

## Determination the Effects of Vocational High School Students' Logical and Critical Thinking Skills on Mathematics Success

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### Abstract

*Problem Statement:* One of the main goals of education is to nurture individuals who know and improve themselves; who is well educated and have scientific perspective; who have developed communal coherency level; who are active, democratic and respectful to human rights. At the present time, according to an up to date mentality in mathematics education which is agreed on, the idea of learning mathematics by doing and experiencing rather than learning pure mathematical knowledge has come into prominence. In this process, there are many significant skills such as how to generate mathematical formulas, how to reach generalizations, how to reason will be developed

*Purpose of the Study:* In this study the direct and indirect relationships between Mathematics success of vocational high school students and their attitudes towards the course, critical thinking tendencies and logical thinking skills were analyzed.

*Method:* The research was conducted with 479 first grade students who study at various departments of Aydın Vocational High School at Adnan Menderes University. SPSS 19.0 and AMOS 16.0 packaged softwares were used for the analysis of the gathered data in the study.

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*Findings:* According to the test which analyses the direct relations among the variables, it was concluded that there was a positive and significant relation between students' critical thinking tendencies and Mathematics course success grades; positive, medium level significant relation between their attitudes towards Mathematics course and Mathematics course success; positive, medium level significant relation between students' critical thinking tendencies and their attitudes towards Mathematics course; positive, low level significant relation between their critical thinking tendencies and logical thinking skills. The results also showed that according to the test which analyses indirect effects among the variables, it was found that although the direct effect (.014) of critical thinking on success was not statistically significant, the indirect effect (.305) formed from the attitudes toward the course was significant. This result indicates that attitudes towards the course had an exact mediation role between critical thinking and Mathematics success. Moreover, the direct effect (.793) of logical thinking upon success was statistically significant. Besides, indirect effect(.031) formed from attitudes was also statistically significant. However, the intensity of this indirect effect decreased according to the first situation. This indicated that attitudes had a partial mediation role between logical thinking and success.

*Conclusion and Recommendations:* The results showed that the students' attitudes towards to the course have to be positive in order to be successful in Mathematics course. Success grades in Mathematics can be increased by using methods which direct students to think critical and develop these thinking strategies. Improvement in Critical thinking tendencies and logical thinking skills which will enable the students to look at everything from different aspects and will give them opportunity to discover where the formulas and rules came from and how they emerged, can improve the academic success rates of Mathematics which is regarded as a difficult and scary course.

*Keywords:* Mathematics success, attitude, critical thinking, logical thinking

## Introduction

One of the main goals of education is to nurture individuals to improve themselves. Through education, students should become well educated and gain a scientific perspective. They should be part of communal coherency, and be active, democratic and respectful of human rights. According to Pykett (2004), raising more democratic and better citizens in society is a result of providing critical thinking skills in schools. In an educational environment, teachers should ask the students to generate solutions for problems they have encountered, instead of discussing pre-planned topics in textbooks; students should discuss their own ideas and opinions about the content that was covered, continually forming their own categorizations

about the related content (Paul, 1990, p. 56-97). Critical thinking is a form of reasoning in which an individual improves his/her thinking potential through analyses of the problems, issues, content; evaluation and reconstructing processes (Paul & Elder, 2006). Stenberg (1999) defines critical thinking as cognitive processes, strategies and presentations, all of which are used in problem solving. On the other hand, Paul (1993, p. 54) describes critical thinking as a process of requiring cognitive standards such as definitions, classifications, analysis, practice and evaluation. According to yet another definition, critical thinking pertains to cognitive activities related to utilizing the intelligence (Cottrell, 2005, p. 1-10). In consideration of these definitions, critical thinking includes cognitive processes such as examining, analyzing the reasons why problems emerge, and interpretation. People sometimes perceive the concept of "criticism" as negative opinions, so while they analyze, they consider only the negative aspects of an issue (Cottrell, 2005, p. 1-10). Although critical thinking is mainly recognized as "negative thinking and error detection", it is actually a concept that includes cognitive and intellectual skills that are needed to define, analyze, evaluate and decide actions (Bassham, Irwin, Nardone & Wallace, 2002). The theory of critical thinking is grounded in asking connective and dioristic questions. In critical thinking, the first three levels include identification of connective questions and core knowledge and understanding. The remaining levels include dioristic questioning, which requires the process of creative knowledge (Martin, 2002).

The most revealing definitions for mathematics, which is regarded as the basis of all sciences, but especially of the physical sciences, is, according to Umay (2002), "an ology which investigates the structures, characteristics and the relations of shapes, numbers and multitudes via logic and branches such as arithmetic (science of numbers), algebra, and space science (TDK, 1983). According to Baykul (1993), mathematics is a logical system that improves individual's rational thinking. If discernment by students cannot be developed, then mathematics simply means following a sequence of operations and modeling the examples without giving thought to what they mean (Ross, 1998). Discernment is regarded not only as a mathematical skill, but also as a core competence (Altıparmak & Öziş, 2005). Logical thinking is a skill which is seen during both the preoperational and concrete operational periods of Piaget's cognitive development (Senemoğlu, 2004, p.46-56). This skill is explained as an individual's problem solving by means of different cognitive operations or reaching principles and codes by abstraction (Korkmaz, 2002). Logical thinking requires thinking constantly to reach a conclusion. The process of sequential thinking lies at the heart of logical thinking. This process requires acquiring all of the ideas, facts and results and putting them in order in a chain (Logical Thinking, 2010). It is one of the sub-stages of problem solving (Howe & Jones, 1993). Logical thinking is "a skill of showing behaviors like using numbers effectively, generating scientific solutions to problems, identifying relations among

concepts, classifying, generalizing, expressing in a mathematical formula, calculation, hypothesis, testing and drawing an analogy" (Bümen, 2010, p.7). Moreover, scientists, mathematicians, accountants, engineers, computer programmers, statisticians, and others are examples of individuals with strong logical intelligence (Demirel, 2009). Research indicates a positive correlation between logical thinking skills and academic success (Johnson & Lawson, 1998). Logical thinking skills are one of the highest predictors of success, as stated by Tobin and Capie (1981). Moreover, it has a significant effect upon self-efficacy and academic success (Lawson, Banks & Logvin, 2006).

Mathematical thinking is not a thinking manner pertaining only to mathematicians. On the contrary, it is a way of reasoning, which must be used by every careerist. Mathematical thinking is a process which enables us to better understand knowledge of the world in which we live and to enhance our options (Taşdemir, 2008). Mathematics not only teaches number operations, but also assists mankind in the struggle for life. It includes important skills, such as thinking, correlating among incidents, reasoning, predicting, and problem solving (Umay, 2003). An individual attempts to find solutions for problems encountered both in school and in one's professional life (Alkan & Bukova Güzel, 2005). Although mathematics is involved in every aspect of life, very few people are aware of this. Mathematics has an extraordinary functionality that enables us to put all of the pieces of our life in order and achieve a greater understanding of life (Henn, 2007). According to an up-to-date mentality in mathematics education, which has been agreed upon, the idea of learning mathematics by doing and experiencing rather than learning pure mathematical knowledge has come into prominence. In this process, many significant skills are developed, such as how to generate mathematical formulas, how to reach generalizations, and how to reason (Olkun & Toluk, 2007). One of the most important goals of mathematics education is to provide a development and improvement in acquiring reasonable answers for the questions "Why?" and "How?"

Mathematics has been an ongoing problem for students. However, contrary to what is believed, any person of average intelligence has the potential for achieving mathematical skills (Kahramaner, 2002). Individuals have a negative attitude relating to the subject, because they do not understand the mathematical content for various reasons (Yıldızlar, 2001). Attitudes can be both approaching (in the positive sense) to ideas and objects of abstaining from them (in the negative sense) (Trawers, 1982). Anderson (1988) defines "attitude" as a medium-level density excitement that ensures a person to have a tendency to or to get ready for the appropriate or inappropriate reaction when he/she meets a special object (Anderson, 1988). When attitudes form a basis for ideas and behaviors, and moreover their guidance for ideas and behaviors are taken into consideration, the need to generate a positive attitude for success is in

evident (Bandura, 1997). Attitude toward mathematics is a current topic which has been studied by many students at different levels from various angles (Pehlivan, 2010; Gürsul, 2008; Başer & Yavuz, 2003). Research has also indicated that students' attitudes toward mathematics have an effect upon their success in the area (Minato & Yanese, 1984; Ethington & Wolfle, 1986; Cheung, 1988; Erkin, 1993). For this reason, generating a positive attitude toward mathematics becomes important in the educational process; in fact, it is one of the most important aims of mathematics education (Reyes, 1984). This issue has also been clearly addressed during in-service training courses of mathematics teachers (MEB, 2008). Additionally, it has been observed that mathematics anxiety of those students who have a positive attitude toward mathematics is low (Baloglu, 2001). The existing literature shows a significant correlation between attitude toward the course and success (Reyes, 1984; Peker & Mirasyedioğlu, 2003) between success and critical thinking tendencies (Akbiyik, 2002; Kökdemir, 2003) and between logical thinking skills and academic success (Güler, 2010). Moreover, empirical research that analyzed the direct correlation between logical thinking skills and critical thinking tendencies could not be found. When the domestic and overseas studies were analyzed, it was concluded that the indirect effects of one variable in logical thinking had not been examined. However, a comparison of direct and indirect effects of the observed independent variables had not been undertaken. Therefore, this research aims at determining the direct effects of critical thinking tendencies and logical thinking skills on mathematics success and the indirect effects formed on the intervening variable of attitude.

The research question is: "What are the direct and indirect relations among the observed variables of critical thinking, logical thinking and attitudes toward the lesson and the dependent variable called mathematics academic success?"

## Method

This study uses descriptive research, and it was conducted by means of grounding on descriptive survey models. This study uses a relational survey model in which correlation between students' critical thinking tendencies, logical thinking skills, attitudes toward mathematics and academic success were analyzed. Relational survey models are research models that aim to determine range existence between two or more variables and/or its level (Karasar, 2009).

### *Sample*

A total of 2418 students who studied at Aydın Vocational High School, Adnan Menderes University, during the 2011-2012 academic year constituted the target population of the study. Five hundred twenty five first grade students who were registered for Basic Mathematics at Adnan Menderes University, Aydın Vocational High School in the spring term of the 2011-2012 academic year formed the research sample.

### *Research Instruments*

In this research, in order to determine vocational high school students' critical thinking tendencies, logical thinking skills, attitudes toward mathematics, and academic success, surveying instruments were used for which validity and reliability had been proven and developed by several researchers. The California Critical Thinking Disposition Inventory (CCTDI), which was translated into Turkish and adapted by Kökdemir (2003), was used to test critical thinking tendencies. One hundred fifty students were included in the pilot scheme for the reliability study. To check internal consistency, statistics using the Cronbach alpha coefficient were. 86The logical thinking skills inventory (LTSI), which is composed of two phased questions and was translated into Turkish and adapted by Geban, Askar & Ozkan, (1992), was used to test logical thinking skills. In the study, the reliability coefficient was calculated as .81. The Attitude Scale relating to mathematics, which was formed by Duatepe and Çilesiz (1999), was used to identify students' attitudes toward mathematics. The reliability coefficient of the inventory composed of 38 articles was .96. Besides, within the scope of this study, the success grades of the students were obtained from the OBIS program in order to determine students' academic success levels of mathematics. The test consisted of 20 questions was broached to two mathematics teachers who specialize in their fields, and an academician who performed many outstanding studies in the field of mathematics. Necessary proofreading was done and at the end of the recommendations it was agreed on that the tests had content validity.

### *Data Analysis*

In this study, data analysis was carried out by means of SPSS 19.0 (Statistics for the Social Science) and AMOS (Analysis of Moment Structures) 16.0 package program. A correlation analysis method known as "Path Analysis" in AMOS was applied to determine existing direct and indirect relations within the scope of research among the observed variables, which were critical thinking tendencies, logical thinking skills, attitudes toward mathematics and academic success in mathematics. A correcting formula was not used for the answers the students gave; calculations were performed on the correct answers. All of the statistical procedures were carried out from the calculated total scores. Multiple linear regression analysis was performed in order to determine to what extent the independent variables of the research explained the variations observed in the dependent variables. In the interpretation of the results, levels of significance for all surveys were evaluated as .05, which is well accepted among educational research.

## **Results**

Significant judgments were reached by determining required data in order to answer research questions or to test hypothesis and the suitability of the type of analysis (Büyüköztürk, 2010, p. 7). The first criteria in determining the suitable analysis type was the type of data (Eymen, 2007, p .87). According to test results,

which were used to determine whether or not the range of observed variables in the study provided normality and homogeneity assumptions, Kolmogorov-Smirnov one sample test was used to test the pertinence of collected data to normal distribution. The Levene test was applied to analyze homogeneity of variables. When normality test results of the mathematics success grades of vocational high school students were examined, it was identified that students' success grades did not range normally, because the relevance for z value ( $z=1.545$ ) was lower than  $p<.05$ . It was identified that the scores did show normal range when the normality value for z value ( $z=.569$ ) of total scores of critical thinking tendencies (CTT) were determined to be higher than  $p>.05$ . According to the Levene test result done to analyze the homogeneity of CTT total scores, the statistical difference among the variance distributions was not significant because the set F value ( $F=2.027$ ) was higher than  $p>.05$ . For this reason, it was identified that CTT total scores acquired normality and homogeneity. It was further determined that according to the normality test of students' logical thinking skills (LTS) scores, total scores did not range normally, and the significance value for the set z value ( $z=3.508$ ) was lower than  $p<.05$ . Additionally, according to the results of the test, which were conducted to determine conformity of students' total attitude scores toward mathematics, it was identified that total attitude scores ranged normally, as the significance value for set z value ( $z=.800$ ) was higher than  $p>.05$ . According to the results of the Levene test, which was done to analyze the homogeneity of attitude scores toward the lesson, it was accepted that the attitude scores provided the homogeneity assumption for the reason that the significance value for set F value ( $F=.009$ ) was higher than  $p>.05$ . Normal usage of the AMOS package was found, which is one of the structural equation models that requires variables to be composed of continuous data with normal distribution (Tezcan, 2008). Therefore, the deemed appropriate transformation belonging to variables that did not show normal range, Q-Q and histogram before application and after transformation was given, and then transformations made for normalizing the distributions were explained respectively.

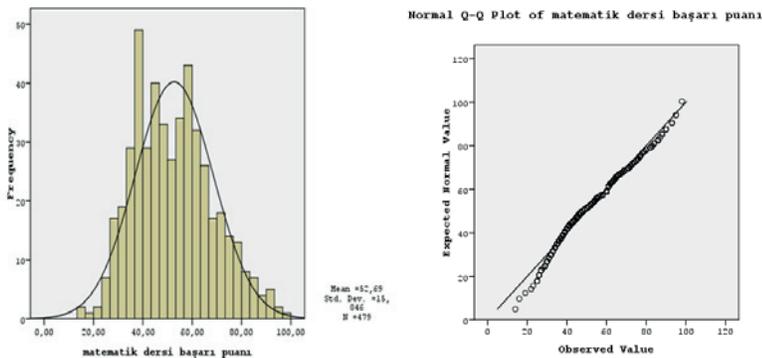


Figure 1. Histogram and Q-Q Graphic belonging to mathematic success grades

In Figure 1, it is seen that mathematics success grades are right-skewed moderately. The figure, according to the Q-Q test results, shows that values deviated from the expected values. This result supports the idea that mathematics success results determined by other methods did not show normal distribution. Deviations within the range of 20-40 scores validate that distribution was moderately right-skewed. Kalaycı (2008) points out that square root transformation application will be accurate for moderate positive skewed distributions. Histogram graphic and Q-Q graphics obtained after the implementation of square root transformation to mathematics results are stated below.

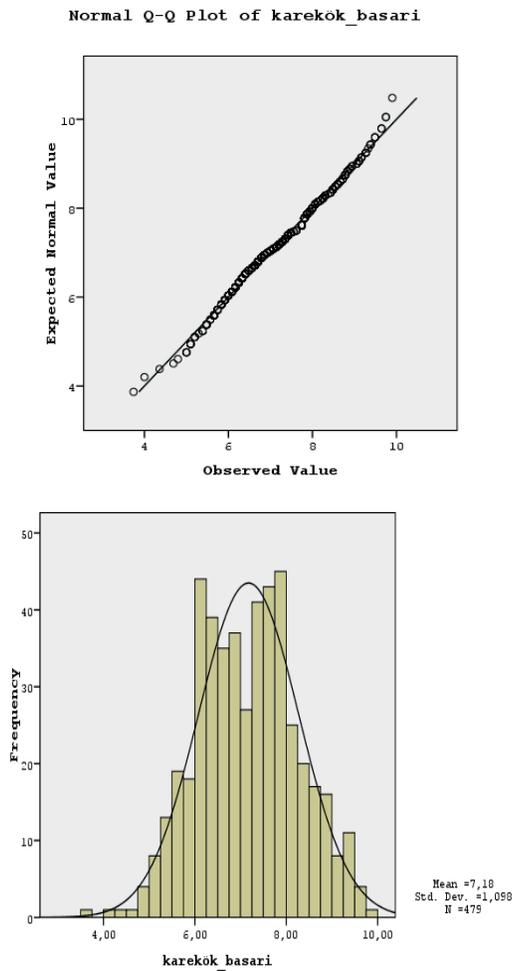
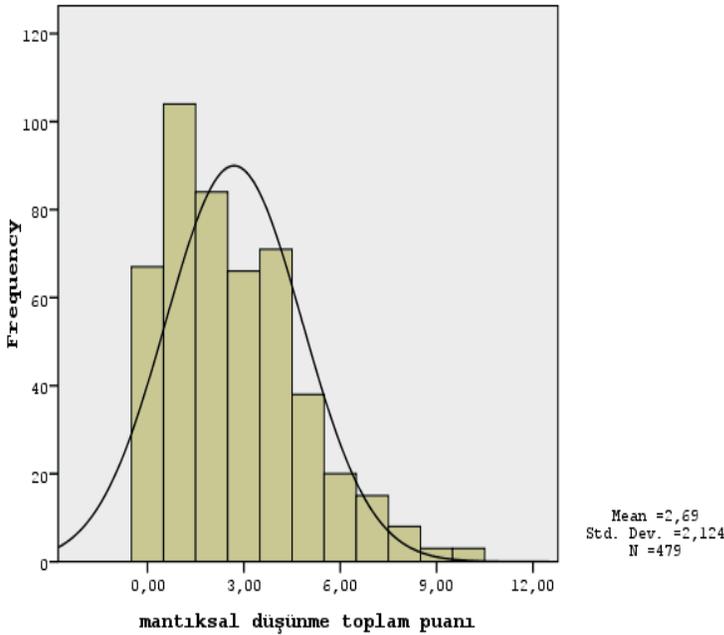


Figure 2. Histogram and Q-Q Graphic of mathematics success grades that were implemented after transformation

When Figure 2 is analyzed, it is apparent that after square root transformation of mathematics success grades was applied, according to the histogram graphic and normal distribution curve, the distribution of success grades did not deviate excessively from normal values. Additionally, it was seen that according to another normality test, the Q-Q plot method, to what extent observed values deviated from the predicted values with respect to Q-Q graphic results, which were obtained after the square root transformation's application to mathematics success grades. It is also shown that after the implementation of the square root transformation, mathematics success grades did not deviate excessively in reference to the normal distribution curve. It was identified that the total scores of logical thinking skills (LTS), one of the observed variables in the research, did not provide the normality and homogeneity assumptions in the population according to the Kolmogorov-Smirnov (K-S) test. The histogram graphic of LTS total scores should be analyzed first because transformation methods differ if the score on which normality is analyzed is moderately or excessively right-skewed. In Figure 3, the histogram graphic normal distribution curve of LTS total scores and distribution graphic of LTS total scores obtained with Q-Q plot method were given together.



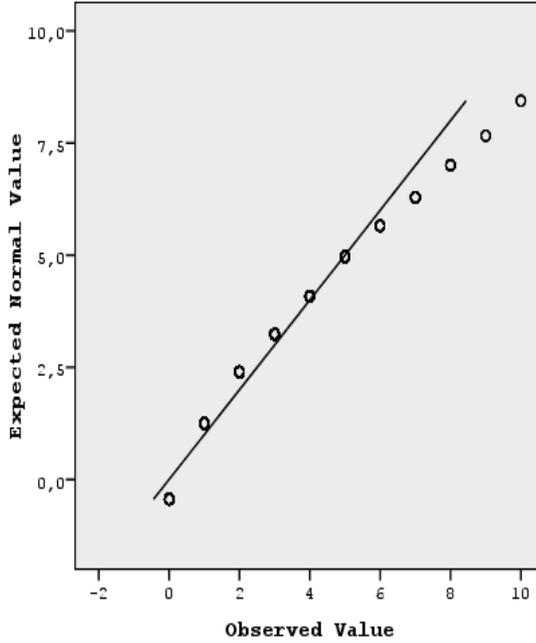
**Normal Q-Q Plot of mantıksal düşünme toplam puanı**

Figure 3. Histogram and Q-Q Graphic of Logical thinking Skills Scores

Figure 3 shows that total scores of logical thinking skills are excessively right-skewed. According to the results of the Q-Q test, it is also clear to what extent the observed variables deviated from the expected value. This result promotes the idea that LTS total scores determined by other methods did not show a normal distribution. Deviation was seen within the range of 6-10 points. Kalaycı (2008) points out that logarithmic transformation implementation will be true for excessively positive skewed distributions. The obtained data after implementing the logarithmic transformation LTS total scores is presented in Figure 4.

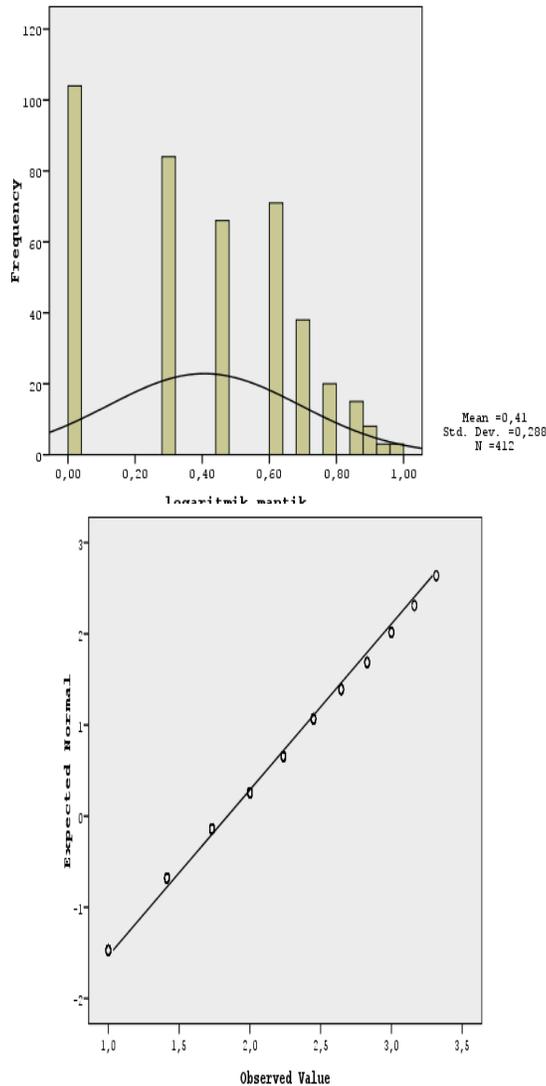


Figure 4. Histogram and Q-Q Graphic of LTS scores to which transformation has been implemented

When Figure 4 is analyzed, it can be clearly seen that distribution of the scores did not deviated excessively according to the histogram graphic and normal distribution curve after logarithmic transformation of LTS total scores was applied. Additionally, according to another normality test, the Q-Q plot method, after logarithmic transformation was applied, it was seen that LTS total scores did not deviate excessively from the normal distribution curve. This result supports the idea

that LTS total scores to which logarithmic transformation determined with other methods was applied showed normal distribution. Implementation of parametric analyses methods was thought to be true, because these methods provided appropriate transformations for mathematics success grades, logical thinking skills total scores, and normality assumptions. After this step of the research, transformed values of mathematic success grades and LTS total scores were analyzed.

#### *Findings about Direct Relations among Observed Variables*

According to the test implemented to determine the direction and the intensity level of correlation among the observed variables (critical thinking tendencies, logical thinking skills, attitude toward mathematics and mathematics course success), the values belonging to correlation coefficient, significance level, and sample population have been presented in Table 1.

**Table 1.**

*Correlation Analysis among the Observed Variables in the Research.*

		Mathematics Success	Critical Thinking	Attitude toward Mathematics	Logical Thinking
Mathematics Success	Correlation Coefficient	1			
	Sig. (2-tailed)				
	N	479			
Critical Thinking	Correlation Coefficient	.177**	1		
	Sig. (2-tailed)	.000			
	N	445	445		
Attitude toward Mathematics	Correlation Coefficient	.360**	.345**	1	
	Sig. (2-tailed)	.000	.000		
	N	460	432	460	
Logical Thinking	Correlation Coefficient	.813**	.163**	.302**	1
	Sig. (2-tailed)	.000	.001	.000	
	N	479	445	469	479

\*\* Shows significance at the level of .01

In Table 1, Spearman's rank correlation coefficient was calculated in order to explain the correlation between the observed continuous variables within the context of this research. According to this calculation, there was a positive and significant correlation between the students' critical thinking tendencies and the mathematics success grades ( $r=.177$ ,  $p=.000$ ). According to this result, as long as students' critical thinking tendencies increased, their mathematics success improved. There was a positive, medium level, significant correlation between students' attitudes toward

mathematics and their mathematics success ( $r=.360$ ,  $p=.000$ ). It was also seen that there was also a positive, medium level significant correlation between students' critical thinking skills and their attitudes toward mathematics ( $r=.345$ ,  $p=.000$ ). According to this result, as long as students' critical thinking skills improved, their attitudes toward mathematics developed as well. It was found that there was a positive, high level significant correlation between students' critical thinking skills and their mathematics success ( $r=.813$ ,  $p=.000$ ). According to this result, as long as their logical thinking skills improved, their mathematics results also improved. It is obvious that there was a positive, medium level significant correlation between students' critical thinking tendencies and their attitudes toward mathematics ( $r=.302$ ,  $p=.000$ ). Accordingly, in the event that students' critical thinking tendencies increase, there will also be an increase in their attitudes toward mathematics. At the end of the study, it was determined that a positive, low level significant correlation between critical thinking tendencies and logical thinking skills ( $r=.163$ ,  $p=.000$ ) exists. Accordingly, it may be said that when critical thinking tendencies increase, logical thinking skills tend to increase as well.

*Findings Belonging to Direct and Indirect Correlations among Observable Variables*

According to the model analyzing the direction, intensity and level of direct and indirect correlations among observable variables in this research (critical thinking tendencies, logical thinking skills, attitude toward mathematics, and mathematics success), direct and indirect effects of critical thinking tendencies and logical thinking skills upon mathematics academic success were investigated. Analyses on direct and indirect correlations among the variables are given in Table 2.

**Table 2**

*Analysis of direct and indirect correlations among the variables: critical thinking, logical thinking, attitude toward mathematics and mathematics success with Path Analysis.*

Full Model	Direct Effect	Indirect Effect
Critical thinking → Attitude toward Mathematics	.303***	
Critical thinking → Academic Success	.014	.305
Logical thinking → Attitude toward Mathematics	.267***	
Logical thinking → Academic Success	.793***	.031
Attitude toward Mathematics → Academic Success	.117***	
R2		
Attitude	.19	
Academic Success	.71	

\* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

In Table 2, Path Analysis was implemented in the AMOS program to determine the direct and indirect correlations among the observable variables: critical thinking

tendencies, logical thinking skills, attitudes toward mathematics, and mathematics academic success. In Table 2 presents direct and indirect effects of critical thinking tendencies and logical thinking skills standardized to mathematics success in terms of attitudes toward the lessons. When the gathered data was analyzed, it was clearly seen that although critical thinking tendencies did not have a statistically significant direct effect on success, they had a statistically significant direct effect on success via attitudes toward lessons. On the other hand, it was also observed that although logical thinking's direct effect upon success was statistically significant, the direct effect decreased via attitudes. When direct effects via attitudes were examined, it was observed that critical thinking tendencies (.303) had a stronger impact in accordance with logical thinking skills (.267). When indirect effects on success via attitude were examined, it was seen that critical thinking tendencies (.305) had a stronger impact in accordance with logical thinking skills (.031). Moreover, Table 2, presents to what extent attitude and success were explained by the model. Accordingly, critical thinking tendencies and logical thinking skills explained 19% of attitudes. Additionally, the totals of critical thinking tendencies, logical thinking skills, and attitude explained 71% of the total variance on success. Data about the obtained findings is shown in Figure 5.

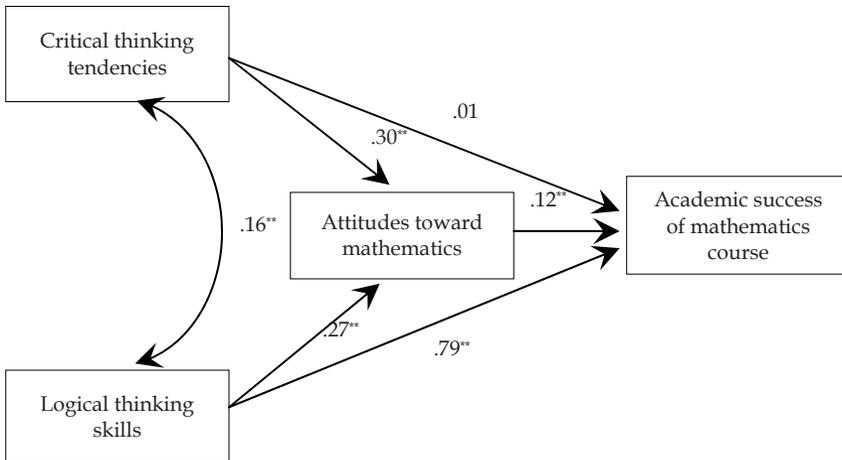


Figure 5. Analysis of Direct and Indirect Correlations among the Observed Variables

*Mediation Effect of Attitude, one of the Observed Variables on Success*

Analyses related to the level of the effect of critical thinking tendencies and logical thinking skills on mathematics success via attitude, and to what extent this effect predicted success directly and in terms of attitude indirectly are given in Table

**Table 3.**

*Determining the effects on critical thinking tendencies and logical thinking skills on success in terms of attitudes toward mathematics using the mediation test method.*

	Indirect effect of critical thinking and logical thinking on success in terms of attitude.			Corrected deviation ranges	
	Point estimate	Bias	SE	Lower	Upper
Critical Thinking →Success(attitude)	.088	.001	.017	.056	.122 <sup>a</sup>
Logical thinking →Success(attitude)	.286	.000	.073	.166	.461 <sup>a</sup>

<sup>a</sup> Identifier indicates that confidence interval does not include zero.

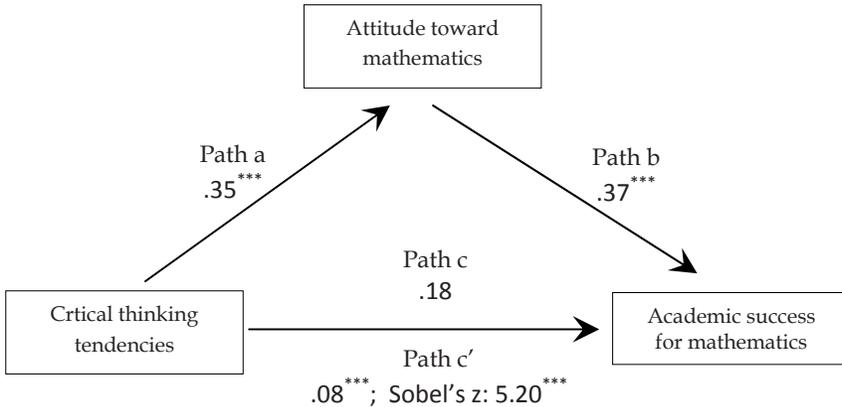
In the correlation of critical thinking tendencies and logical thinking skills respectively with mathematics academic success, the mediating variable analysis method suggested by Baron and Kenny (1986) was implemented in order to determine the role of attitude. According to this, the independent variable (critical thinking and logical thinking) and the mediator variable (attitude) each had a direct effect on the dependent variable (success). There must be a correlation between the independent variable and the mediator variable. According to Baron and Kenny (1986), the following conditions must be met to determine a variable's mediator role:

- Change in the independent variable must cause a change in the mediator variable.
- Change in the mediator variable must cause a change in the dependent variable.
- The effect of the independent variable on the dependent variable must decrease or disappear when the mediator and independent variables are both included in the analysis. The total disappearance of this effect indicates a strong and sole mediator variable; on the other hand, zero indicates the existence of other mediator variables.

In addition to Baron and Kenny's mediator variable analysis method (1986), it is accepted that independent variables have a significant effect on dependent variables via mediator variables when minimum and maximum values for the deviation gaps are corrected according to the mediation tests. This is a newer test developed by to determine the power of independent variables to predict dependent variables when mediator variables do not contain zero (Hayes, 2009; Preacher & Hayes, 2008).

There are three variables and three correlations connecting these variables to each other in Figures 6 and 7. In the figure, Paths a,b, and c show the direct correlation

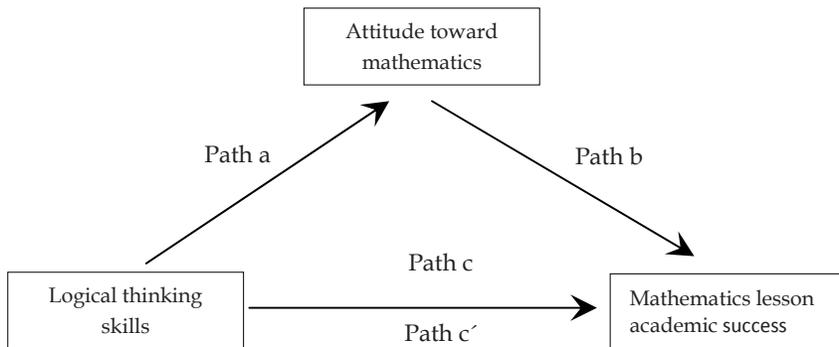
among these variables. For instance, in Figure 6, "a" shows whether there is a direct correlation between critical thinking tendencies and attitude scores toward mathematics. Additionally, in the model, indirect correlation among mediator variable and variables was also given (c).



Values give standardized regression coefficient . \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

Figure 6. Direct and indirect effects of critical thinking tendencies on success

When Figure 6 was analyzed, the direct effect ( $B = .18$ ) of critical thinking tendency on mathematics academic success was not statistically significant. There was a direct significant effect of critical thinking on attitude toward mathematics with .35 intensity. Similarly, there was a significant effect of attitude on success with .37 intensity. Sobel z value (5.20), which was determined for the significance of indirect effect of critical thinking on success via the mediator variable attitude, was found to be statistically significant at the level of  $p = .001$ . Therefore, it was observed that although critical thinking did not have a significant direct effect on success, it predicted success via attitude. According to this result, attitude had a mediator variable role between critical thinking and success. The direct effect of logical thinking skills on mathematics success and the indirect effect of logical thinking skills on attitude are shown in Figure 7.



Values give standardized regression coefficients. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

Figure 7. Direct and Indirect Effects of Logical Thinking Skills on Success

When Figure 7 was analyzed, the direct effect ( $B = .83$ ) of logical thinking skills on mathematics academic success was statistically significant. However, there was not a statistically significant direct effect of logical thinking on attitude toward mathematics, with .32 intensity. Similarly, it was observed that attitude had a significant effect on success with .37 intensity. Sobel  $z$  value (3.28), which was determined for the significance of indirect effect of logical thinking on success via the mediator variable attitude was found to be statistically significant at the level of  $p = .001$ . As a result of this, although logical thinking did not have a direct significant effect on success, it was observed that indirect effect was lower via attitude than the first situation. After the attitude mediator variable was included in the model, the direct effect between them was significant, but the fact that correlation was still significant indicates that attitude had a partial mediator effect. According to this result, attitude had a partial mediator variable role between logical thinking and success.

### Discussion, Conclusion and Recommendations

Direct and indirect correlations among the observed variables in the study were determined using the Path Analysis method. In the study, although critical thinking tendencies did not have a direct statistically significant effect on success, they had a statistically significant effect on success via attitudes toward lessons. This result is consistent with the studies of Kökdemir (2003), Akbıyık (2002) and Küçükgüçlü and Kanbay (2011). However, in a study carried out by Kanbay, Işık, Aslan and Özdemir (2012) on academic personnel, there was no significant difference between critical thinking tendencies of undergraduate, masters and PhD graduates. On the other hand, in a study carried out using physics lessons by Yüksel and Ertaş (2013), a significant relationship between attitude toward physics lessons and critical thinking tendencies was observed. Considering the related literature, the findings of our

study are consistent with the literature. Therefore, it can be stated that improving critical thinking tendencies will develop a positive attitude toward the lesson and thus will indirectly increase academic success of the related lesson. On the other hand, although the direct effect of logical thinking on success was statistically significant, it was observed that indirect effect formed via attitude decreased according to the first situation. This confirmed the hypothesis that critical thinking tendencies and logical thinking skills had a significant effect on mathematics success via attitude mediator variable. This result is consistent with the findings of Güler (2010). Kılıç (2009) reported that logical thinking is the best predictor of academic success for biology lessons, which is consistent with our results. Studies that show that logical thinking improves academic success directly and indirectly reveal the significance of this skill. For this reason, conducting activities to emphasize this skill both during the lessons and at the program development stage are considered to be of great importance for increasing success. Students must have positive attitudes toward the lessons in order to be successful in mathematics. A review of the literature revealed that there was a significant relationship between attitude and academic success even in different lessons. Kırkız (2010) reported statistically significant relationships between attitude and success for English lessons; Serin (2004) and Saracaloğlu, Serin and Bozkurt (2002) reported significant relationships in science; Kurbanoğlu and Takunyacı (2012) reported significant relationships in mathematics lesson; Emir (2003) reported significant relationships in health sciences lessons; and finally, Akkaya (2009) reported significant relationships in vocational lessons. Therefore, students need to develop a positive attitude toward the lesson in order to be successful. However, students often develop a negative attitude toward mathematics due to the formulas and rules that they think that they should memorize. Improvement in students' critical thinking tendencies, which will enable them to discover where and how these formula and rules they think that they have to memorize emerged from, will allow them to gain a different point of view and may increase their academic success in mathematics. Therefore, academic success for mathematics can be increased by using methods to encourage critical thinking and to improve these thinking strategies.

As a result of the analyses related to how critical thinking tendencies and logical thinking skills predicted mathematics success directly and indirectly via attitude, it was concluded that critical thinking, one of the independent variables, did not have a direct, significant effect upon success. As a result of analyses done to determine the mediator variable role of attitude toward the lesson, it was observed that critical thinking had a statistically significant effect on attitude. Moreover, attitude had a statistically significant effect on success, as well. According to this result, although critical thinking did not have a direct, significant effect on success, it was observed that this effect was significant via attitude mediator variable. A review of the literature in Council of Higher Education database, ULAKBIM and index found no

empirical research findings related to direct and indirect effects among these variables were encountered with in literature. At the end of the study, the reason for the significant effect of critical thinking on success via attitude can be about fact that mathematics's basis depends on questioning, researching and discovering. The researchers who point out that the operation steps of critical thinking process and problem solving process are similar have supported this idea (Marcut, 2005; Kazancı, 1989). Semerci (2000) emphasizes the importance of questioning continuously for the improvement of critical thinking. As a result of the studies and gathered experiences, it has been considered that students tended to accept all of the new concepts instead of questioning when they did not understand the subject. This situation indicated that students couldn't perform mathematics's essential skills such as questioning, discovering, understanding the correlations, and reasoning so they were unsuccessful. However, in some of the studies in literature, there were some examples in which although students had positive attitudes toward mathematics, they had low mathematics success grades (Peker & Mirasyedioğlu, 2003). The reason of this failure can be methods and strategies primary and middle school teachers used. As previously stated by Korkmaz (2009) implementation of skill and content based critical thinking education in mathematics caused a positive increase in attitudes toward lesson. This increase can cause a significant will increase mathematics achievement and this increase in attitude will have a significant impact on mathematics success. So, critical thinking can be considered one of the important concepts that teachers should touch.

The direct effect of logical thinking skills on mathematics success was statistically significant. Additionally, it was observed that the indirect effect of logical thinking skills on mathematics success grades via attitude toward the lesson was also significant. However, when attitude became a mediator variable, the indirect effect of logical thinking on success decreased. This result indicates that attitude has a partial mediator effect on success. Therefore, enhancing logical thinking skills of students is believed to significantly increase mathematics success. Gathered results showed that logical thinking skills and critical thinking tendencies intensely predicted mathematics success.

#### *Suggestions for Researchers*

At the completion of the study, it was seen that creating a positive attitude toward mathematics gained importance. Private teaching methods, class management, material usage and studies related to students' personal development can have a positive contribution on attitudes toward mathematics. Teachers should be enlightened as to how critical thinking and logical thinking skills can be implemented using various practices, such as seminars, conferences, in-service training, critical thinking skills, tendencies and logical thinking skills. These can be used as an effective way to increase achievement and make this situation permanent. Critical thinking and logical thinking are not characteristics that form during

university years and developed over this period. In order to enable students to acquire these characteristics at an early age, curriculum development specialists and teachers must acquire and gain these skills. Activities related to enabling students to acquire critical thinking skills in the curriculum started to be implemented in 2006 in our country. The effects of this curriculum on students' critical thinking tendencies and skills should be studied. After determining the teachers' awareness, success in students' attitudes and in their achievement may be indirectly obtained. Mathematics course books should be revised to consider critical thinking and logical thinking skills. It is only then that the desired skills can be acquired.

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## **Matematik Başarısı ile Tutum, Mantıksal Düşünme Yetenekleri ve Eleştirel Düşünme Eğilimleri Arasındaki Doğrudan ve Dolaylı İlişkiler**

### **Atıf:**

- Aksu, G. & Koruklu, N. (2015). Determination the effects of vocational high school students' logical and critical thinking skills on mathematic success. *Eurasian Journal of Educational Research*, 59, 181-206  
<http://dx.doi.org/10.14689/ejer.2015.59.11>

### **Özet**

*Problem Durumu:* Eğitimin temel amaçları arasında, kendini tanıyan ve geliştiren, iyi bilgilenmiş ve bilimsel bakış açısına sahip, toplumsal uyum düzeyi gelişmiş, aktif, demokratik, insan haklarına saygılı bireyler yetiştirmek yer alır. Toplumda daha demokratik daha iyi vatandaşlar yetiştirebilmenin yolu, okullarda öğrencilere eleştirel düşünebilme ve mantıksal düşünme becerilerini kazandırmaktan geçmektedir. 20. yüzyıl süresince yapılan araştırmalar, okullarda sunuş ve ezber

yöntemlerinin baskın olduğunu, öğrencilerin edilgen olarak bilgiyi alıp, sadece basit düzeyde hatırlama ve kavrama gerektiren öğretmen sorularını yanıtladıklarını ortaya koymuştur. Bunu anlayışın sonucu olarak da öğrenciler, üreten ve eğitim ortamında etkin bir unsur olarak değil, edilgen ve alıcı konumunda görülmüşlerdir. Günümüzde ise bilgi, “aranılan ve keşfedilen” bir şey olarak kabul edilmektedir. Bu durumda ise öğrenci etkin, bilgiyi arayan ve keşfeden bir özelliğe sahip olacaktır. Tüm bilimlerin, özellikle de fen bilimlerinin temelini oluşturduğu kabul edilen matematik dersinde başarılı olabilmek için öğrencilerin sürekli soru sorma ve öğrendikleri kavramları sorgulamaları büyük önem taşımaktadır. Matematik öğretiminin en önemli hedeflerinden birisi öğrencilerin devamlı üzerinde düşündükleri “neden?” ve “niçin?” sorularına karşılık mantıklı cevaplar elde etmenin diğer bir ifadeyle muhakeme yapabilmenin gelişimini sağlamaktır. Bu nedenle matematik dersinde başarılı olabilmek için eleştirel ve mantıksal düşünme ile derse ilişkin tutumlar önemli birer değişken olarak görülmektedir.

*Araştırmanın Amacı:* Bu çalışmada öğrencilerin iş ve meslek hayatında kendileri için gerekli olan matematik ile eleştirel düşünme eğilimleri ve mantıksal düşünme becerileri arasındaki doğrudan ilişkilere ek olarak derse ilişkin tutum üzerinden oluşan dolaylı ilişkilerin nasıl değiştiği; matematik başarısında eleştirel ve mantıksal düşünmenin nasıl bir etkisi olduğunu belirlemek amaçlanmıştır.

*Araştırmanın Yöntemi:* Bu araştırma, betimsel nitelikte bir araştırma olup, tarama modelleri esas alınarak gerçekleştirilmiştir. Bu çalışma, Meslek Yüksekokulu öğrencilerinin eleştirel düşünme eğilimleri, mantıksal düşünme becerileri, matematik dersine ilişkin tutumları ile akademik başarıları arasındaki ilişkinin araştırıldığı ilişkiyel tarama modelinde bir çalışmadır. Araştırmanın çalışma evrenini, Adnan Menderes Üniversitesi Aydın Meslek Yüksekokulu 2011-2012 Öğretim Yılı içerisinde öğrenim gören Temel Matematik dersine kayıtlı 479 (190 Kız-289 Erkek) öğrenci ile gerçekleştirilmiştir. Araştırmada öğrencilerin eleştirel düşünme eğilimlerini belirlemek için “California Eleştirel Düşünme Eğilimleri Ölçeği”, mantıksal düşünme yeteneklerini ölçmek amacıyla “Mantıksal Düşünme Yetenekleri Ölçeği”, matematiğe ilişkin tutumlarının düzeyini belirlemek amacıyla “Matematiğe İlişkin Tutum Ölçeği” ve matematik dersi başarı puanlarını belirlemek için vize ve final sınavları ağırlıklı ortalamaları kullanılmıştır. Araştırmada elde edilen verilerin çözümlenmesinde SPSS 19.0 ve AMOS 16.0 paket programları kullanılmıştır.

*Araştırmanın Bulguları:* Araştırma kapsamında gözlenen sürekli değişkenler arasındaki doğrudan ilişkiyi açıklamak amacıyla Spearman Brown Sıra Farkları korelasyon katsayısı hesaplanmıştır. Buna göre, öğrencilerin eleştirel düşünme eğilimleri ile matematik dersi başarı puanları arasında pozitif yönde ve anlamlı bir ilişki bulunmaktadır ( $r=.177, p=.000$ ). Bu sonuca göre öğrencilerin eleştirel düşünme eğilimleri arttıkça matematik dersi başarılarının da arttığı söylenebilir. Öğrencilerin matematik dersine ilişkin tutumları ile matematik başarıları arasında pozitif yönde, orta düzeyde anlamlı bir ilişki olduğu görülmektedir ( $r=.360, p=.000$ ). Yine öğrencilerin eleştirel düşünme eğilimleri ile matematik dersine ilişkin tutumları arasında pozitif yönde, orta düzeyde anlamlı bir ilişki olduğu görülmektedir ( $r=.345, p=.000$ ). Bu sonuca göre öğrencilerin eleştirel düşünme eğilimleri arttıkça matematik dersine ilişkin tutumlarında da bir artış olacaktır. Öğrencilerin mantıksal düşünme becerileri ile matematik başarıları arasında pozitif yönde, yüksek düzeyde anlamlı

bir ilişki olduğu görülmektedir ( $r=.813$ ,  $p=.000$ ). Buna göre, mantıksal düşünme becerileri arttıkça öğrencilerin matematik dersi başarıları da arttığı söylenebilir. Öğrencilerin eleştirel düşünme eğilimleri ile matematiğe ilişkin tutumları arasında pozitif yönde, orta düzeyde anlamlı bir ilişki olduğu görülmektedir ( $r=.302$ ,  $p=.000$ ). Buna göre, öğrencilerin eleştirel düşünme eğilimlerinde artış olması durumunda matematik dersine ilişkin tutumlarda da artış olacaktır. Araştırma sonucunda ayrıca eleştirel düşünme eğilimleri ile mantıksal düşünme becerileri arasında pozitif yönde, düşük düzeyde anlamlı bir ilişki olduğu görülmektedir ( $r=.163$ ,  $p=.000$ ). Buna göre, eleştirel düşünme eğilimlerinin artması durumunda mantıksal düşünme becerilerinde de artma eğiliminde olduğu söylenebilir. Araştırma sonucunda eleştirel düşünmenin başarı üzerinde doğrudan etkisi (.014) istatistiksel olarak anlamlı olmamasına karşın, derse ilişkin tutum üzerinden oluşan dolaylı etki (.305) istatistiksel olarak anlamlı bulunmuştur. Bu durum derse ilişkin tutumun eleştirel düşünme ile matematik başarıları arasında tam aracılık etkisine sahip olduğu göstermektedir. Araştırma sonucunda ayrıca mantıksal düşünmenin başarı üzerinde doğrudan etkisi (.793) istatistiksel olarak anlamlı olmasının yanında tutum üzerinden oluşan dolaylı etki (.031) de istatistiksel olarak anlamlıdır.

*Araştırmanın Sonuçları ve Önerileri:* Mantıksal düşünmenin başarı üzerinde doğrudan etkisi istatistiksel olarak anlamlı olmasına karşın, tutum üzerinden oluşan dolaylı etkinin ilk duruma göre azaldığı görülmektedir. Bunun yanında eleştirel düşünme eğilimlerinin başarı üzerinde istatistiksel olarak doğrudan anlamlı bir etkisi olmamasına karşın; derse ilişkin tutum üzerinden başarıya istatistiksel olarak anlamlı bir etkide bulunduğu belirlenmiştir. Bu durum eleştirel düşünme eğilimleri ile mantıksal düşünme becerilerinin tutum ara değişkeni üzerinden matematik başarılarında anlamlı bir etkiye sahip oldukları varsayımını doğrulamaktadır. Bu sonuca göre, öğrencilerin matematik dersinde başarılı olabilmeleri için derse ilişkin tutumların olumlu olması gerekir. Matematik dersinde eleştirel düşünmeye yöneltici ve bu düşünme stratejilerini geliştirici yöntemleri işe koşarak matematik dersinde başarı artırılabilir. Matematikte öğrencilerin ezberlemeleri gerektiğini düşündükleri formül ve kuralların nereden ve nasıl ortaya çıktığını keşfetmelerini sağlayacak ve onların her konuda farklı bakış açıları kazanabilmelerini sağlayacak olan eleştirel düşünme eğilimleri ve mantıksal düşünme becerilerinde oluşacak artış, zor ve korkulan bir ders olan matematik dersindeki akademik başarılarında da artış sağlayabilir.

*Anahtar Kelimeler:* Matematik Başarısı, Tutum, Eleştirel Düşünme, Mantıksal Düşünme.