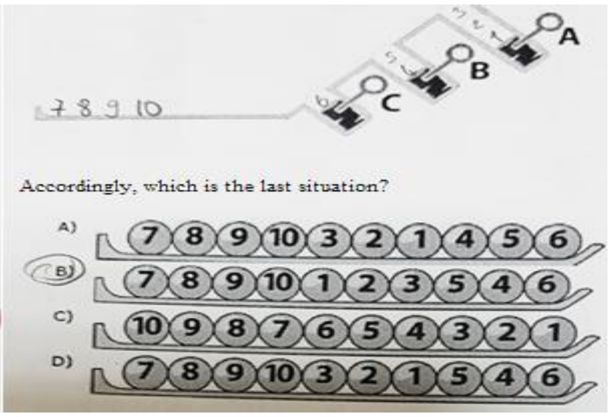


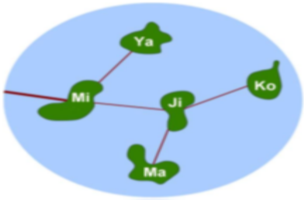
Figure 6. The wrong answer of S_{18}.



It can be seen that the student in Figure 5 gives correct answers about the order in which the balls are arranged. The student in Figure 6 has made incorrect determinations about the order in which the balls falling into the channels will be arranged after the springs are pulled.

Logic tasks

Figure 7: Sample question placed in *Logic Tasks* of ATT.



The Miyakojima archipelago includes 5 islands, Mi, Ya, Ko, Ji and Ma. Mi is the largest archipelago. It is connected to the Internet with a large cable. Also, Mi and Ya, Mi and Ji, Ji and Ko, and Ji and Ma are connected by small cables. With these cables, all islands are connected to Mi' and therefore to the Internet.People living in Miyakojima want all the islands to remain connected to the Internet, even if there is a problem with any small cable. Therefore, the Internet needs to be flexible and durable.

If only two cables are to be connected to the Internet network to be flexible and durable, which of these two cables is correct?

A) It must be connected between the Min and Ma, Ya and Ko.
B) It must be connected between Ji and Ma, Ko and Ma.
C) It must be connected between Ji and Ya, Ya and Ko.
D) Two additional cables are not sufficient to make the Internet network flexible and durable.

It is necessary to use the given algorithm for the desired solution of the problem with the effective use of reasoning skill. 44.92% of the students answered this question correctly. Besides 26.81% of the students marked D option and 14.49% of the students marked B option of this question. 13.76 of the students did not answer this question. When these answers are examined, it can be said that the students think that there should be a cable between the islands in order to share the internet mostly, and they ignore the algorithmic logic given in the question.

Analysis tasks

Figure 8: Sample question placed in *Analysis Tasks* of ATT.

A school of espionage training teach students the way to hide messages (encryption). Accordingly, the original message must replace each letter according to one of the following rules.

- XY instead of V
- Z instead of W
- WV instead of X
- V instead of Y
- VW instead of Z

Spies are not used in messages except W, V, X, Y, Z. The trainer gives a message to Ali. Ali encrypts the message according to the above rules and sends it to Ahmet. Ahmet re-encrypts the message and sends it to Ayşe. Ayse encrypts the message and sends it to the trainer. If the message received by the trainer is in VZZXYXY format, the first message the trainer sends is the following.

A) V B) W C) X D) Y E) Z

It is necessary to determine the sequence of steps that best suits the expected solution for this problem. 34.05% of the students answered this question correctly. The right and wrong student solutions for this question are exemplified below.

Figure 9: The true answer of S_{43}.

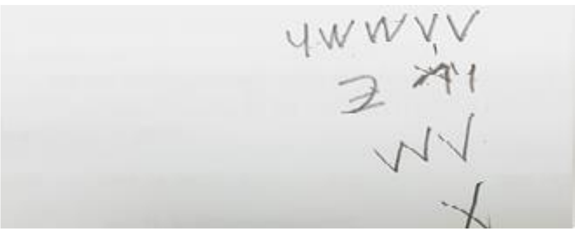
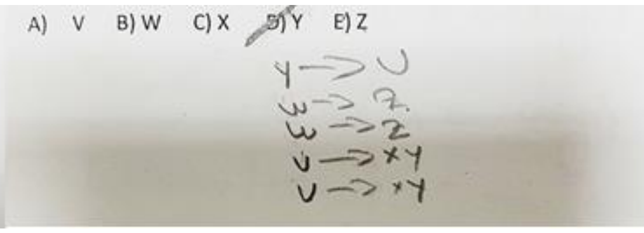


Figure 10: The wrong answer of S_{47}



In Figure 11, the student appears to solve the problem correctly by making reverse coding. Figure 12 shows that the student could not understand the logic of the algorithm given in the question and solved the question incorrectly.

DISCUSSION AND CONCLUSION

In this study, the algorithmic thinking skills of fifth and sixth grade students were examined and the results show that students cannot use these skills effectively. It has been observed that students are more successful in using a given algorithm and monitoring their progress than developing, using, or determining the effectiveness of an algorithm that is appropriate for the current situation. It is thought that there is a need for enriching the learning environments with the activities to ensure that students develop their algorithmic thinking skills. With the development of this skill, it is thought that students will develop computational thinking and programming skills in this context. Because algorithmic thinking is one of the sub-dimensions of computational thinking and programming (Gökoğlu, 2017; ISTE, 2015).

When the literature is examined; it is stated that the students who have programming education have different thinking, creativity, metacognition and orientation skills than the students who don't have (Clements and Gullo, 1984). Besides programming education has been found to be effective in teaching mathematical subjects, developing problem solving strategies, collaborative, systematic and creative thinking that many studies (Ananiadou and Claro, 2009; Department of Education Research and Development [EARGED], 2011, Pinto and Escudeiro, 2014; Trilling and Fadel, 2009) suggest for individuals to have in the 21st century. Research on programming education and algorithm concept examine the reasons for the failures of students in their programming lessons and the difficulties they experienced during the process (Özmen and Altun, 2014), and generally several approaches (Arabacıoğlu, Bülbül and Filiz, 2007; Durak, 2009; Ersoy, Madran and Gülbahar, 2011; Köse and Tüfekçi, 2015) have been developed to be used in teaching programming and algorithmic logic (cited from Gökoğlu, 2017). In the study of Özmen ve Altun (2014) examining the difficulties experienced during the programming process, the students emphasized that the biggest causes of their failure in programming are lack of information, inadequacy of implementation and lack of developing an algorithm. So, it can be said that these results are in line with the results obtained from the present study.

Besides, algorithms include not only the scheduling of the programming but also all the finite-processes that people are doing in their daily lives (Akçay and Çoklar, 2016). Therefore, this skill is also needed for people to use and find solutions for their problems in daily lives. So, there must be new and different scientific studies to improve the algorithmic thinking skill which is one of the most important skills required by the human profile of the future. In these studies, it is suggested to develop written materials based on problem solving and reasoning processes different from the existing studies. It is thought that mathematical reasoning and problem solving skills are also thought to be influential for the development of algorithmic thinking skills in addition to technological tools and software.

REFERENCES

Akçay, A., & Çoklar, A. N. (2016). *Bilişsel becerilerin gelişimine yönelik bir öneri: Programlama eğitimi.* A. İşman, H. F. Odabaşı and B. Akkoyunlu (Eds.), *EğitimTeknolojieri Okumaları 2016* (s. 121-139). Ankara: TOJET.

Ananiadou, K., & Claro, M. (2009). *21st Century Skills and Competences for New Millennium Learners in OECD Countries.* OECD Education Working Papers, No. 41, OECD Publishing.

Arabacıoğlu, T., Bülbül, H. İ., & Filiz, A. (2007, Şubat). *Bilgisayar programlama öğretiminde yeni bir yaklaşım.* IX. Akademik Bilişim Konferansı, Kütahya, Türkiye.

Brown, W. (2015). *Introduction to algorithmic thinking.* Retrieved from https://raptor.martincarlisle.com/Introduction%20to%20Algorithmic%20Thinking.doc

Burton, B. A. (2010). Encouraging algorithmic thinking without a computer. *Olympiads in Informatics, 4*, 3-14.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö.E., Karadeniz, Ş., & Demirel, F. (2018). *Bilimsel araştırma yöntemleri.* Ankara: PegemA Yayıncılık.

Clements, D. H., & Gullo, D. F. (1984). Effects of computer programming on young children's cognition. *Journal of Educational Psychology, 76*(6), 1051-1058.

Durak, G. (2009). *Algoritma konusunda geliştirilen "Programlama mantığı öğretici-P.M.Ö" yazılımının öğrenci başarısına etkisi* (Unpublished Master Thesis). Balıkesir Üniversitesi, Balıkesir.

EARGED (2011). MEB 21.yy Öğrenci Profili. http://www.meb.gov.tr/earged/earged/21.%20yy_og_pro.pdf

Ersoy, H., Madran, R. O., & Gülbahar, Y. (2011, Şubat). *Programlama dilleri öğretiminde bir model önerisi: Robot programlama.* XIII. Akademik Bilişim Konferansı, Malatya, Türkiye.

Futschek, G. (2006). Algorithmic Thinking: The Key for Understanding Computer Science. In R.T. Mittermeir (Ed.), ISSEP 2006, LNCS 4226, pp. 159 – 168, Berlin: Springer.

Gökoğlu, S. (2017). Programlama Eğitiminde Algoritma Algısı: Bir Metafor Analizi. *Cumhuriyet International Journal of Education, 6*(1), 1-14.

Grover, S., Cooper, S., & Pea, R. (2014, June). Assessing computational learning in K-12. In Proceedings of the 2014 conference on Innovation & technology in computer science education (pp. 57-62). ACM.

Hromkovič, J., Kohn, T., Komm, D., & Serafini, G. (2016). Examples of algorithmic thinking in programming education. *Olympiads in Informatics, 10*(1-2), 111-124.

International Society for Technology in Education (ISTE). (2015). *ISTE standards for students.* Retrieved from: https://www.iste.org/docs/pdfs/20-14_ISTE_Standards-S_PDF.pdf

Kalelioğlu, F. (2017). Uluslararası enformatik ve bilgi-işlemsel düşünme etkinliği, Retrieved from May 5 2017 http://www.bilgekunduz.org/wp-content/uploads/2017/12/2017-Bilge-Kunduz_5-6.pdf.

Korkmaz, Ö., Çakir, R., & Özden, M. Y. (2017). A validity and reliability study of the Computational Thinking Scales (CTS). *Computers in Human Behavior, 72*, 558-569.

Korkmaz, Ö., Çakır, R., Özden, M. Y., Oluk, A., & Sarıoğlu, S. (2015). Bireylerin bilgisayarca düşünme becerilerinin farklı değişkenler açısından incelenmesi. *On dokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi, 34*(2), 68-87.

Köse, U., & Tüfekçi, A. (2015). Algoritma ve akış şeması kavramlarının öğretiminde akıllı bir yazılım sistemi kullanımı. *Pegem Eğitim ve Öğretim Dergisi, 5*(5), 569-586.

L. Snyder, Interview by F. Olsen (2000). Computer scientist says all students should learn to think 'algorithmically', The Chronicle of Higher Education, May 5, 2000: http://chronicle.com/free/2000/03/2000032201t.htm/

Merriam, S. B. (1998). *Qualitative research and case study applications in education.* San Francisco, CA: Jossey-Bass Publishers.

Oluk, A., Korkmaz, Ö., & Oluk, H. A. Scratch'ın 5. sınıf öğrencilerinin algoritma geliştirme ve bilgisayarca düşünme becerilerine etkisi. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 9*(1), 54-71.

Özmen, B., & Altun, A. (2014). Undergraduate students' experiences in programming: difficulties and obstacles. *Turkish Online Journal of Qualitative Inquiry, 5*(3), 9-27.

Papert, S. (1980). *Mindstor ms: Children, computers and powerful ideas.* New York: BasicBooks.

Patton, M. Q. (2002). *Qualitative research & evaluation methods.* Thousand Oaks, CA: Sage Publications.

Pinto, A., & Escudeiro, P. (2014). *The use of Scratch for the development of 21st century learning skills in ICT,* 9th Iberian Conference on Information Systems and Technologies (CISTI), Barcelona.

Trilling, B., & Fadel, C. (2009). *21st century skills: learning for life in our times*. San Francisco: John Wiley & Sons.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3), 33-5.

Yıldırım, A., & Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* (9. baskı). Ankara: Seçkin Yayıncılık.

Yünkül, E., Durak, G., Çankaya, S., & Abidin, Z. (2017). The effects of scratch software on students' computational thinking skills. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED), 11* (2), 502-517.

Zsakó, L., & Szlávi, P. (2012). ICT Competences: Algorithmic Thinking. *Acta Didactica Napocensia, 5*(2), 49-58.