JOURNAL OF EDUCATIONAL AND INSTRUCTIONAL STUDIES
IN THE WORLD
February, March, April 2013, Volume: 3 Issue: 1 Article: 10
ISSN: 2146-7463

AN ANALYSIS OF MATHEMATICS TEACHER CANDIDATES' LOGICAL THINKING LEVELS: CASE OF TURKEY

Assist. Prof. Dr. Abdulkadir Tuna
Kastamonu University, Educational Faculty
Kastamonu-TURKEY
atuna@kastamonu.edu.tr

Assist. Prof. Dr. Abdullah Çağrı Biber
Kastamonu University, Educational Faculty
Kastamonu- TURKEY
acbiber@kastamonu.edu.tr

Assist. Prof. Dr. Lütfi İncikapı
Kastamonu University, Educational Faculty
Kastamonu- TURKEY
lincikabi@kastamonu.edu.tr

Abstract
The aim of this study was to investigate whether the logical thinking level of mathematics teacher candidates were being affected by the variables of grade level, graduated high school type, and gender. The study was conducted as survey study and included 99 mathematics teacher candidates who were students in a state college placed in the northern part of Turkey. The data were collected through the group assessment of logical thinking (GALT) instrument developed for measuring logical thinking level. The GALT instrument included six sub-scales; conservational reasoning (4 items), proportional reasoning (6 items), controlling variables (4 items), combinational reasoning (3 items), probabilistic reasoning (2 items), and correlational reasoning (2 items). The instrument included 18 double multiple-choice items (items 1 through 18) and three constructed-response items (items 19-21). In responding the items 1 through 18, students were posed with a problem supported with pictorial presentation and asked to choose the best answer (from 2 to 5 possible answers available) for each stated problem. Then, students were required to choose the best justification for the chosen answer from a list of 2 to 5 possible justification. The results of the study indicated that the logical thinking level of mathematics teacher candidates was significantly affected by the variables of grade level and high school type, but not by the gender.

Key Words: Mathematics Education, Mathematics Teacher Candidates, Logical Thinking.

INTRODUCTION

Piaget (1969) defines logical thinking as mental operations used by individuals when they encounter specific problems. Researchers (e.g. Inhelder & Piaget, 1958; Lawson, 1982, 1985; Linn, 1982) have identified five different modes of formal logical thinking, namely proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning and combinatorial reasoning. According to Demirel (2003), logical thinking includes the abilities of using numbers effectively, providing scientific solutions to problems, detecting the separations between the concepts, classifying, generalizing, representing with a mathematical formula, computing, providing a hypothesis, testing and simulating.

The development of thinking abilities had considerate interest in the world of education. According to Cohen (1980), the ability of logical thinking is positively correlated with the ability of performing the roles in the society. Hence, being responsible for preparing individuals for their future positions in the social life, schools (or educational institutions) aim to improve the formal reasoning and thinking abilities of their clients. The

ability of logical thinking has a fundamental role in students' academic performance and their construction of the concepts (Atay, 2006; Lawson, Banks ,& Logvin, 2006; Tobin & Capie, 1982). Literature points out that among the priorities of the mathematics and science education was developing students' logical thinking abilities (Lawson, 1982). Logical thinking ability is a requirement for success not only in mathematics and science course (Valanides, 1996) but also in others too (Lawson, 1992). Previous researchers (DeLuca, 1981; Hernandez, Marek, & Renner, 1984; Howe & Shayer, 1981; Meehan, 1984; Shemesh, 1990) have found a significant difference in logical thinking abilities of male and female students (in favor of males) while some studies (Fah, 2009; Kıncal & Deniz Yazgan, 2010) indicated that having a different gender did not cause meaningful difference in the logical thinking abilities (except for conservational reasoning). Moreover, Kıncal and Deniz Yazgan (2010) pointed significant differences in the students' formal operational thinking abilities based on the variables of type of the school, academic success, socio-economic and socio-cultural background. Improving the ability of logical thinking is a key factor for conceptual learning since constructivist process that forms the conceptual knowledge requires logical thinking operations (Lawson, 1992). Moreover, the ability of logical thinking can be improved by means of education. Individuals with high logical thinking ability are more successful in attaining their goals, appraising the chances of the complex world and competing with challenges (Savant, 1997).

It is assumed that students improve their logical thinking when they can judge through hypothesis. For example, a student who can prove a hypothesis in the form of "If …., then …." can be categorized in the period of abstract operations (Kaya, 2012). This is a proof for student's improvement in his/her logical thinking. Tobin and Garnet (1984) state that detecting students' level of logical thinking precedes designing teaching programs to improve logical thinking skills. Besides its contribution on development of problem solving skills and academic achievement, logical thinking is also beneficial for improving social life (Linn, Pulos, & Gans, 1981). Linn et al., 1981stress out the necessity of using logical thinking strategies for solving problems encountered in daily life.

The above literature shows the fundamental role of logical thinking in education' especially students' academic performance, and attaches an importance to the determination of the potential variables affecting students' ability of logical thinking and to the development of logical thinking skills, which is among the principals stated in the middle school (grades 6 through 8) mathematics teaching program in Turkey (MONE, 2009). Hence, the aim of this study was to determine teacher candidates' level of logical thinking and to investigate whether mathematics teacher candidates' logical thinking ability was affected by the variables of grade level, high school type that they were graduated, and gender. Towards this aim, the research questions were

1. Is there any difference in logical thinking ability scores of mathematics teachers candidates based on their grade level?
2. Is there any difference in logical thinking ability scores of mathematics teachers candidates based on their high school type that was graduated?
3. Is there any difference in logical thinking ability scores of mathematics teachers candidates based on their gender?

METHODOLOGY

This study was a case study, in which a researcher can examine a situation within its *context*, limited by *time and activity*, and collects *detailed information* (Yin, 2003). The case that was investigated in this research involves the determination of the effect of the mentioned variables to the logical thinking ability of the mathematics teacher candidates.

Sampling Procedures

The participants of the study were a total of 99 mathematics teacher candidates who were students in the department of elementary mathematics education at a university in Turkey. The demographics of the teacher candidates were provided in Table 1. The percentage of the female participants was more than double of the one of the males (70 percent versus 29 percent, respectively). Fifty one percent of the participants was graduated form Anatolian high schools where as 27 percent of them was graduated from regular high schools, and 21 percent from Anatolian Teacher high schools. The number of the teacher candidates who were their in

second year in college (n=65) was more than the total number candidates who were in their third and fourth year in college.

Table 1: Demographic Information Regarding Mathematics Teacher Candidates Participated to The Study

Demographic Categories		f	%
Gender	Female	70	70,7
	Male	29	29,3
Graduated high school type	Anatolian high school	51	51,5
	Anatolian teacher high school	21	21,2
	Regular high school	27	27,3
Grade in College	Second grade	65	65,7
	Third grade	22	22,2
	Fourth grade	12	12,1
Total		99	100

Data Collection Tool

The data were collected through Turkish version of the group assessment of logical thinking (GALT) instrument. The instrument was developed by Roadrangka, Yeany and Padilla (1982) for measuring logical thinking abilities and translated into Turkish by Aksu, Berberoğlu and Paykoç (1990). The GALT instrument was composed of 21 items that were selected from the items of other instruments (Lawson, 1978; Longeol 1968). The reliability coefficient of Turkish version of the GALT instrument was calculated as 0.88 (Aksu et al., 1990).

The GALT instrument included six sub-scales; conservational reasoning (4 items), proportional reasoning (6 items), controlling variables (4 items), combinational reasoning (3 items), probabilistic reasoning (2 items), and correlational reasoning (2 items). The instrument included 18 double multiple-choice items (items 1 through 18) and three constructed-response items (items 19-21). In responding the items 1 through 18, students were posed with a problem supported with pictorial presentation and asked to choose the best answer (from 2 to 5 possible answers available) for each stated problem. Then, students were required to choose the best justification for the chosen answer from a list of 2 to 5 possible justification. In scoring of the participants' scores on the GALT instrument, for the multiple-choice items, teacher candidates received 1 point for providing the correct answer with the correct reasoning behind it and 0 point when failed to detect any of them. For the constructed-response items, mathematics teacher candidates received 1 point for correct answers and 0 point for wrong answers.

Data Analysis

Data collected through the GALT instrument was analyzed by using SPSS 15.0. General characteristics of the research sample was determined by means of descriptive statistics and analyzed in order to answer the related research question. In order to test the meaningfulness of the score differences between independent samples, the researchers utilized a one-way analysis of variance (ANOVA) and independent-samples t-test. The effect size for each analysis was also reported. During all computations, p value was taken as 0,05.

FINDINGS

The results relating mathematics teacher candidates' logical thinking ability were provided according to the research questions.

Results relating to the first research question

Table 2 shows the mean scores for the mathematics teacher candidates' logical thinking ability based on their grade level. The highest mean score (M=12.7727) occurred at the third grade while the least (M=9.8923) was

JOURNAL OF EDUCATIONAL AND INSTRUCTIONAL STUDIES
IN THE WORLD
February, March, April 2013, Volume: 3 Issue: 1 Article: 10
ISSN: 2146-7463

calculated for the second grade level.

Table 2: Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates in Terms of Their Year in College

Grades	Mean	n	Std. Deviation
Second	9.8923	65	3.07268
Third	12.7727	22	3.25037
Fourth	12.2500	12	2.98861
Total	10.8182	99	3.33309

In order to determine whether these differences in the mean scores were statistically meaningful, a one-way analysis of variance (ANOVA) test was utilized, and Table 3 shows the results obtained. As seen from the table, there was a significant difference [$F(2;96)=8.535$; $p<0.05$] in mathematics teacher candidates' logical thinking ability scores in terms of grade level.

Tablo 3: ANOVA Test Results for The Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates Based on The Grade Variable

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	164.367	2	82.184	8.535	0.000
Within Groups	924.360	96	9.629		
Total	1088.727	98			

Scheffe analysis of Post Hoc tests was applied to detect between which grades the difference was meaningful. Table 4 demonstrates that the meaningful differences were evident between the second and the third grades by favoring the third graders while there was no significant difference between the grade pairs of second-fourth and third-fourth. Moreover, although the logical thinking ability mean scores of mathematics teacher candidates was at the peak at the third grade level, their mean scores decreased at the fourth grade level (see Figure 1), though the decrease was not statistically significant.

Table 4: Post Hoc Results of Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates Based on The Grade Variable

(I) Grade	(J) Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Second	Third	-2.88042*	0.76538	0.001	-4.7835	-0.9774
	Fourth	-2.35769	0.97495	0.059	-4.7819	0.0665
Third	Second	2.88042*	0.76538	0.001	0.9774	4.7835
	Fourth	0.52273	1.11358	0.896	-2.2461	3.2916
Fourth	Second	2.35769	0.97495	0.059	-0.0665	4.7819
	Third	-0.52273	1.11358	0.896	-3.2916	2.2461

* The mean difference is significant at the 0.05 level.

JOURNAL OF EDUCATIONAL AND INSTRUCTIONAL STUDIES
IN THE WORLD
February, March, April 2013, Volume: 3 Issue: 1 Article: 10
ISSN: 2146-7463

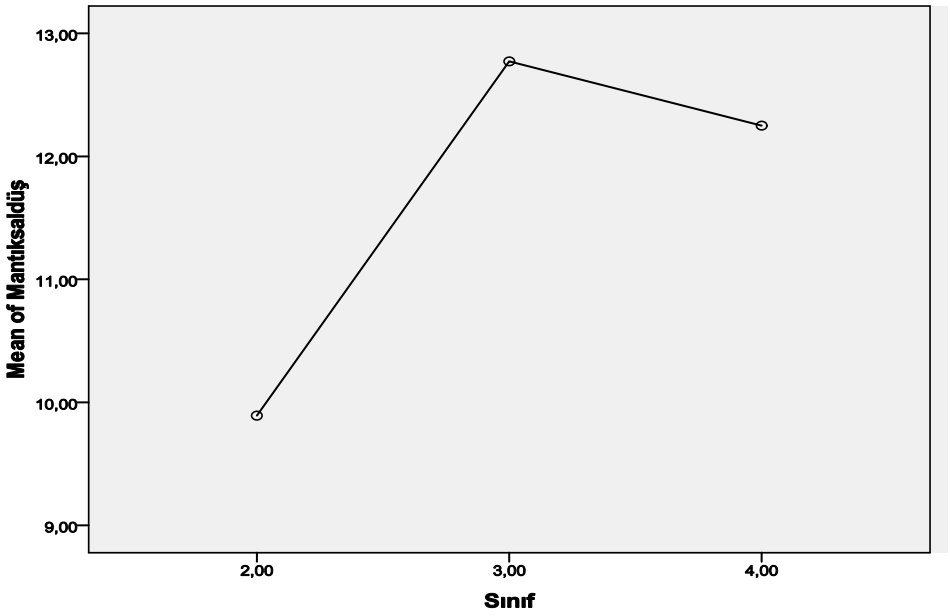

Figure 1. Distribution of Mean Scores for Logical Thinking Ability of Mathematics Teacher Candidates Among Grade Levels

Results relating to the second research question

Table 5 provides the descriptive statistics regarding the logical thinking ability mean scores of mathematics teacher candidates based on the high school type that they were graduated. The mathematics teacher candidates who came through Anatolian teacher high school possessed the highest mean score (M=11.9048) while regular high school graduates held the least logical thinking ability mean score (M=8.9259).

Table 5: Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates in Terms of The Variable of High School Type

School Type	Mean scores	N	Std. Deviation
Anatolian high school	11.3725	51	3.17465
Anatolian teacher high school	11.9048	21	3.37498
Regular high school	8.9259	27	2.90789
Total	10.8182	99	3.33309

In order to determine whether these differences in the mean scores were statistically significant, a one-way analysis of variance (ANOVA) test was applied. As seen from Table 6, mathematics teacher candidates' logical thinking ability scores differed significantly [$F(2;96)=6.918$; $p<0.05$] based on their high school type.

Table 6: ANOVA Test Results for The Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates Based on The High School Type Variable

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	137.144	2	68.572	6.918	0.002
Within Groups	951.583	96	9.912		
Total	1088.727	98			

JOURNAL OF EDUCATIONAL AND INSTRUCTIONAL STUDIES IN THE WORLD
February, March, April 2013, Volume: 3 Issue: 1 Article: 10
ISSN: 2146-7463

Scheffe analysis of Post Hoc tests proved that the meaningful differences were evident between the mathematics teacher candidates who were graduated from Anatolian high school and the teacher candidates from regular high schools, in favor of Anatolian high school graduates (Table 7). The scores of the mathematics teacher candidates who were graduated from Anatolian teacher high school also significantly differed from those of who were from regular high school by favoring the ones graduated from Anatolian teacher high school. Although the logical thinking ability mean scores of Anatolian teacher high school graduates were higher than those of the one who were graduated from Anatolian high school, the difference was not statistically meaningful. The achievement of Anatolian high schools and Anatolian teacher high schools over regular high schools might be caused the fact that these schools accepts students who receive high scores on the Level Determination Exam (SBS), a nation-wide exam to be used in transition to the high schools in Turkey.

Table 7: Post Hoc Results of Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates Based on The High School Type Variable

(I) High School Type	(J) High school type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Anatolian high school	Anatolian teacher high school	-0.53221	0.81632	0.809	-2.5619	1.4975
	Regular high school	2.44662*	0.74932	0.006	0.5835	4.3098
Anatolian teacher high school	Anatolian high school	0.53221	0.81632	0.809	-1.4975	2.5619
	Regular high school	2.97884*	0.91604	0.007	0.7011	5.2565
Regular high school	Anatolian high school	-2.44662*	0.74932	0.006	-4.3098	-0.5835
	Anatolian teacher high school	-2.97884*	0.91604	0.007	-5.2565	-0.7011

* The mean difference is significant at the 0.05 level.

Results relating to the third research question

Table 8 shows the descriptive statistics and independent-samples t-test results regarding the logical thinking ability mean scores of mathematics teacher candidates based on the gender variable. As seen from Table 8, although the logical thinking ability mean scores of female mathematics teacher candidates (M=11.1379) were higher than those of the male teacher candidates (M=10.6857), the difference was not statistically meaningful [F(97)=0.617; P>0.05].

Table 8: An Independent-Samples T-test Result for The Logical Thinking Ability Mean Scores of Mathematics Teacher Candidates Based on The Gender Variable

Gender	Mean	N	Std. Deviation	df	F	Mean Difference	p
Male	10.6857	70	3.40308	97	-0.617	0.452	0.542
Female	11.1379	29	3.19290				
Total	10.8182	99	3.33309				

CONCLUSIONS AND DISCUSSION

This study aimed to investigate whether the logical thinking level of mathematics teacher candidates were being affected by the variables of grade level, graduated high school type, and gender. The results obtained during this study were limited to the participants.

Among the results of the study was that mathematics teacher candidates' grade levels significantly affected their logical thinking ability. Teacher candidates who were in their second year in college possessed lower logical thinking ability than those who were in their third and last year in college. Kıncal and Deniz Yazgan (2010) also resulted that there were a significant difference between the students' formal operational thinking abilities in terms of the school type variables. This result might be caused the fact that mathematics teacher education programs in Turkey places an important part of the pedagogical content knowledge courses in the second and third years.

The current study also indicated that mathematics teacher candidates' logical thinking abilities were also affected by the high school that they were graduated. Teacher candidates who were graduated from Anatolian or Anatolian teacher high schools presented more ability regarding logical thinking than those who came through regular high schools. A cause for this result could be the fact that students who were placed in Anatolian and Anatolian teacher high schools usually hold higher scores in SBS examinations than those who placed in regular high schools. Similar results were also evident from the studies conducted with science and primary education teacher candidates (Aksu & Berberoğlu, 1991; Güler, 2010; Kılıç & Sağlam, 2009; Sert, 2006; Bozdoğan, 2007; Tekbıyık& İpek, 2007; Yaman& Karamustafaoğlu, 2006).

Another result of the study was that gender was not distinctive variable of logical thinking ability of mathematics teacher candidates. Although female mathematics teacher candidates scored higher in terms of logical thinking ability than male teacher candidates, the difference was not statistically meaningful. On the other hand, previous researchers (Gabel, 2002; Howe & Shayer, 1981; Meehan, 1984; Shemesh, 1990; Zarotiadou & Tsaparlis, 2000) indicated that males had significantly higher level of logical thinking ability than females. Moreover, some studies (Fah, 2009; Kıncal & Deniz Yazgan, 2010) indicated that there was no significant difference in the mean of logical thinking abilities based on the gender variable. Putting all together, one can result that gender variable provides a delicate and fickle base in judgment of the logical thinking.

Under the lights of the above results, some recommendations were as follows. Research indicates that teaching methodologies significantly contributes on one's ability of logical thinking (Gerber, Marek & Cavallo, 1997; Johnson & Lawson, 1998; Yenilmez, Sungur & Tekkaya, 2005). At that point, during the preparation of mathematics teaching candidates, uses of special teaching techniques and measurement and evaluation strategies would have an important role. Moreover, activities requiring such critical skills as problem solving, creative, critical and reflective thinking would also improve teacher candidates' logical thinking ability. Future studies investigating logical thinking abilities of students in different education level (elementary school, high school etc.) and teachers would be beneficiary in reinforcement of the results of the current study.

REFERENCES

Aksu, M., Berberoğlu, G. & Paykoç, F. (1991). "Mantıksal düşünmenin belli değişkenlere göre incelenmesi", Eğitimde Arayışlar I. Sempozyum bildiri metinleri (ss.291-294). İstanbul: Kültür Yayınları.

Atay, P. D. (2006). "Relative ınfluence of cognitive and motivational variables on genetic concepts in traditional and learning cycle classrooms", (Published Doctoral Dissertation). Middle East Technical University, Ankara.

Bozdoğan, A. (2007). "Fen bilgisi öğretiminde çalışma yaprakları ile öğretimin öğrencilerin fen bilgisi tutumuna ve mantıksal düşünme becerilerine etkisi" (Master' thesis). Çukurova University, Adana.

Cohen, H.G. (1980). "Dilemma of the objective paper-and-pencil assessment within the Piagetian framework" Science Education, 64(5), 741-745.

Demirel, Ö. (2003). "Planlamadan değerlendirmeye öğretme sanatı", Ankara: Pegem A Yayıncılık.

DeLuca, F.P. (1981). "Application of cluster analysis to the study of Piagetian stages of intellectual development", Journal of Research in Science Teaching, 18(1), 51-59.

Fah, L. Y. (2009). "Logical thinking abilities among form 4 students in the ınterior division of Sabah, Malaysia", Journal of Science and Mathematics Education in Southeast Asia, 32(2), 161-187.

Gerber, B. L., Marek, E. A., & Cavallo, A. M. L. (1997, March). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. Annual Meeting of the National Association for Research in Science Teaching, Oak Brook, IL.

Güler, Z. (2010). "Ilköğretim öğrencilerinin SBS puanları ile ders başarıları, bilimsel süreç becerileri ve mantıksal düşünme yetenekleri arasındaki ilişki", (Master' thesis). Abant İzzet Baysal University, Bolu.

Hernandez, L. De., Marek, E. A., & Renner, J. W. (1984). "Relationships among gender, age, and intellectual development", Journal of Research in Science Teaching, 1(4), 365-375.

Howe, A. C., & Shayer, M. (1981). "Sex related differences on a task of volume and density", Journal of Research in Science Teaching, 18(2), 169-175.

Inhelder, B., & Piaget, J. (1958). The growth of logical thinking: From childhood to adolescence. New York: Basic Books, Inc.

Johnson, M. A., & Lawson, A. E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and ınquiry classes? Journal of Research in Science Teaching, 35(1), 89-103.

Kaya, Z. (2012). Gelişim ve Oğrenme, "Oğrenme ve Oğretme Kuramlar yaklaşımlar modeller",(Ed;Zeki Kaya), Pegem Akademi, Ankara.

Kılıç, D., & Sağlam, N. (2009). "Öğrencilerin mantıksal düşünme yeteneklerinin bazı değişkenler açısından incelenmesi", Ege Eğitim Dergisi, 2(10), 23-38.

Kıncal, R. Y., & Deniz Yazgan, A. (2010). "Investigating the formal operational thinking skills of 7th and 8th grade primary school students according to some variables", Elementary Education Online, 9(2), 723-733.

Lawson, A.E. (1982). "Formal reasoning, achievement, and intelligence: An issue of importance", Science Education, 66(1), 77-83.

Lawson, A.E. (1985). "A review of research on formal reasoning and science teaching", Journal of Research in Science Teaching, 22(7), 569-617.

Lawson, A. E. (1992). "The development of reasoning among college biology students- a review of research", Journal of College Science Teaching, 21, 338-344.

Linn, M. C. (1982). Theoretical and practical significance of formal reasoning. Journal of Research in Science Teaching, 19(9), 727-742.

Linn, M. C., Pulos, S., & Gans, A. (1981). "Correlates of formal reasoning: Content and problem effects", Journal of Research in Science Teaching, 18(5), 435-447.

Piaget, J. (1969). The origins of intelligence in children, "New York, International University Press".

Roadrangka, V., Yeany, R.H., & Padilla, M.J. (1983). "The construction of a Group Assessment of Logical Thinking (GALT)", Paper presented at the 56th annual meeting of the National Association for Research in Science Teaching. Dallas, Texas, April, 5-8.

Savant, M. (1997). "The power of logical thinking". St. Martin's Press, New York.

Sert, A. (2006). "Proje tabanlı öğrenme yaklaşımının fen bilgisi dersinde öğrencilerin mantıksal düşünme becerilerine ve tutumlarına etkisi", (Master' thesis). Çukurova University, Adana.

Shemesh, M. (1990). "Gender-related differences in reasoning skills and learning interests of junior high school students", Journal of Research in Science Teaching, 27(1), 27-34.

Tobin, K. G., & Capie, W. (1982). " Relationships between formal reasoning ability, locus of control, academic engagement and integrated process skill achievement", Journal of Research in Science Teaching, 19(2), 113-121.

Valanides, N. C. (1996). "Formal reasoning and science teaching", School Science and Mathematics, 96(2), 99-111.

Yenilmez Türkoğlu, A. (2006). "Öğrencilerin Önbilgisi, Öğrenme Yaklaşımları, Mantıksal Düşünme Yetenekleri, Farklı Öğretim Yöntemleri ve Fen Başarıları Arasındaki İlişkilerin Araştırılması. http://www.fedu.metu.edu.tr, (Ziyaret Tarihi:18.05.2008).

Tekbıyık, A., & İpek, C. (2007). "Pre-service primary teachers' attitudes toward science and their logical thinking skills", Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, 4(1) 102-117.

Yaman, S., & Karamustafaoğlu, S. (2006). "Öğretmen adaylarının mantıksal düşünme becerileri ve kimya dersine yönelik tutumlarının incelenmesi", Erzincan Eğitim Fakültesi Dergisi, 8(1).

Yin, R. K. (2003). "Case Study Research - Design and Methods", Thousand Oaks, London, New Dehli: Sage Publications.

Zarotiadou, E., & Tsaparlis, G. (2000). "Teaching lower-secondary chemistry with a Piagetian constructivist and an Ausbelian meaningful-receptive method: A longitudinal comparison, Chemistry Education:" Research and Practice in Europe, 1(1), 37-50.