Logical Thinking and Cognitive Development Levels of Pre-service Science Teachers[1]

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ABSTRACT

The aim of this study is to determine logical thinking and cognitive development levels of pre-service science teachers. The sample of this survey study consists of 241 pre-service science teachers attending the 1st, 2nd, 3rd and 4th grade of the Science Teaching Program, at the Faculty of Education of Mehmet Akif Ersoy University, Turkey, selected through the proportional stratified sampling method. As for data collection, Group Assessment of Logical Thinking Test (GALT) was used, which includes 21 items and was developed by Roadrangka, Yeany and Padilla (1982 Cited in: Aksu, Berberoğlu, Martin & Paykoç, 1990) and adapted into Turkish by Aksu et al. (1990). Cronbach's Alpha reliability coefficient of the tool is calculated as .64 for this study. In analysis of the data, descriptive statistics, t-test and ANOVA test were used. According to the results of the study, it was determined that 38.17% of pre-service science teachers are in concrete operations stage, 61.41% of them are in transitional stage and 0.42% of them are in formal operations stage; and that in general, they are in transitional stage with an average of 9.25 points. Besides, it was determined that logical thinking levels of pre-service science teachers do not vary by gender; in contrast, they statistically differ according to grade level and type of graduated high school.

Key Words: Cognitive development, GALT, Logical thinking, Piaget, Pre-service science teachers

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INTRODUCTION

Learning is defined as "change of thought, emotion and behavior emerging as a result of an individual's interaction with his/her surroundings" (Özden, 2003). In the behavioral theory, as one of the basic theories describing learning, learning is considered as a response to stimulus (Özden, 2003; Çepni & Çil, 2010), and the knowledge is considered as external realities discovered regardless of the learner (Çepni & Çil, 2010). Özden (2003) suggests that the important thing in the behaviorist approach, is behaviors with a beginning and an end, namely measurable behaviors. According to cognitive theory, as another theory that explains learning, learning is an individual's attribution of meaning to events around him/herself, and is a mental process that cannot be directly observed (Özden, 2003). Fidan and Erden (1993) emphasize that it is necessary to know how learning takes place in order to make teaching effective, and accordingly, the importance of fully understanding cognitive development, namely the human nature and development periods. Cognitive development is related to the facts of how the process of knowledge acquisition, and its processing and organization take place in both children and adults (Oakley, 2004). One of the psychologists describing cognitive development with the period concept, Piaget, indicated that children's way of thinking is different from that of adults, and children of various ages have different ways of thinking (Oakley, 2004) and suggested four stages such as sensorimotor stage, pre-operational stage, concrete operations stage and formal operations stage (Fidan & Erden, 1993; Blake & Pope, 2008; Çepni & Çil, 2010).

Piaget's Cognitive Developmental Stages

Sensorimotor stage (ages 0-2). During this stage, trying to understand the object (Kail, 2004), visual tracking and accordingly continuity of the object emerge (Fidan & Erden, 1993; Blake & Pope, 2008; Simatwa, 2010). One of the important developments taking place during this stage is purposive behaviors (Philips, 1969; Fidan & Erden, 1993). Furthermore, children within this period lack logical inquiry (Hansen & Zambo, 2005) and they use symbols (Kail, 2004).

Pre-operational stage (ages 2-7). During this stage, the intuitive mode of thinking reigns (Simatwa, 2010). At the beginning of the stage, the child expresses experiences with symbols (Philips, 1969; Fidan & Erden, 1993; Simatwa, 2010). In this period, the child can conduct classification and single-step mental problems, the language develops, there exists egocentrism (Philips, 1969; Fidan & Erden, 1993; Blake & Pope, 2008) and centering, namely focusing on one center and ignoring other directions (Kail, 2004).

Concrete operations stage (ages 7-11). Children in this stage have skills in conservation, classification, ranking and reversing a process, and logical thinking begins to transform (Philips, 1969; Fidan & Erden, 1993; Kail, 2004; Woolfolk, 2004). Although egocentrism exists even in this period, it decreases by the end (Kail, 2004). Simatwa (2010) argues that teaching programs within this period should be qualified enough for children to learn necessary basic skills in reading, writing and calculating arithmetic problems. Since children during the concrete operations stage are more enthusiastic and excited, teachers should provide the children with opportunities to utilize their enthusiasm and excitements (Simatwa, 2010).

Formal operations stage (age 11 and older). Some pedagogues specify this period as between the ages of 11-15 (Philips, 1969; Fidan & Erden, 1993) and some of them specify as the ages of 11 and older (Kail, 2004; Woolfolk, 2004; Çepni & Çil, 2010). Fidan and Erden

(1993) refer to formal operations stage as the period when systematic thinking emerges. During the formal operations stage, children are active in understanding the ideas of others and communicating with them (Simatwa, 2010). According to Woolfolk (2004), individuals during this period start to think more scientifically and show interest in social events and personality. Way of thinking covering logical, rational and abstract thinking is one of the features of the formal operations period (Fidan & Erden, 1993; Woolfolk, 2004; Simatwa, 2010; Oloyede, 2012). At the age of 11 on average, children moving towards the formal operations stage from the concrete operations stage tend towards thinking like an adult; and about of the age of 15, they think of ideas and reach the highest level of mental development (Charles, 2001). Hypothesis testing, proportional reasoning, inductive reasoning, reasoning of combinations, probabilities and correlations are the characteristics of formal operations stages (Genovese, 2003).

Concrete-Formal Operations Stages and Logical Thinking

The most important way of thinking particular to concrete and formal operations stages is the skill of logical thinking (Atherson, 2013). Considered as a universal human characteristic, the skill of logical thinking is regarded as a high cognitive skill, and it is a function in Piaget's developmental schema that cannot emerge before concrete operations stage (Minderovic, 2001). According to Demirel (2003), logical thinking includes effective usage of numbers, finding scientific solutions to problems, realizing differences among concepts, classification, making generalization and calculations, and providing hypotheses. Roadrangka (1991) notices three developmental stages by utilizing logical thinking level including concrete, transitional and formal stages. In other words, the level of logical thinking provides us with information about an individual's cognitive developmental level.

Why is logical thinking, and hence transition from concrete stage to formal stage, important in science education? It is because there are several research studies related to the fact that formal thinking and logical thinking are predictors of scientific process skills (Bitner, 1991); that there is a positive relationship between spatial skills and these ways of thinking (Kayhan, 2005); that there is a significant relationship between abstract thinking and scientific process skills and success in chemistry, and students using abstract thinking tend to be more successful compared to those not using abstract thinking, and low level reasoning brings about low level performance (Oloyede, 2012), and that science success and understanding science concepts are directly associated with formal reasoning skills (Hackling, Garnett & Dymond, 1990). Cohen (1980) emphasizes the importance of abstract thinking by indicating that the more abstract an individual's way of thinking is, the more effective its function in society is.

According to Othman, Hussain and Nikman (2010), many people fail in realizing that logical thinking is among the most important factors in determining students' qualifications in learning programs. Program development specialists should make a special effort to understand the world of children and offer pedagogical experiences based on children's interest and requests (Simatwa, 2010). Roadrangka (1991) emphasizes that in many science classes, teachers are faced with students of many different levels in terms of the skills required to acquire scientific concepts and use scientific thinking skills. As students tend to learn concepts suitable for their development levels more easily, science curriculum should be matched with students' development levels and hence students' cognitive developments should be examined.

This study is of importance in terms of determining the logical thinking levels of pre-service science teachers and therefore their cognitive development levels. Therefore, it is considered beneficial for teacher education experts and program development specialists to determine future science teachers' logical thinking level and hence their cognitive developments that affect various characteristics such as acquisition of scientific concepts, spatial thinking and scientific process skills. In this study, conducted for the purpose of analyzing pre-service science teachers' logical thinking skills, answers to the following research questions are sought:

1. What is the logical thinking level of pre-service science teachers?
2. Do logical thinking levels of pre-service science teachers vary significantly by gender?
3. Do logical thinking levels of pre-service science teachers vary significantly by grade level?
4. Do logical thinking levels of pre-service science teachers vary significantly by graduated high school?

METHOD

In this study, survey model was used; one of the most widely used models in the field of educational research (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2009; Karakaya, 2009). Survey model researches are among those in which individuals' or their established groups' opinions on phenomenon or events are collected and current situations are determined (Karasar, 2002; Büyüköztürk et al., 2009; Karakaya, 2009).

Population and Sample

The study population consists of 464 pre-service science teachers attending the 1st, 2nd, 3rd and 4th grades in the Faculty of Education of Mehmet Akif Ersoy University, Turkey. The study sample consists of 241 pre-service science teachers selected from the study population. While forming the sample, the proportional stratified sampling method was employed. For this, the spread of students by percentage within each section were determined, and according to these percentages, students were selected from each stratum for the sample. In Table 1, percentage and frequency are shown regarding the descriptive distribution per grade level of pre-service science teachers participating in the research.

Table 1. *Percentage/frequency distributions of pre-service science teachers per grade level*

Grade level	*F (population)*	*% (population)*	*F (sample)*	*% (sample)*
1st grade	127	27.37	67	27.80
2nd grade	133	28.66	75	31.12
3rd grade	116	25.00	59	24.48
4th grade	88	18.96	40	16.60
Total	464	100.00	241	100.00

As shown in Table 1, second grades constitute the largest percentage, then first grades, third, whereas fourth grades constitute the smallest percentage. While in the first and third grades, one-to-one harmony was achieved in terms of percentage, in the second and fourth grades, an approximate rate was achieved. The reason for approximate basic percentage in the second and fourth grades is that some of the pre-service science teachers were not included in the sampling due to giving incomplete information in their personal data forms. 63.9% of the pre-service science teachers participating in the research are female and 36.1% are male. As per the graduated high school type, 60.5% of teacher candidates graduated from General High Schools, 18.7% from Anatolian High Schools, 3.3% from Anatolian Teacher Training High Schools, 3.3% from Vocational High Schools, 2.9% from Technical High Schools and 11.2% from other high schools.

Data Collection Tool

The original version of the Group Assessment of Logical Thinking Test (GALT) was developed by Roadrangka, Yeany and Padilla (1982, as cited in Aksu, Berberoğlu, Martin & Paykoç, 1990). The test was adapted to Turkish by Aksu et al. (1990). Aksu et al. (1990) in their study to adapt the Logical Thinking Group Test into Turkish, found that difficulty indexes of items in the test vary between -.01 and .93, selectivity indexes vary between .09 and .64, and internal consistency coefficient (KR-20) acquired from the 21 items of the test is determined as being 0.68. Besides, results of factor analysis reflect a single-factor test on item basis (Aksu et al., 1990). GALT consists of 21 items and six reasoning modes, one concrete and five formal operations; conservation, proportional reasoning, controlling variables, probabilistic reasoning, correlational and combinational reasoning (Bitner-Corvin, 1988; Bitner, 1991; Rodrangka, 1991). Scores obtained from this test with sufficient reliability and validity between the 6th grade to university level show the concrete operations stage between 0-8 points; transitional stage between 9-15 points and formal operations stage between 16-21 points (Bitner, 1991; Rodrangka, 1991). For this study, Cronbach Alpha reliability coefficient of the tool is calculated as .64.

Data Analysis

In analysis of the data, descriptive statistics, t-test and ANOVA test were conducted. For each conducted analysis, the required assumptions were tested. For normal distribution, Skewness (-0,248) and Kurtosis (-0,280) values were controlled and GALT scores were observed to show normal distribution.

FINDINGS

Results of descriptive analysis conducted with a view to determine logical thinking levels of pre-service science teachers are given in Table 2.

Table 2. *Descriptive statistics related to logical thinking levels of pre-service science teachers*

	N	*Minimum*	*Maximum*	$\overline{X}$	*S*
GALT	241	1.00	17.00	9.25	3.14

Analyzing Table 2, it can be seen that the lowest score obtained by the pre-service science teachers is one, the highest score is 17, and the average score is 9.25. According to the average score, it can be seen that pre-service science teachers are in the “transitional” stage. Frequency distributions of scores by pre-service science teachers from GALT are given in Table 3.

Table 3. *Frequency distributions of scores by pre-service science teachers from GALT*

Scores	*F*	*%*
0-8 points (concrete thinker)	92	38.17
9-16 points (transitional thinker)	148	61.41
17-21 points (formal thinker)	1	0.42
Total	241	100.00

According to frequency distribution in Table 3, 38.17% of the pre-service science teachers participating in the research are in concrete operations, 61.41% are transitional and 0.42% in the formal operations stage. Results of t-test conducted for the purposes of determining whether logical thinking levels of pre-service science teachers vary by gender can be seen in Table 4.

Table 4. *T-test results of changes in logical thinking levels of pre-service science teachers by gender*

Group	*N*	$\bar{X}$	*S*	*t*	*df*	*p*
Female	154	9.17	3.02	.53	239	.60
Male	87	9.39	3.35			

As can be seen in Table 4, there are no significant differences between logical thinking test score averages of female pre-service science teachers ($\bar{X}$=9.17, S=3.02) and male pre-service science teachers ($\bar{X}$=9.39, S=3.35; $t_{(239)}$=.53, p>.05). In other words, logical thinking levels of pre-service science teachers do not significantly differ by gender. Results of ANOVA conducted for the purposes of determining whether logical thinking levels of pre-service science teachers vary by grade level can be seen in Table 5.

Table 5. *Comparison of logical thinking levels of pre-service science teachers per grade level*

Scores	Grade level	n	$\bar{X}$	S	df	F	p	Scheffe
GALT	1^{st} grade	67	8.60	3.16	3-237	5.634	.00	1-4
	2^{nd} grade	75	8.84	2.86				2-4
	3^{rd} grade	59	9.36	3.10				
	4^{th} grade	40	10.95	3.14				

According to Table 5, logical thinking group test scores of pre-service science teachers differ significantly as per grade level (F_{3-237}=5.634; p<.05). To find in which grade levels this difference exists, Scheffe test was conducted as one of the multiple comparison tests. According to Scheffe test results; logical thinking group test average score of fourth grade pre-service science teachers ($\bar{X}$=10.95, S=3.14) is significantly higher compared to second grade pre-service science teachers' scores ($\bar{X}$=8.84, S=2.86). Accordingly, it can be said that grade level does have a significant effect on pre-service science teachers' logical thinking levels. Results of ANOVA conducted for the purposes of determining whether logical thinking levels of pre-service science teachers vary by the type of graduated high school are shown in Table 6.

Table 6. *Comparison of logical thinking levels of pre-service science teachers per type of graduated high school*

Scores	*Graduated High School (HS) Type*	*n*	$\overline{X}$	*S*	*df*	*F*	*p*	*Scheffe*
GALT	1. General HS	146	8.58	2.97	5-235	6.67	.00	1-4
	2. Technical HS	7	8.71	2.14				1-5
	3. Vocational HS	8	7.75	2.76				
	4. Anatolian HS	45	10.91	3.00				
	5. Anatolian Teacher Training HS	8	12.37	3.42				
	6. Other HS	27	9.74	3.00				

As can be seen in Table 6, logical thinking group test scores of pre-service science teachers differ significantly based on the type of graduated high school ($F_{5\text{-}235}=6.67$; $p<.05$). To find out in which high school types this difference exists, Scheffe test was conducted as one of the multiple comparison tests. According to Scheffe test results; logical thinking group test average score of pre-service science teachers graduated from General High School ($\overline{X}=8.58$, S=2.97) is significantly lower compared to pre-service science teachers' scores from Anatolian High Schools ($\overline{X}=10.91$, S=3.00) or Anatolian Teacher Training High Schools ($\overline{X}=12.37$, S=3.42). Accordingly, it can be said that the type of graduated high school has a significant effect on pre-service science teachers' logical thinking levels.

RESULT, DISCUSSION AND SUGGESTIONS

According to this study, which was conducted to analyze the logical thinking and cognitive development levels of pre-service science teachers, most of the pre-service science teachers that participated in this research are in transitional stage. Accordingly, participants are mostly in the transitional stage rather than formal operations stage as suggested by Piaget's cognitive development theory. There are some studies in the literature that support these findings. Although the study group was dissimilar to that within this study, in a study conducted with 3,191 young adults (16 years old) who were expected to be in formal stage according to Piaget's cognitive development theory, it was revealed that 98% of them were in concrete operations stage, and the remaining 2% in transitional stage (Fah, 2009). As a result of Reyes's (1987) study, it was found that pre-service science teachers are not in formal operations stage as proposed in Piaget's theory, and most of the university students participating in the research are either in formal operations stage or in transitional stage. McConnell, Steer, Owens and Knight (2005) state that nearly half of the students taking the basic geography courses in university do not have the required skills to understand abstract concepts. Snowman and McCown (2012) and Ojose (2008) state that many adolescents are not in the period of formal operations stage. Based on studies conducted in this field, we can say that abstract inquiry is not a rule but an exceptional case (Snowman & McCown, 2012).

Woolfolk (2004) explains the reason of such problems related to periods and ages specified by Piaget: While the first three periods of Piaget is largely dependent on the physical environment, formal operations period is not closely related to physical environment. These operations can be the product of using experiences, applications related to solution of hypothetical problems and abstract scientific reasoning. Accordingly, everyone at high school and latter stages cannot be expected to approach problems with hypothetical ways of thinking (Woolfolk, 2004).

Problems related to ages and periods proposed by Piaget are still discussed by many pedagogues. Criticisms of this theory include; underestimating children's abilities (Oakley, 2004; Blake & Pope, 2008; Snowman & McCown, 2012), overestimating adolescents' abilities (Kail, 2004; Oakley, 2004; Woolfolk, 2004; Ojose, 2008; Snowman & McCown, 2012), ambiguous explanations and cultural differences in cognitive growth (Woolfolk, 2004; Ojose, 2008; Snowman & McCown, 2012). According to Bybee and Sund (1990), although many intercultural studies confirm the stages of Piaget's cognitive development, there are findings showing that formal operations stage is not acquired in some cultures, ages covering the periods vary by culture, and also that cognitive performance in each period varies. For example, some simple formal operations such as classification may not be simple for all people within some cultures (Woolfolk, 2004). Piaget (1972) indicated that ages covering the stages may vary by social environment, country, and even by religion (Cited in: Bybee & Sund, 1990). Obviously, cultural factors are important in cognitive development. Vygotsky emphasized the effect of culture on cognitive development by placing the interaction between the child and other individuals in society at the focal point of psychological growth (Wood, 2003). Eberts and Eberts (1995) indicate that Asian cultures, religions and education systems discourage and reduce individuals' logical thinking (Cited in: Kanazawa, 2006). Another criticism made regarding Piaget's cognitive development theory is that Piaget ignored the importance of language (Wood, 2003). The reason for children's failure in answering Piaget's questions may not be related to their inadequacy in this respect, but certain problems related to understanding the language (Wood, 2003). For example, Hannas (2003) indicates that the languages of Asia prevents Asian people from creative and abstract thinking (as cited in Kanazawa, 2006). In this case, it can be said that skills of reading and reading comprehension are also important in cognitive development.

Another finding of this study is that logical thinking levels of pre-service science teachers do not differ significantly by gender. This finding related to logical thinking and gender is supported by the findings of some studies (Yaman, 2005; Fah, 2009; Tuna, Biber & İncikap, 2013) found in the field literature.

Other finding obtained from this study is that logical thinking levels of pre-service science teachers differ significantly as per the grade variable. Fourth grade pre-service science teachers' logical thinking levels were found to be higher than those of first and second grade pre-service science teachers'. In other words, as the grade level increases, logical thinking levels of pre-service science teachers also increase. This finding of the study shows parallelism with the findings of Tuna et al. (2013). Tuna et al. (2013) indicated that third grade and fourth grade pre-service teachers' logical thinking levels were significantly higher than those of second grade pre-service teachers'. This increase in logical thinking level by grade level may originate from increase in educational level or teacher training program. Again in another study, in which logical thinking level was examined according to grade level, despite not being similar in terms of study group, grade level was found to have significant effect on logical thinking level (Yenilmez, Sungur & Tekkaya, 2005).

Another finding of the study is that pre-service science teachers' logical thinking levels differ significantly as per type of graduated high school. In this regard, logical thinking levels of pre-service science teachers that graduated from Anatolian High Schools and Anatolian Teacher Training High Schools were found to be significantly higher than logical thinking levels of pre-service science teachers that graduated from General High Schools. In a study conducted with pre-service mathematics teachers by Tuna et al. (2013), it was found that logical thinking levels of pre-service mathematics teachers that graduated from Anatolian Teacher Training High Schools and Anatolian High Schools were significantly higher than those of pre-service mathematics teachers that graduated from General High School. In findings acquired from both studies, the reason for logical thinking levels of pre-service teachers that graduated from Anatolian and Anatolian Teacher Training High Schools being higher than those of pre-service teachers that graduated from General High Schools may be that both schools used to admit students who scored high in the Level Determination Exam during the time the studies were performed.

In conclusion, in this study, findings have been acquired about the fact that logical thinking levels, and therefore cognitive development levels, of pre-service science teachers are within transitional period rather than formal operations stage as proposed by Piaget. While logical thinking levels do not differ significantly by gender, they do differ significantly in terms of grade level and graduated high school. The fact that the majority of pre-service science teachers that participated in the study are in transitional period may result from cultural factors, educational system and reading habits. Considering that grade level and graduated high school affect logical thinking, it can be said that education and educational level are therefore also important in logical thinking.

According to Lawson (1985), abstract thinking skills of students can be improved with effective education (Cited in: Shaibu & Mari, 2003). Studies supporting this claim are available in the field literature. Among these studies, factors increasing logical thinking levels include: Frear and Hirschbuhl (1999) suggest interactive multimedia education; Oloyede (2012) suggests active learning environments such as research-based learning; Altındağ, Göksel, Koray and Koray (2012), Koray and Köksal (2009) suggest critical and creative thinking based laboratory activities; Aydın and Kaptan (2014) suggest activities based on argumentation; Othman et al. (2010), McConnell et al. (2005) suggest cooperative learning method; Shaibu and Mari (2003) suggest activities based on scientific process skills; Demirel and Coşkun (2010) suggest interdisciplinary project studies. Oloyede (2012) indicates that all children learn best with activities based on personal experience, and gives two basic suggestions based on research related to mental development. These suggestions are; 1) Since students start university during their formal operations stage, samples shaped by students' experiences should be used with a view to ensuring meaningful development of concepts. 2) It is necessary to include the students in discussions to determine students' understanding levels and misconceptions, to overturn the balance of their existing inadequate mental models and to change these models to more suitable models.

Based on all these studies, educational environments that are critical, support creative thinking, are enriched with cooperative learning activities, and in which students are active and can benefit from their own experiences while assuming knowledge, should be organized to improve logical thinking levels of pre-service teachers and hence to improve transition from concrete operations stage to formal operations stage. However, while arranging the learning environment, the cognitive development levels of pre-service science teachers should be taken into consideration they are supposed to be in formal operations stage according to Piaget's theory, but most are in concrete operations stage.

REFERENCES

Aksu, M., Berberoğlu, G., Martin, F. & Paykoç, F. (1990). Problem çözme becerilerinin ölçülmesi: GALT'ın Türkiye'deki uyarlamasına ilişkin bir ön çalışma. *I. Ulusal Eğitim Bilimleri Kongresi Bildiri Kitabı.* pp.215-224.

Altındağ, C., Göksel, Ç., Koray, Ö. & Koray, A. (2012). Eleştirel ve yaratıcı düşünme temelli fen ve teknoloji laboratuvarı uygulamalarının problem çözme ve yaratıcılık üzerine etkisi. *X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi*. 27-30 June 2012. Niğde Üniversitesi, Niğde.

Atherson, J.S. (2013). *Learning and teaching: Piaget's developmental theory* [Online :UK]. Retrieved 29 December 2014 from http://www.learningandteaching.info/learning/piaget.htm

Aydın, Ö. & Kaptan, F. (2014). Fen-teknoloji öğretmen adaylarının eğitiminde argümantasyonun biliş-üstü ve mantıksal düşünme becerilerine etkisi ve argümantasyona ilişkin görüşler. *Eğitim Bilimleri Araştırma Dergisi, 4 (*2), 163-188.

Bitner, B. L. (1991). College science courses, ACT science, C-Base science and GALT: Predictors of science process skills and physical science misconceptions. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching.* 7-10 April. Lake Geneva, WI.

Bitner-Corvin, B. L. (1988). Is the GALT a reliable instrument for measuring the logical thinking abilities of students in grade six through twelve? *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching.* 10-13 April. Lake of the Ozaks, MD.

Blake, B. & Pope, T. (2008). Development psychology: Incorporating Piaget's and Vygotsky's theories in classrooms. *Journal of Cross-Disciplinary Perspectives in Education, 1(*1), 59-67.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö.E., Karadeniz, Ş. & Demirel, F. (2009). *Bilimsel araştırma yöntemleri*. 4.Baskı. Ankara: PegemA Akademi.

Bybee, R. W. & Sund, R. B. (1990). *Piaget for educators (*Second Edition). USA: Waveland Press.

Charles, C. H. (2001). *Öğretmenler için Piaget ilkeleri*. (Çev: G. Ülgen). 4. Baskı. Ankara: Nobel Yayın.

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

Çepni, S. & Çil, E. (2010). *Fen ve teknoloji programı: İlköğretim 1.ve 2. kademe öğretmen el kitabı.* 2. Baskı. Ankara: Pegem A.

Demirel, M. & Coşkun, Y. D. (2010). Case study on interdisciplinary teaching approach supported by project based learning. *The International Journal of Research in Teacher Education, 2 (*3), 28-53.

Demirel, Ö. (2003). *Planlamadan değerlendirmeye öğretme sanatı.* Ankara: PegemA.

Fah, L.Y. (2009). Logical thinking abilities among Form4 students in the interior division of Sabah, Malaysia. *Journal of Science and Mathematics Education in Southeast Asia, 32* (2), 161-187.

Fidan, N. & Erden, M. (1993). *Eğitime Giriş.* 4. Baskı. Ankara: Meteksan Matbaacılık.

Frear, V. & Hirschbuhl, J. J. (1999).Does interactive multimedia promote achievement and higher level thinking skills for today's science students? *British Journal of Educational Technology, 33 (*4), 323-329.

Genovese, J. E. C. (2003). Piaget, pedagogy, and evolutionary psychology. *Evolutionary Psychology, 1*, 127-137.

Hackling, M., Garnett, P. & Dymond, F. (1990). Improving the scientific thinking of preservice secondary science teachers. *Australian Journal of Teacher Education, 15 (*2), 19-27.

Hansen, C. C. & Zambo, D. (2005). Piaget meet Lilly: Understanding child development through picture book characters. *Early Childhood Education Journal, 33 (*1), 39-45.

Kail, R. V. (2004*). Children and their development*. Third Edition. New Jersey: Pearson Prentice Hall.

Kanazawa, S. (2006). No, it ain't gonna be like that. *Evolutionary Psychology, 4*, 120-128.

Karakaya, İ. (2009). Bilimsel araştırma yöntemleri. *Bilimsel araştırma yöntemleri* (Edt: A. Tanrıöğen). Ankara: Anı Yayıncılık.

Karasar, N. (2002). Bilimsel araştırma yöntemleri. *Bilimsel araştırma yöntemleri* (11. Baskı). Ankara: Nobel. pp. 59-61

Kayhan, E. B. (2005). Investigation of high school students' spatial ability. *Unpublished Master Dissertation.* Middle East Technical University, Ankara.

Koray, Ö. & Köksal, M. S. (2009). The effect of creative and critical thinking based laboratory applications on creative and logical thinking abilities of prospective teachers. *Asia-Pacific Forum on Science Learning and Teaching, 10 (*1), 1-13.

McConnell, D. A., Steer, D. N., Owens, K. D. & Knight, C. C. (2005). How students think: Implications for learning introductory geoscience courses. *Journal of Geoscience Education, 53(*4), 462-470.

Minderovic, Z. (2001). *Logical Thinking: Gale encyclopedia of psychology.* Retrieved, 29 December 2014 from http://www.encyclopedia.com/doc/1G2-3406000395.html

Oakley, L. (2004). *Cognitive development*. USA: Routledge.

Ojose, B. (2008). Applying Piaget's theory of cognitive development to mathematics instruction. *The Mathematics Educator, 18(*1), 16-30.

Oloyede, O. I. (2012). The relationship between acquisition of science process skills, formal reasoning ability and chemistry achievement. *IJAAS, 8(*1), 1-4.

Othman, M., Hussain, F. M. & Nikman, K. (2010). Enhancing logical thinking among computer science students through cooperative learning. *Gading Business and Management Journal, 14,* 1-10.

Özden, Y. (2003). *Öğrenme ve Öğretme*. 5. Baskı. Ankara: PegemA.

Philips, J. L. (1969). *The origins of intellect Piaget's Theory*. USA: W.H. Freeman and Company.

Reyes, D. J. (1987). Cognitive development of teacher candidates: An analysis. *Journal of Teacher Education, 38*, 18-21.

Roadrangka, V. (1991). The construction of a Group Assessment of Logical Thinking (GALT). *Kasetsant Journal: Social Sciences, 12(*2), 148-154.

Shaibu, A. A. M. & Mari, J. S. (2003). The effects of process skill instruction on secondary school students' formal reasoning ability in Nigeria. *Science Education International, 14 (*4), 51-54.

Simatwa, E. M. W. (2010). Piaget's theory of intellectual development and its implication for instructional management at pre-secondary school level. *Educational Research on Review, 5 (*7), 366-371.

Snowman, J. & McCown, R. (2012). *Psychology applied to teaching*. China: Wadsworth Cengage Learning.

Tuna, A., Biber, A. Ç. & İncikap, L. (2013). An analysis of mathematics teacher candidates' logical thinking levels: Case of Turkey. *Journal of Educational and Instructional Studies in The World, 3(*1).

Wood, D. (2003). *Çocuklarda düşünme ve öğrenme*. (Çev: M. Özlü). Ankara: Doruk Yayıncılık.

Woolfolk, A. (2004). *Educational psychology*. 9th Edition. USA: Pearson.

Yaman, S. (2005). Fen bilgisi eğitiminde probleme dayalı öğrenmenin öğrenme ürünlerine etkisi. *Yayınlanmamış Doktora Tezi*. Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Yenilmez, A., Sungur, S. & Tekkaya, C. (2005). Investigating students' logical thinking abilities: The effects of gender and grade level. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 28*, 219-225.

Fen Bilgisi Öğretmen Adaylarının Mantıksal Düşünme ve Bilişsel Gelişim Düzeyleri[4]

Selda BAKIR[5] & Esra ÖZTEKİN-BİÇER[6]

Giriş

Fidan ve Erden (1993) eğitimin etkili olabilmesi için öğrenmenin nasıl gerçekleştiğinin bilinmesi gerektiğini, bunun için de insanın doğasının ve gelişim dönemlerinin yani bilişsel gelişimin tam olarak anlaşılmasının önemini vurgulamaktadır. Bilişsel gelişim, bilginin kazanılması, işlenmesi ve organize edilmesini içeren sürecin, çocuklarda ve yetişkinlerde nasıl geliştiği ile ilgilidir (Oakley, 2004). Bilişsel gelişimi, dönem kavramı ile açıklayan psikologlardan biri olan Piaget, çocukların düşünme biçimlerinin yetişkinlerden farklı olduğunu ve farklı yaşlardaki çocukların düşünme biçimlerinin farklı olduğunu belirtmiş (Oakley, 2004) ve duyusal-hareket, işlem öncesi, somut ve soyut işlemler dönemi olmak üzere dört dönem önermiştir (Fidan & Erden, 1993; Blake & Pope, 2008; Çepni & Çil, 2010).

Ortalama ilkokula başlama yaşının yedi olduğu kabul edilirse, ilkokul ve daha üst seviyedeki öğrencilerin bilişsel gelişimleri açısından somut ve soyut işlemler dönemleri bu çalışma için önem taşımaktadır. Somut ve soyut işlemler dönemlerine özgü olan en önemli düşünme biçimi, mantıksal düşünme becerisidir (Atherson, 2013). Evrensel bir insanoğlu özelliği olarak kabul edilen mantıksal düşünme becerisi, yüksek bir bilişsel beceri olarak kabul edilir ve Piaget'nin gelişimsel şemasında, somut işlemler döneminden önce ortaya çıkmayan bir işlevdir (Minderovic, 2001). Demirel'e (2003) göre mantıksal düşünme, sayıları etkin kullanma, problemlere bilimsel çözümler bulma, kavramlar arasındaki farklılıkları fark etme, sınıflama, genelleme ve hesaplama yapma, hipotez sunma gibi becerileri içerir. Roadrangha (1991) mantıksal düşünme seviyesinden yararlanarak, somut, geçiş ve soyut olmak üzere üç gelişim döneminden bahsetmektedir. Bir başka deyişle mantıksal düşünme seviyesi bize kişinin bilişsel gelişim düzeyi hakkında bilgi sağlamaktadır.

Othman, Hussain ve Nikman'a (2010) göre, insanların birçoğu öğrenme programlarındaki öğrencilerin yeterliliklerini belirlemede en önemli faktörlerden biri olan mantıksal düşünmeyi fark etmekte hata yapmaktadır. Program geliştirme uzmanları, çocukların dünyalarını anlamak için özel çaba sarf etmelidir ve çocukların ilgi ve isteklerine dayalı eğitsel deneyimler sağlamalıdır (Simatwa, 2010). Roadrangha (1991) birçok fen sınıfında öğretmenlerin, bilimsel kavramları kazanmak ve bilimsel düşünme becerilerini kullanmak için gerekli beceriler konusunda çok değişik düzeyde öğrencilerle karşı karşıya kaldığını, öğrencilerin gelişim düzeylerine uygun olan kavramları daha kolay öğrendiklerini, fen müfredatının, öğrencilerin gelişim düzeyleriyle uyumlu hale getirilmesi gerektiğini ve bunun için de öğrencilerin bilişsel gelişimlerinin sorgulanması gerektiğini vurgulamaktadır.

Bu çalışma, fen bilgisi öğretmen adaylarının mantıksal düşünme düzeylerini ve dolayısıyla bilişsel gelişim düzeylerini belirlemek açısından önem taşımaktadır. Çünkü

[4] Bu çalışmanın verileri, Mehmet Akif Ersoy Üniversitesi Eğitim Bilimleri Enstitüsü'nde, Yrd. Doç. Dr. Selda BAKIR'ın danışmanlığında, Esra Öztekin tarafından tamamlanmış yüksek lisans tezinden alınmıştır.

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geleceğin fen bilgisi öğretmenlerinin bilimsel kavramları kazanma, uzamsal düşünme ve bilimsel süreç becerileri gibi birçok özelliğini etkileyen, mantıksal düşünme düzeyi ve dolayısıyla bilişsel gelişimlerinin belirlenmesinin, öğretmen yetiştirme uzmanları ve programcılara faydalı olacağı düşünülmektedir. Fen bilgisi öğretmen adaylarının mantıksal düşünme becerilerini incelemek amacıyla yapılan bu çalışmada aşağıdaki sorulara cevap aranmıştır: 1) Fen bilgisi öğretmen adayları mantıksal düşünmede hangi düzeydedir? 2) Fen bilgisi öğretmen adaylarının mantıksal düşünme düzeyleri cinsiyete göre anlamlı bir farklılık göstermekte midir? 3) Fen bilgisi öğretmen adaylarının mantıksal düşünme düzeyleri sınıf düzeyine göre anlamlı bir farklılık göstermekte midir? 4) Fen bilgisi öğretmen adaylarının mantıksal düşünme düzeyleri mezun olunan lise türüne göre anlamlı bir farklılık göstermekte midir?

Yöntem

Bu çalışmada, eğitim alanında en yaygın kullanılan modellerden biri olan tarama modeli (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2009; Karakaya, 2009) kullanılmıştır. Tarama modeli araştırmalar, bireylerin ya da oluşturdukları grupların kendi koşulları içinde, olgu ya da olaylara dair görüşlerinin alınarak var olan durumların belirlendiği araştırmalardır (Karasar, 2002; Büyüköztürk vd, 2009; Karakaya, 2009). Çalışmanın evrenini Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesinde öğrenim gören 1, 2, 3 ve 4. sınıf 464 fen bilgisi öğretmen adayı, örneklemini ise, bu kişiler arasından seçilen 241 fen bilgisi öğretmen adayı oluşturmaktadır. Örneklem oluşturulurken, oranlı tabakalı örnekleme yöntemi kullanılmıştır. Bu çalışmada kullanılan MDGT (Mantıksal Düşünme Grup Testi= Group Assessment Of Logical Thinking Test) testinin orijinali Roadrangka, Yeany ve Padilla (1982) tarafından geliştirilmiştir (Akt: Aksu, Berberoğlu, Martin & Paykoç, 1990). Test, Aksu, Berberoğlu, Martin ve Paykoç (1990) tarafından Türkçeye uyarlanmıştır. MDGT, korunum, orantısal düşünme, değişkenleri kontrol etme, olasılığa dayalı sorgulama, korelasyonel sorgulama ve kombinasyonel sorgulama olmak üzere, biri somut beşi soyut işlemler olmak üzere altı sorgulama modu ve 21 maddeden oluşmaktadır (Bitner-Corvin, 1988; Bitner, 1991; Rodrangha, 1991). 6. sınıftan üniversite düzeyine kadar yeterli güvenilirlik ve geçerliğe sahip olan bu testten alınan puanlar, 0-8 puan ise somut, 9-15 puan ise geçiş dönemi ve 16-21 puan ise soyut işlemler döneminde olduğunu göstermektedir (Bitner, 1991; Rodrangha, 1991). Bu çalışma için ölçme aracının Cronbach Alfa güvenirlik katsayısı .64 olarak hesaplanmıştır.

Bulgular

Araştırmada elde edilen verilerin analizi sonucunda, öğretmen adaylarının %38.17'sinin somut işlemler, %61.41'inin geçiş ve %0.42'sinin soyut işlemler döneminde oldukları, genel olarak ise ortalama 9,25 puanla geçiş döneminde oldukları belirlenmiştir. Ayrıca fen bilgisi öğretmen adaylarının mantıksal düşünme düzeylerinin cinsiyete göre değişmediği; buna karşın, sınıf düzeyine ve mezun olunan lise türüne göre istatiksel olarak farklılaştığı belirlenmiştir.

Sonuç, Tartışma ve Öneriler

Fen bilgisi öğretmen adaylarının mantıksal düşünme düzeylerini incelemek amacıyla yapılan bu çalışmaya göre, araştırmaya katılan fen bilgisi öğretmen adaylarının büyük kısmı geçiş döneminde bulunmaktadır. Buna göre katılımcılar, Piaget'nin bilişsel gelişim kuramında iddia ettiği gibi soyut dönemde değil, çoğunlukla geçiş döneminde bulunmaktadırlar. Piaget'nin önerdiği yaş ve dönemlerle ilgili sorunlar birçok eğitimci tarafından hala tartışılan bir konudur. Bu kurama getirilen eleştiriler; çocukların yeteneklerinin hafife alınması (Oakley, 2004; Blake & Pope, 2008; Snowman & McCown, 2012), ergenlerin yeteneklerinin abartılması (Kail, 2004; Oakley, 2004; Woolfolk, 2004; Ojose, 2008; Snowman & McCown, 2012), bilişsel büyüme için belirsiz açıklamalar ve kültürel farklılıklar (Woolfolk, 2004; Ojose, 2008; Snowman & McCown, 2012) olarak söylenebilir.

Bu çalışmanın bulgularından bir diğeri, öğretmen adaylarının mantıksal düşünme düzeylerinin cinsiyete göre anlamlı bir değişiklik göstermemesidir. Bir başka deyişle cinsiyetin mantıksal düşünme üzerine anlamlı bir etkisinin bulunmamasıdır. Alan yazında mantıksal düşünme ve cinsiyet ile ilgili bu bulgu, bazı çalışmaların bulguları tarafından desteklenmektedir (Yaman, 2005; Fah, 2009; Tuna, Biber & İncikap, 2013).

Bu çalışmadan elde edilen bir diğer bulgu fen bilgisi öğretmen adaylarının mantıksal düşünme düzeylerinin sınıf değişkenine göre anlamlı bir şekilde değişmesidir. Dördüncü sınıf öğretmen adaylarının mantıksal düşünme düzeyleri, birinci ve ikinci sınıf öğretmen adaylarınınkinden anlamlı düzeyde yüksek bulunmuştur. Yani, sınıf düzeyi arttıkça öğretmen adaylarının mantıksal düşünme düzeyleri de artmıştır. Çalışmanın bu bulgusu, Tuna, Biber ve İncikap'ın (2013) bulgularıyla paralellik göstermektedir.

Öğretmen adaylarının mantıksal düşünme düzeylerinin mezun olunan lise türüne göre anlamlı olarak değişmesi, bu çalışmanın bulgularından bir diğeridir. Buna göre Anadolu ve Anadolu Öğretmen Liselerinden mezun olan öğretmen adaylarının mantıksal düşünme düzeyleri, genel liselerden mezun olan öğretmen adayların mantıksal düşünme düzeylerinden anlamlı olarak yüksektir. Tuna, Biber ve İncikap'ın (2013), matematik öğretmen adaylarıyla yaptıkları çalışmalarında, Anadolu öğretmen lisesi ve Anadolu lisesi mezunu öğretmen adaylarının mantıksal düşünme düzeyleri, genel liseden mezun öğretmen adaylarının mantıksal düşünme düzeylerinden anlamlı olarak yüksek bulunmuştur. Her iki çalışmada da elde edilen sonuçlarda, Anadolu ve Anadolu Öğretmen Lisesinden mezun olan öğretmen adayların mantıksal düşünme düzeylerinin, genel liselerden mezun olanlardan anlamlı olarak daha yüksek olmasının sebebi, bu iki okulun, çalışmanın yapıldığı dönemde liseye geçiş için yapılan, Seviye Tespit Sınavı' dan (SBS) yüksek puan alan öğrencileri kabul etmeleri olabilir.

Özetle, bu çalışmayla fen bilgisi öğretmen bilişsel gelişim düzeylerinin, Piaget'nin kuramına göre beklenildiği gibi soyut işlemler döneminde değil geçiş aşamasında olduğu ve mantıksal düşünme düzeylerinin cinsiyete göre anlamlı bir farklılık göstermezken, sınıf ve mezun olunan lise türüne göre anlamlı farklılık gösterdiği sonuçları elde edilmiştir. Bu çalışmaya katılan fen bilgisi öğretmen adaylarının büyük çoğunluğunun geçiş döneminde olmaları, kültürel faktörden ve buna bağlı olarak eğitim sistemi ve okuma alışkanlıklarından kaynaklanıyor olabilir. Sınıf düzeyi ve mezun olunan lisenin mantıksal düşünmeyi etkilediğine dayanarak, eğitimin ve eğitim düzeyinin mantıksal düşünmede önemli olduğu söylenebilir.

Lawson'a (1985) göre öğrencilerin soyut düşünme becerileri etkili eğitimle artırılabilir (Aktaran: Shaibu & Mari, 2003). Alanyazında bu iddiayı destekleyecek çalışmalar mevcuttur. Bunlardan Frear ve Hirschbuhl (1999), interaktif multimedia eğitiminin, Oloyede (2012), araştırmaya dayalı öğrenme gibi aktif öğrenme ortamlarının, Altındağ, Göksel, Koray ve Koray (2012) ve Koray ve Köksal (2009), eleştirel ve yaratıcı düşünme temelli laboratuvar uygulamalarının, Aydın ve Kaptan (2014), argümantasyona dayalı yapılan uygulamaların, Othman, Hussain ve Nikman (2010) ve McConnell vd. (2005), işbirlikli öğrenme yönteminin, Shaibu ve Mari (2003), bilimsel süreç becerilerine dayalı uygulamaların, Demirel ve Coşkun (2010), disiplinlerarası proje çalışmalarının mantıksal düşünme düzeyini artırdığını önemle vurgulamaktadırlar. Oloyede (2012), tüm çocukların, en iyi, kişisel deneyimlerine dayalı uygulamalarla öğrendiklerini belirtmekte ve zihinsel gelişimle ilgili bir araştırmaya dayalı olarak iki temel öneride bulunmaktadır. Bunlar; 1) Öğrenciler, üniversiteye somut işlemler döneminde geldikleri için, kavramların anlamlı yapılanmasını sağlamak amacıyla, öğrencilerin deneyimlerinden yola çıkarak şekillendirilen örnekler kullanılmalıdır. 2)Öğrencilerin anlama düzeylerini ve kavram yanılgılarını belirlemek, var olan yetersiz zihinsel modellerinin dengesini alabora etmek ve bu modelleri daha uygun modellerle değiştirmek için öğrenciler tartışmalara sokulmalıdır.

Tüm bu çalışmalara dayanarak, öğretmen adaylarının mantıksal düşünme düzeylerini ve dolayısıyla somut işlemler döneminden soyut işlemler dönemine geçişi artırmak için eleştirel, yaratıcı düşünmenin desteklendiği, işbirlikli öğrenme etkinlikleriyle zenginleştirilmiş, öğrencilerin aktif olacakları, bilgiyi oluştururken bizzat kendi deneyimlerinden yararlanacakları öğrenme ortamları düzenlenmelidir. Fakat öğrenme ortamları düzenlenirken, Piaget'nin kuramına göre soyut işlemler döneminde olması gereken ama yarıdan fazlası geçiş, geri kalanı da somut dönemde olan öğretmen adaylarının bilişsel gelişim düzeyleri mutlaka göz önünde bulundurulmalıdır.

Anahtar Sözcükler: Bilişsel gelişim, Fen bilgisi öğretmen adayları, GALT, Mantıksal düşünme, Piaget

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