



Longitudinal Investigation of Elementary Students' Science Academic Achievement in 4–8th Grades: Grade Level and Gender Differences

Murat BURSAL^a

Cumhuriyet University

Abstract

This study investigated the change of the science academic achievement by grade level and gender where 222 elementary students' science and technology course scores between the 4th and 8th grades and science success percentages in 6th and 8th grades Level Determination Exam were longitudinally analyzed. Based on the findings of this study, consistent with the results of the national achievement tests, a significant decrease was observed in elementary students' science academic achievement as their grade level increased. From the analysis of the changes in science academic achievement by gender, a significant difference between the 4-8th grade science scores was found out. Based on the comparisons for each grade level, girls were consistently found to have at least slightly higher science success than boys; furthermore, it was observed that this difference became statistically significant as the grade level increased. In light of the findings of this study, recommendations were listed for enhancing the low science academic achievement of elementary students, and about closing the gap between genders, which was emphasized among the goals of the new science and technology teaching program.

Key Words

Science Academic Achievement, Longitudinal Study, Elementary Students, Science and Technology Course, Level Determination Exam.

The purpose of a teaching program is the major factor determining the content of the program and also the teaching and evaluation methods that are used (Demirel, 2011). The Ministry of Education employed a new science and technology course teaching program starting from the 2006-2007 academic year and it was aimed that student-centered constructive learning approach would replace the traditional teaching applications. Considering the individual differences in student-centered teaching, the vision of the program was announced as "whatever individual differences are present, the goal of the program is to prepare students as scientifically literate" (MEB, 2006, p.5). Therefore, it is crucial to investigate whether the program fulfills its goals for all student profiles.

A common source of individual differences, which is aimed to be eliminated, is the science achievement gap between girls and boys. The international literature on the science achievement of students usually reports findings in favor of boys (Bacharach, Baumeister, & Furr, 2003; Evans, Schweingruber, & Stevenson, 2002; Keeves, 1992; Nosek et al., 2009), however some researchers report that there is no achievement gap in terms of gender (Cole, 1997; Keeves). Among the studies comparing the success of boys and girls in different subject areas, some of them conclude that boys perform better in areas like mathematics and science and girls perform better in language and arts (Evans et al.; Hedges & Nowell, 1995), however there is a growing number of studies (Goldin, Katz, & Kuziemko, 2006; Spelke, 2005)

- a** Murat BURSAL, Ph.D., is currently an assistant professor at the Department of Elementary Education. His research interests include preservice teachers' self-efficacy beliefs and sources of efficacy beliefs, cooperative learning, graphic literacy and scale development in educational studies. Correspondence: Cumhuriyet University, College of Education, Department of Elementary Education, 58140 Sivas, Turkey. E-mail: mbursal@cumhuriyet.edu.tr Phone: +90 346 2191010/2264.

reporting that science related skills and interest in science do not differ between girls and boys.

The science achievement level between girls and boys is also a significant concern for large-scaled international studies conducted by International Association for the Evaluation of Educational Assessment [IEA] and Organization for Economic Co-operation and Development [OECD]. The First International Science Study [FISS] was conducted in 19 countries in 1970-71 and the Second International Science Study [SISS] was conducted in 23 countries in 1983-84 by IEA. The common finding of these studies about science achievement was that, boys performed better than girls in all countries and the achievement gap widens as the grade level increases (Çakıroğlu, 1999; Keeves, 1992).

According to the 1995 Trends in International Mathematics and Science Study [TIMSS] report, 4th grader boys performed better in science than girls in about half of the participant countries, while 8th grader boys performed better in science than girls in most of the participant countries. These results indicated that, as the grade level increased, the science achievement gap between boys and girls increased in favor of boys (Mullis et al., 2000). The high science achievement level of boys in 1999 TIMSS (Martin et al., 2000), has disappeared in the 2003 study among 4th graders (Martin, Mullis, Gonzales, & Chrostowski, 2004). After the 2007 TIMSS, it has been reported that in some countries, including Turkey, girls outperformed boys (Martin et al., 2008). Turkey has participated in the 1999 and 2007 TIMSS, but performed lower than the international average in both studies (Eğitimi Araştırma ve Geliştirme Dairesi [EARGED], 2003; Martin et al., 2008).

Similar to the TIMSS results, it can be observed from PISA results that girls have closed the science achievement gap by time and started to outperform boys. In 2003 PISA study, compared to only 3 countries where girls outscored boys in science, boys performed better than girls in 13 countries (OECD, 2004). In 2006 PISA study, science achievement difference in favor of boys has been observed in 8 countries, whereas differences in favor of girls were observed in 12 countries (OECD, 2007). Although significant differences in mathematics and reading achievement in terms of gender have been reported in 2009 PISA study, it has been concluded that there is a minor difference in science achievement of boys and girls (OECD, 2010). Turkey has participated in PISA studies, but performed lower than the OECD average in all three studies (EARGED, 2005, 2007a, 2010).

In the national context, starting from the 2002, the Ministry of Education has been conducting the student achievement level determination study (Öğrenci Başarılarını Belirlenmesi Sınavı [ÖBBS]) where students are tested in the following subject areas: Turkish, Mathematics, Science and Social Sciences. Based on the three consecutive studies, it has been concluded that no significant difference in science achievement of girls or boys has been observed (EARGED, 2002, 2007b, 2009).

Purpose and Significance of the Study

In almost all previous studies on science academic achievement, one-shot research design has been used and the use of different samples in measurements is the major limitation for generalizing the findings of these studies. To be able to have a better understanding about the change of students' science achievement throughout the elementary years, studies using the same sample in all measurements from 4th to 8th grades as a longitudinal study are needed.

Longitudinal studies are rarely conducted in the literature due to mortality of the sample and required time period (Fraenkel & Wallen, 2003; Karasar, 2008). Probably due to this reason, no previous longitudinal study on the science achievement change of elementary students has been located in the literature. Therefore, the findings of this study, where the science achievement of the same sample from 4th to 8th grades are investigated, would provide a significant contribution to the literature. The research problems and related sub-problems investigated in this study are:

1. How the science and technology course scores of elementary students change from 4th to 8th grades?
 - a. Is there any significant difference in the change of the science and technology course scores of elementary students from 4th to 8th grades in terms of class level?
 - b. Is there any significant difference in the change of the science and technology course scores of elementary students from 4th to 8th grades in terms of gender?
 - c. Is there any significant difference in the science and technology course scores in terms of gender in any class level between 4th and 8th grades?
2. How the Level Determination Exam (SBS) science test success of elementary students change from 6th to 8th grades?

- Is there any significant difference in the change of the Level Determination Exam (SBS) science test success of elementary students from 6th to 8th grades in terms of class level?
- Is there any significant difference in the change of the Level Determination Exam (SBS) science test success of elementary students from 6th to 8th grades in terms of gender?
- Is there any significant difference in the Level Determination Exam (SBS) science test success in terms of gender in any grade level between 6th and 8th grades?

Method

Research Design

This study was designed as a longitudinal study (Karasar, 2008), where a group of elementary students' science and technology course scores between 4-8th grades and their science success in the Level Determination Exam (SBS) were investigated by their gender and grade level.

Sample

The participants of this study were 222 elementary students (116 boys and 106 girls) from the Yozgat city, Kadişehri province of Turkey. The participants were selected with purposive sampling method among 448 students and the selection criteria was having full access to the science course scores from 4th to 8th grades and Level Determination Exam (SBS) results from 6th to 8th grades.

Data Analysis

The research problems about the longitudinal change (Problem 1a, 1b, 2a and 2b) were investigated with repeated measures ANOVA and multivariate tests. When the comparisons were done for multi grade-levels (Problem 1c and 2c), multivariate ANOVA [MANOVA] tests were used. The significance level was used as $\alpha=.05$ in all statistical analyses. When MANOVA was used, the Bonferroni correction method was employed, where the alpha level was divided by the number of dependent variables to ensure that the total error rate does not exceed the 5% level (Pallant, 2007).

Findings

Problem 1. a. Is there any significant difference in the change of the science and technology course scores of elementary students from 4th to 8th grades in terms of class level? From the data in table 1, it can be seen that students' course scores are above 70 in the 4th and 5th grades, but their scores decrease in upper class levels. Based on the multivariate test results, the decrease in the course scores between 4th and 8th grades has been found to be statistically significant [Wilks' Lambda=0.67; $F(4,217)=27.03$; $p<.001$; Eta-Squared=.33]. The effect size for this analysis indicates that grade level has a large effect size (Cohen, 1988) on the change of the science course scores. The pairwise multiple comparisons test results show that although the course scores do not differ between grades of 4,5 and 6, the course scores in the 7th and 8th grades are significantly lower ($p<.001$) than those in previous grades.

Problem 1. b. Is there any significant difference in the change of the science and technology course scores of elementary students from 4th to 8th grades in terms of gender? When the change of the science course scores by gender is checked in table 1, it is clear that, both genders experience decreases as the grade level increases. On the other hand, compared to girls, boys seem to experience a sharper decrease especially after the 6th grade. The multivariate test results indicate that there is a significant difference in the change of the science course scores of boys and girls [Wilks' Lambda=0.95; $F(4,217)=2.68$; $p=.03$; Eta-Squared =.05]. The effect size for this analysis indicates that gender has a medium effect size (Cohen, 1988) on the change of the science course scores.

Table 1.
Science and Technology Course Scores of Elementary Students between 4-8th Grades

	Girl (n = 106)		Boy (n = 116)		Total (n = 222)	
	Mean	s	Mean	s	Mean	s
4th Grade	73,3	12,05	71,9	13,65	72,6	12,90
5th Grade	72,7	12,88	72,4	14,95	72,5	13,97
6th Grade	72,3	11,75	69,7	15,42	71,0	13,82
7th Grade	68,7	11,47	64,4	13,97	66,4	12,99
8th Grade	69,0	13,91	63,2	14,70	66,0	14,59

Problem 1. c. Is there any significant difference in the science and technology course scores in terms of gender in any class level between 4th and 8th grades? As can be seen from Table 1, girls have higher science course scores than boys in all grade levels. The MANOVA results indicate that while there is no difference between boys and girls among 4-7th grades, a significant difference in favor of girls has

Table 2.
Level Determination Exam (SBS) Science Test Success Ratios of Elementary Students between 6-8th Grades

	Girl (n = 106)		Boy (n = 116)		Total (n = 222)		National'	
	Mean	s	Mean	s	Mean	s	Mean	s
6th Grade	41,1	19,67	33,0	23,20	36,9	21,91	39,9	3,98
7th Grade	27,5	23,95	24,2	27,83	25,8	26,04	26,5	5,26
8th Grade	39,1	23,67	35,4	25,78	37,2	24,67	35,6	5,66

*: Source: (MEB, 2009, 2010, 2011)

been obtained for 8th grade [$F(1, 220)=9.03, p=.003$; Eta-Squared =.04]. The effect size for this analysis indicates that gender has a medium effect size (Cohen, 1988) on the 8th grade level science course scores.

Conclusion and Discussion

Science Achievement and Grade Level

This study has investigated the changes in the science achievement of elementary students from 4th to 8th grades. Although no significant difference was found between 4-6th grades, the course scores in 7th and 8th grades were found to be significantly lower than the previous grades. This finding is consistent with the related studies, where science achievement was found to decrease as the grade level increases (EARGED, 2002, 2007b, 2009). Another notice worthy finding of this study is that, both the participants of this study and the overall elementary student population in Turkey have lower than 50% success in science tests. Combined with the low science achievement scores of Turkish students in international (EARGED, 2005, 2007a, 2010; Martin et al., 2000, 2008) and national (EARGED, 2002, 2007b, 2009) tests, the findings of this study show that Turkish elementary students' science achievement levels are very low.

The decrease in science achievement in upper grades can be associated with various factors. The current science and technology course teaching program starts with everyday topics in grades 4 and 5, such as living organisms and physical events, but focuses on more abstract topics in grades 6-8 (Bahar, 2006). The increasing abstract nature of the topics in 8th grade, such as the structure of atom, chemical binding, cell division etc., possibly make it difficult for students to understand the course topics. Even though using teaching materials in the science classroom would help students understand the abstract concepts, studies conducted with preservice an inservice science teachers report that teachers usually lack effectively using materials in science classes (Bursal & Yiğit, 2012; Karamustafaoğlu, 2006; Korkmaz, 2011).

Science Achievement and Gender

A second purpose of this study was to investigate the change of science achievements of elementary students by their gender. While both genders lower their science success in upper grades, girls experience comparatively higher scores than boys as the grade level increases due to a sharper decrease in boys. As a result of these differences, girls significantly outperformed boys in the 8th grade. These results are consistent with previous international TIMSS (Martin et al., 2008), PISA (OECD, 2007, 2010) and national (EARGED, 2007b, 2009) studies reporting a higher science achievement in favor of girls.

According to Bloom (1976), attitudes are one of the major indicators of a person's success in a subject area and he developed a hypothesis that 25% of the variance in success can be explained by the attitudes of a person. This hypothesis was tested by many researchers, and although they did not usually obtain the same ratio, it has been well stated that attitudes toward science and science achievement are related (Evans et al., 2002; Keeves, 1992; Mattern & Schau, 2002; Papanastasiou & Zembylas, 2002; Weinburgh, 1995). Unlike the past studies, the recent studies about the impact of gender on attitudes toward science, no more conclude in favor of males, not only in Turkey (Akman, İzgi, Bağçe, & Akıllı, 2007; Kozcu Çakır, Şenler, & Göçmen Taşkın, 2007; Turhan, Aydoğdu, Şensoy, & Yıldırım, 2008) both also in the world (Cole, 1997; Greenfield, 1997; Sorge, 2007; Spelke, 2005). Furthermore, significant differences in terms of gender are now mostly in favor of girls (Mıhladız, Duran, & Doğan, 2011; Serin, 2010; Uzun & Keleş, 2010; Yaman & Dede, 2007; Yaman & Öner, 2006; Yavuz Göçer, Sungur, & Tekkaya, 2011; Yılmaz & Huyugüzel Cavaş, 2007). In light of these studies, it can be argued that the higher science achievement of girls, compared to boys, can be explained by their more positive attitudes toward science.

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