Eğitim ve Bilim
2014, Cilt 39, Sayı 172
Geniş Ölçekli Test Uygulamaları Özel Sayısı

Education and Science
2014, Vol. 39, No 172
Large-Scale Assessment Special Issue

The Multilevel Effects of Student and Classroom Factors on the Science Achievement of Eighth Graders in Turkey

Türkiye'de Sekizinci Sınıf Öğrencilerinin Fen Başarısına Öğrenci ve Sınıf Faktörlerinin Çok Düzeyli Etkileri

Mehmet İkbal YETİŞİR[1]
Ankara University

Abstract

This study investigated the science achievement of eighth graders in Turkey in terms of the relationship of science achievement with the selected student- and classroom-level variables, and modeled the relationship among these variables. The TIMSS 2011 data were used for this purpose. A hierarchical linear model was used to analyze the data. The results of the analysis revealed that the variance in science achievement among eighth-grade classrooms is statistically significant. The variance is about 32%. The result also showed that while attitudes towards science and parents' level of education are positively related to science achievement, student engagement has no relation with science achievement. Furthermore, the analysis showed that while teacher collaboration and inquiry-related activities do not have a statistically significant effect; class average-engagement and readiness to learn have a significant effect on science achievement.

Keywords: Science achievement, TIMSS, engagement, inquiry-related activities, readiness to learn

Öz

Bu çalışma, Türkiye'deki 8. sınıf öğrencilerinin fen başarısını öğrenci ve sınıf düzeyindeki değişkenlerle ilişkisi bakımından incelemekte; bu değişkenler arasındaki ilişkiyi modellemektedir. Bu amaçla TIMSS 2011 uygulamasından elde edilen veriler HLM (hierarchical linear model) kullanılarak analiz edilmiştir. Yapılan analizler sonucunda sekizinci sınıflar arasında fen başarı varyansının %32 olup istatistiksel olarak anlamlı olduğu ortaya çıkmıştır. Çalışmada ayrıca, fene ilişkin tutum ve ebeveynlerin eğitim durumunun fen başarısı ile pozitif yönde bir ilişkisi olduğu; ancak öğrencilerin derse katılımı ile fen başarıları arasında anlamlı bir ilişkinin olmadığı bulgusuna ulaşılmıştır. Yapılan analizler sonucunda, öğretmen işbirliğinin ve araştırmaya dayalı etkinliklerin fen başarısı üzerinde istatistiksel olarak anlamlı bir etkisi bulunmazken; öğrencilerin derse katılımına ilişkin sınıf ortalamasının ve öğrenmeye hazır bulunuşluğun fen başarısı üzerinde anlamlı bir etkisi olduğu ortaya çıkmıştır.

Anahtar Sözcükler: Fen başarısı, TIMSS, derse katılım, araştırmaya dayalı etkinlikler, öğrenmeye hazır bulunuşluk

[1] Assist. Prof. Dr. Mehmet İkbal YETİŞİR, Ankara University, Faculty of Educational Sciences, SSME Department; mehmetikbal@yahoo.com

Introduction

Science and mathematics education have been occupying a prestigious position in many countries' school curricula. This is because; most educational systems consider these subjects fundamental to transform their societies into technologically skilled ones. In this respect, IEA (International Association for the Evaluation of Educational Achievement) has been measuring student achievement, and collecting related contextual data to figure out student learning in both subjects (Mullis et al., 2003). The results of large-scale studies (TIMSS, PISA, PIRLS, etc.) or small-scale studies point out that student achievement is affected by multiple factors that originate from various related social layers.

Much research has been conducted to explain the variance in science achievement, and to determine potential contextual variables. Educators and policy-makers are interested in improving students' science achievement at schools. The TIMSS studies after 2005 present great opportunities for understanding the effects of the reforms in science education in Turkey (MEB, 2005). In this context, particularly TIMSS 2011 has a potential to provide more significant data. TIMSS collects a range of information about the context of gaining scientific knowledge. The contextual factors associated with students' science achievement encompass five areas: (1) students, (2) teachers, (3) classroom, (4) school, and (5) curriculum.

Within the scope of the TIMSS assessments, which have been conducted in many countries so far, a strong positive relationship has been reported between students' attitudes toward science and their science achievement (Martin et al., 2012). Similarly, a wide range of studies indicate that attitude towards science is closely linked to science achievement (Weinburgh, 1995; Simpson & Oliver, 1990; Osborne & Collins, 2000; Mo et al., 2013). Attitude towards science can be seen as one of the important student factors. Researchers working on science education have focused for a long time on the investigation of the relationship between students' science achievement and their attitudes towards science. Although there is much research related to the concept of attitude towards science, it is somewhat nebulous, often poorly articulated, and not well understood (Osborne et al., 2003).

Student engagement can be seen another important student factor which has been included in TIMSS 2011 in order to investigate its relationship with science achievement. A number of different definitions related to student engagement can be seen in the literature (Newman et al., 1992; Fredricks et al., 2004; McLaughlin et al., 2005; Mo et al., 2013). According to Newman et al., student engagement can be defined as "*student's psychological investment in and effort directed toward learning, under-standing, or mastering the knowledge, skills, or crafts that academic work is intended to promote*" (1992; p.12). Newman et al. contended that student engagement includes both emotional and behavioral factors. In science learning, *behavioral engagement* can be specified as the completion of science assignments, participation in science classes and experiments, and performing extra science work. *Emotional engagement* can be defined as having an interest in and efficacy toward science (Mo et al. 2013). Fredricks and her colleagues (2004) contended that there are three dimensions of student engagement: emotional engagement, behavioral engagement and cognitive engagement. However, McLaughlin and her colleagues (2005) had a different approach and defined "student content engagement" in this regard. According to their work, student content engagement can be characterized in terms of students' in-the-moment engagement with instructional content. The concept of 'student content engagement' emphasizes bringing the student and the subject matter content together. Consistently, the TIMSS 2011 International Results in Science refers to engagement as the interaction between the student and the instructional content, which may take the form of listening to the teacher or providing an explanation of a problem solution (Martin et al., 2012).

Teacher collaboration is also considered a significant variable which can affect student achievement. Strengthening the relationship among school teachers is important for increasing student achievement in the school context (Avalos, 1998; Utley, Basile & Rhodes, 2003). The concept of teacher collaboration has been investigated in connection with various concepts such as professional community (Louis & Marks, 1998), learning community (McLaughlin & Talbert, 2001), professional learning community (Bolam et al., 2005; A. Hargreaves, 2007), and teacher networks (e.g., Adams, 2000; Lieberman & McLaughlin, 1992; Smith & Wohlstetter, 2001). In the context of TIMSS 2011, the concept of collaboration is considered as the idea of collaboration for the purpose of improving teaching. The studies investigating the relationship between professional community and student achievement report that there are significant effects ranging from small to medium. On the same token, after a meta-analysis of the studies investigating the effects of professional community on student achievement, Lomos (2011) and her colleagues indicated that there is a small but positive effect.

Another important factor which can have an effect on student achievement is parents' level of education. Academic studies consistently show a strong positive relationship between student achievement and parents' level of education (Chevalier, 2004; Haveman, et al., 1995; Schnabel et al., 2002). It is generally accepted that higher levels of parental education can lead to higher-paying occupations, higher socioeconomic status, and more home resources. Although parents' level of education and income/socioeconomic status are considered together in the literature in terms of their effects on student achievement; the total effect of parents' educational attainment is much stronger than that of income on student achievement (Sirin, 2005; Davis-Kean, 2005). Correspondingly, TIMSS, PIRLS, and PISA have found strong positive relationships between parents' level of education and the achievement of their children (Martin, 2012).

In addition to attitudes towards science; student engagement, teacher collaboration, and parents' level of education, inquiry-based instruction are also considerable factors affecting student achievement. Most of the contemporary science curricula across the world dramatically put emphasis on engaging students to the class process through inquiry based activities. Realizing the nature of science depends mostly on inquiry processes. Accordingly, to an important extent, contemporary science curricula encourage the use of inquiry-based learning for providing a better grasp of the concepts and processes of science. According to Munck (2007), teachers have to possess the skills related to inquiry-based instruction rather than traditional pedagogy. By analyzing 138 reports, Minner and her colleagues (2009) revealed that there is a positive relationship between inquiry-based instruction and student achievement.

Student readiness, in addition to the aforementioned variables, is a highly discussed variable which is thought to be closely related to student achievement. The TIMSS results indicated the importance of student characteristics in describing variances in science achievement. In terms of its effects on learning environment, student characteristics (as part of readiness) are of crucial importance. Referring to the literature, TIMSS 2011 included some student characteristics such as lack of prior knowledge, lack of nutrition, sleep duration, students' disinterestedness for their effects on science achievement. Besides TIMSS results, the related literature also emphasizes their impacts on achievement (Jones & Byrnes, 2006; Johnson & Lawson, 1998; Powell et al., 1998; Brown et al., 2008; Curcio et al. 2006; Morales, 2013).

In Turkey, any study which takes into consideration all of these variables, of which the relationship with science achievement is briefly discussed above, is yet to exist. It is hoped that revealing the effects of these variables on science achievement, together with the existing literature, will contribute to better understanding of the variance in the science achievement of students. In sum, the purpose of this study was to estimate the effect of student class average-engagement, teacher collaboration, inquiry-based activities and student readiness to learn on the science achievement of eighth graders who participated in TIMSS 2011 in Turkey. Also some student-level factors such as attitude toward science, parents' level of education and student engagement were included in the study to better estimate the effect of the classroom-level variables. The student-level variables are closely associated with achievement as explained above.

Research questions:

The study aims to answer the following questions:

1. Does science achievement vary significantly among eighth graders in Turkey?
2. Do attitude toward science, parents' level of education and student engagement affect science achievement in Turkey?
3. Are teacher collaboration, inquiry-related activities, readiness to learn and engagement associated with achievement at the eighth grade stable in the subject?

Research Methods and Procedures

Data Source

The data used in this study were derived from TIMSS 2011. TIMSS studies are the largest international comparative studies which mainly assess trends in the science and mathematics achievement of students at fourth and eighth grades in the related context. TIMSS 2011 was the fifth in the series of TIMSS studies. The sample design preferred in the TIMSS studies is generally referred to as a two-stage stratified cluster sampling design. As this research was concerned with Turkish eighth graders, the data related to eighth graders which include schools and science teachers' responses were used in this study. The responses of 6928 eighth graders and 239 science teachers were analyzed in an attempt to answer the research questions. The data were collected by the TIMSS 2011 student questionnaire, the TIMSS 2011 teacher questionnaire, and the student achievement test in science. The questionnaires and tests were developed and validated by TIMSS 2011 (Martin & Mullis; 2012).

Dependent Variables

The dependent variable in this study is the science achievement of students. The science test has two dimensions – the content dimension specifying the domains (physics, chemistry, biology and earth science) to be assessed within science, and the cognitive dimension specifying skills and sets of behaviors (i.e., knowing, applying, and reasoning). To define the science proficiency level of students depending on their answers, the IRT (Item Response Theory) method was used. All science plausible values were used in the analysis (Martin et al., 2012).

Level-1(Student-level) independent variables:

Attitude toward science, parents' level of education and student engagement were employed at student level.

Attitude toward science. TIMSS 2011 included three scales about motivational constructs to identify students' attitude toward science: intrinsic value (interest), utility value and ability beliefs. In this study, twenty items from the TIMSS 2011 student questionnaire were selected to identify students' attitude toward science. Some examples of the selected items were: "I enjoy learning <science>", "I usually do well in <science>", "I think learning <science> will help me in my daily life" (Martin et al., 2012). The positive items were coded as 1=disagree a lot; 2=disagree a little; 3=agree a little, and 4=agree a lot. The negative items were reverse-coded. Cronbach's alpha was 0.90 for the attitude toward science scale.

Parents' level of education. There was a question in the TIMSS 2011 student questionnaire asking to the students about their parents' level of education. Their responses to the question about their parents' level of education ranged from "Did not go to school or did not complete first stage of primary education" to "Tertiary education, second degree (MS/MA, PhD)".

Engagement. The data related to student engagement in science classes were originally available on the *Engaged in Science Lessons* scale through the TIMSS 2011 student questionnaire. The student responses were scored according to their degree of agreement about the five statements on the scale. Some example statements were: "My teacher is easy to understand", "l know what my teacher expects met to do" and "I am interested in what my teacher says". The items were coded as 1=disagree a lot; 2=disagree a little; 3=agree a little; 4=agree a lot. Cronbach's alpha for the scale was 0.66.

Level-2 (Classroom-level) independent variables:

Four classroom-level variables (teacher collaboration, inquiry, class average - engagement, and readiness to learn) were selected to be used in the analytic model.

Collaboration. The TIMSS 2011 teacher questionnaire included the Collaborate to Improve Teaching scale. The scale was designed to focus on the idea of collaboration for the purpose of improving teaching (Martin et al., 2012). Therefore, the Collaborate to Improve Teaching scale was based on the frequency of teacher interaction with other teachers concerning each of the five areas. Some of them were: "Discuss how to teach a particular topic", "Collaborate in planning and preparing instructional materials", "Share what I have learned about my teaching experiences". Teachers' responses on each item were coded as 1=never or almost never; 2=2 or 3 times per month; 3=1-3 times per week; 4=daily or almost daily. Cronbach's alpha for the Collaborate to Improve Teaching scale was 0.80.

Inquiry-related activities. The Emphasize Science Investigation scale at the eighth grade is based on the responses of science teachers to the question on how often they engage in the seven activities. Some examples of the scale were: "Use scientific formulas and laws to solve routine problems", "Observe natural phenomena such as the weather or a plant growing and describe what they see", "Watch me (the teacher) demonstrate an experiment or investigation". Teachers' responses on each item were coded as 1=never; 2= some lessons; 3=about half the lessons; 4=every or almost every lesson. Cronbach's alpha for the Emphasize Science Investigation scale was 0.71.

Students' readiness to learn. Some of the characteristics associated with students are of great importance in the context of student's readiness to learn. TIMSS 2011 included some student characteristics such as healthy breakfast, sleep duration, prerequisite knowledge or skills, disruptive or uninterested students in terms of their relation to readiness to learn. Some examples of the related items were: "Students suffering from lack of basic nutrition", "Students lacking prerequisite knowledge or skills", "Students suffering from not enough sleep". Teachers' responses on each item were coded as 4=not a lot, 3=some, 2=a lot. Cronbach's alpha for the Student Readiness to Learn was 0.70.

Class Average – Engagement. The data related to student engagement in science classes were aggregated from the student level to the classroom level. The data were originally available on the *Engaged in Science Lessons* scale of the TIMSS 2011 student questionnaire. Some details about the scale are mentioned above.

Descriptive statistics and bivariate correlations of the variables are shown in the Table-1 for both levels.

Table 1.
Descriptive Statistics and Bivariate Correlations

	M	SD	1	2	3	4
Student level (n=6928)						
1. Attitude toward science	3.10	0.58	-			
2. Parents' level of education.	2.09	1.28	0.09	-		
3. Engagement	3.22	0.61	0.69	0.05	-	
4. Science achievement	483	103	0.32	0.37	0.24	-
Class level (n=237)						
1. Collaboration	2.17	0.62	-			
2. Inquiry-related activities	3.06	0.48	0.26**	-		
3. Student readiness to learn	2.87	0.38	0.03	-0.01	-	
4. Class average - engagement	3.21	0.24	0.02	0.17*	0.07	-

Note: **p<.01; *p<.05

Missing values were imputed using expectation-maximization (EM) algorithm in SPSS 15.0 before the analyses. Because of there aren't any data in the teacher data file belonging to teachers from two school, the number of schools was 237.

Analytical Models

Historically, people in most cases are inclined to live within organizational structures. For example, in the educational sector, students exist within a hierarchical social structure that can include family, peer group, classroom, grade level, school, school district, state, and country (Osborne, 2000). Traditional techniques and methods of analyzing data from such nested structures ignore the characteristic dependencies. Consequently, applying an ordinary least squares regression analysis to the nested structure fails and the Type I error is likely to be inflated (Raudenbush & Bryk, 2002; Young et al., 1996).

HLM overcomes these problems by modeling both levels (student level and classroom level) of the nested structure. HLM simultaneously investigates relationships within and between hierarchical levels of grouped data, thereby making it more efficient at accounting for variance among variables at different levels than other existing analyses (Woltman et al., 2012).

In order to avoid errors mentioned above, HLM analysis was conducted to investigate the relationships between student and classroom levels of grouped data related to science achievement at schools. For the analysis, the following three HLM models were run:

1. Fully unconditional model (ANOVA with random effects)
2. Partially conditional model (random coefficient model)
3. Fully conditional model (intercepts and slopes as outcomes model)

Fully unconditional- Unconstrained model. As the first step, fully unconditional model was run. This preliminary model is equivalent to a one-way ANOVA with random effects (Saed & Hammouri, 2010). The aim here is to confirm that the variability in the outcome variable, by classroom level (level-2) group, is significantly different from zero. This tests whether there are differences at the group level on the outcome variable, and confirms whether HLM is necessary or not (Woltman et al., 2012). In the fully unconditional model following equations are used:

Level 1 model (student level): $Y_{ij} = \beta_{0j} + r_{ij}$, $Var(r_{ij}) = \sigma^2 =$ within group variance in science achievement.

Level 2 model (classroom level): $\beta_{0j} = \gamma_{00} + u_{0j}$, $Var(u_{0j}) = \tau =$ between group variance in science achievement.

For the student level model, β_{0j} indicates the mean of science achievement in classroom j; and r_{ij} indicates the error variance for student i in classroom j. For the classroom level model, γ_{00} represents grand mean science achievement; u_{0j} represents the random effect associated with classroom j (Raudenbush & Bryk, 2002).

Random intercepts model (Partially conditional model). This model tests the relationship between the student level predictor variable and the outcome variable (science achievement) and the relative strength of the effects of level-1 variables (Woltman et al., 2012; Raudenbush & Bryk, 2002). The equations of partially conditional model are:

Level 1 model (student level): $Y_{ij} = \beta_{0j} + \beta_{1j}(Attitudes) + \beta_{2j}(Parents'Education) + \beta_{3j}(Engagement) + r_{ij}$, $Var(r_{ij}) = \sigma^2$

Level 2 model (classroom level): $\beta_{0j} = \gamma_{00} + u_{0j}$, $Var(u_{0j}) = \tau_{00}$; $\beta_{1j} = \gamma_{10} + u_{1j}$ $Var(u_{1j}) = \tau_{11}$; $\beta_{2j} = \gamma_{20} + u_{2j}$ $Var(u_{2j}) = \tau_{22}$; $\beta_{3j} = \gamma_{30} + u_{3j}$ $Var(u_{3j}) = \tau_{33}$

In the models above, σ^2 represents the level-1 residual variance; γ_{00} represents average classroom means on science achievement across the population of classrooms. The increment regarding classroom j is represented as u_{0j}. $\gamma_{10}$is the mean slopes (between attitude and science achievement); the increment to the slope related to classroom j is represented as u_{1j}. γ_{20} represents the mean slopes between parents' education and science achievement; the increment to the slope related to classroom j is represented as u_{2j}. γ_{30} represents the mean slopes between student engagement and science achievement; the increment to the slope related to classroom j is represented as u_{3j} (Saed & Hammouri, 2010).

Fully conditional model (Means as outcomes model). Fully conditional model examines whether level-2 factors affect the average science achievement of students within the same classroom, and how much variance in science achievement among classrooms could be explained by these level-2 factors.

The equations used in this model are:

Level 1 Model (student level):$Y_{ij} = \beta_{0j} + \beta_{1j}(Attitudes) + \beta_{2j}(Parents'Education) + \beta_{3j}(Engagement) + r_{ij}, Var(r_{ij}) = \sigma^2$.

Level 2 Model (classroom level): $B_0 = \gamma_{00} + \gamma_{01}(collaboration) + \gamma_{02}(ready\ to\ learn) + \gamma_{03}(Inquiry) + \gamma_{04}(Class\ Avarage - Engagement) + u_{0j}$

Results

The results of the fully unconditional model, partially conditional model and fully conditional model are presented in the following sections.

Results Related to the First Research Question

The fully unconditional model was used to answer the first research question. The results related to the first research question are shown in Table-2. The results showed that the average class science achievement mean (γ_{00}) was 484.49. There was a significant between-class variance in science achievement. For example, the between-class variability in science was 3441.77 and the within-class variability was 7297.60. The results of the analysis indicate that x^2(236) =3373.72, p<0,001, which supports the use of hierarchical linear modeling.

In the next step, the intraclass correlation (ICC) for the subject is found as 0.32. ICC can be calculated to estimate which percentage of the variance in science achievement is attributable to group membership and which percentage is at the individual level. The ICC result suggests that 32% of the variance in science achievement is at the group level.

Table 2. *Results of Fully Unconditional Model for Science Subject*

γ_{00} (Grand mean)	484.49
Between-class variability (τ)	3441.77
Within-class variability across all students (σ^2)	7297.60
Intraclass correlation (ICC)	0,32

Results Related to the Second Research Question

The partially conditional model was used to answer the second research question. The results of the HLM analysis for partial conditional model are shown in Table 3. The results showed that the association between the mean of parents' educational level and the mean of science achievement was statistically significant (γ_{10}=10.64, p<0.001), even when controlling for the attitudes towards science and student engagement. In other words, a one SD increase in parents' educational level was significantly associated with a 10.64-point increase in science achievement.

Table 3. *The Effects of Student-level Variables on Science Achievement.*

Fixed effect	Coefficient	SE	p-Value
Overall mean achievement (γ_{00})	484.49	4.67	0.000
Mean parents' education - achievement slope (γ_{10})	10.64	1.14	0.000
Mean attitudes - achievement slope (γ_{20})	49.85	3.29	0.000
Mean Engagement*- achievement slope (γ_{30})	5.52	3.38	0.105

Random Effect	Var. component	p-Value
Intercept U_0	3492.13	0.000
Parents' education - achievement slope, U_1	39.61	0.006
Attitudes - achievement slope, , U_2	349.53	0.002
Engagement* - achievement slope, U_3	560.80	0.000
Level-1 effect, r_{ij}	6013.09	

* *Student reported*

Under the control of parents' educational level and student engagement, the results also revealed that students' attitudes toward science were significantly associated with science achievement (γ_{20}=49.85, p<0.001). Besides the effect of parents' level of education, a one SD increase in attitude toward science subject was significantly associated with a 49.85 -point increase in science achievement. Consequently, students with higher scores on attitudes towards science, higher engagements and higher levels of parental education had higher science achievement scores.

The random effect section in Table-3 showed that there were significant (α <0.05) variances in parents' education level-achievement slopes among classrooms for science subject. Further, there was also a significant (α <0.05) variance in the strength of association between attitudes towards science and science achievement among classrooms for students who had the same level of parental education. The significant p-value indicated that the relationships of attitudes, parental education, and engagement with achievement had different strength (α <0.05) among classrooms.

Results Related to the Third Research Question

The fully conditional model was used to answer the third research question. The results of the HLM analysis related to third research question (Table 4) showed that teacher collaboration had no statistically significant effect on science achievement (γ_{02}=-1.33 and p=0.815). As expected, student engagement to science classes had a significant positive effect on science achievement (γ_{01}=98.05, p=0,000). Similarly, students' readiness to learn had a significant positive effect on science achievement (γ_{04}=34.91, p=0,001).

Surprisingly, inquiry-related activities had no significant effect on science achievement (γ_{03}=0.25, p=0.976). The results of fully conditional model showed that the variations in science achievement were significant even after controlling for collaboration, readiness to learn, inquiry and student engagement.

Table 4.
Estimating Effects of Classroom-level Variables on Science Achievement

Fixed effect	Coefficient	SE	p-Value
Intercept	483.58	4.36	0.000
Class average - engagement* (γ_{01})	98.05	20.25	0.000
Collaboration (γ_{02})	-1.33	5.66	0.815
Inquiry (γ_{03})	0.25	8.06	0.976
Readiness to learn (γ_{04})	34.91	10.42	0.001

Random Effect	Var. component	p-Value
Intercept (U_0)	3071.84	0.000
Parents' education-achievement slope (U_1)	40.01	0.006
Attitudes-achievement slope, (U_2)	341.41	0.002
Student engagement** - achievement slope (U_3)	538.60	0.000
Level-1 effect, r_{ij}	6017.66	

** Aggregated from the student level to the classroom level; ** Student reported*

Discussion and Conclusions

Because of the nested data structure, the HLM analyses were used for this study. The results of this study revealed that the variance in science achievement among eighth grade classrooms was statistically significant. Among Turkish classrooms, the variance in science achievement is 32%. The variability in science achievement is also consistent with some researchers' findings (Stemler, 2001; Saed & Hammouri, 2010).

The estimated variance in fully unconditional model was 7297.60 for within-class as seen in Table-2. But, the estimated variance in partially conditional model was 6013.09 for the same level (Table-3). The difference between these two estimated variances means that adding student attitude toward science, parents' level of education, and student engagement as predictors of science achievement reduces the within-school variance by 18%.

However, for the class level, the estimated variance in fully unconditional model was 3441.77 (Table-2), and the estimated variance in partially conditional model was 3071.84 (Table-4). Based on these two estimated variances it can be said that adding students' readiness to learn and class-average engagement as predictors of science achievement reduces the between-school variance by 11%.

One of the results of the analysis was that some student-level variables were significantly associated with science achievement at schools. In the other words, attitude toward science and students' parental educational level were significant predictors for eighth graders' science achievement. The student who has more positive attitudes towards science is more likely to perform better in the subject. There are several studies supporting these findings (e.g., Hammouri, 2004; House, 2008; Young et al., 1996; Atar & Atar, 2012). However, these findings are inconsistent with

Ceylan & Berberoglu's (2007) study. Ceylan & Berbeoglu (2007) analyzed the TIMSS 1999 data and found that student attitude toward science was negatively associated with their science achievement. The inconsistent results may be attributed to the formulation of the students' attitude toward science variable (Atar & Atar, 2012).

Additionally, the result showed that parents' level of education affects the science achievement of students. While results of some studies support this finding (Haveman et al., 1995; Ramirez, 2006; Saed & Hammouri, 2010) Chepete's findings are inconsistent with the findings of this study (2008). Eventually, it can be said that both attitude towards science and educational level of parents have important effects on science achievement and good predictors of science achievement.

The result of partially conditional model showed that there was no relationship between student engagement and science achievement. But, the result of fully conditional model showed that there was positive relationship between class average-engagement and science achievement. It is possible to find different and inconsistent results in the literature related to engagement. For example, while Chang et al. (2007) and House (2000) found a small effect of science behavioral engagement on students' science achievement; Papanastasiu and Zembylas (2004) found an important effect. In spite of the presence of some of the evidence based on the positive role of student engagement in achievement, it is still unclear what kinds of activities lead to engagement and achievement. However, Li et al. (2006) found no relation between engagement and science achievement. Most of the previous studies investigating the effect of student engagement on science achievement showed complicated and inconsistent effects.

Fully conditional model produces another result which indicated significant relationship between readiness to learn and science achievement. This result is consistent with the literature. For example, some studies revealed that lack of prerequisite knowledge is a cognitive obstacle to new learning (Jones & Byrnes, 2006; Johnson & Lawson, 1998). There are also some studies arguing that lack of nutrition (Powell et al., 1998; Brown et al., 2008) and sleep duration (Curcio et al., 2006; Morales, 2013) have an impact on achievement.

One of the striking results of the analysis was that there was no significant relationship between inquiry-based instruction and science achievement. Some previous research has shown that students experiencing inquiry-based instruction were more likely to have higher levels of science achievement (Istrate, 2006; Von Secker, 2002; Hamilton et al., 2003). However, the results of some other studies have indicated that there was no relation (Munck, 2007) or a negative relation (Kaya & Rice, 2010) between inquiry-based learning and science achievement. Because inquiry-based instruction requires teacher skills beyond the traditional pedagogy (Munk, 2007), a possible explanation for this finding may relate to whether teachers possess the skills to effectively implement inquiry learning pedagogy. The preferences of teachers related to the use of teaching methods can be affected by the examinations that are conducted in the educational system. It seems to be inevitable that teachers with such concerns usually prefer teacher-centred approaches.

The studies investigating the relationship between professional community and student achievement report significant effects ranging from small to medium (Lomos, 2011). However, another unexpected result of this study was that there was no relationship between teacher collaboration and science achievement. Since no relationship could be found between these variables in Turkey although the literature strongly points out the existence of such relationship, the quality of collaboration processes can be questioned. There is a need for research on the effects of teacher collaboration on science achievement to reveal possible reasons behind this result. Accordingly, it can be suggested to carry to research on the functioning and effectiveness of the professional community which is expected to ensure teacher collaboration in the educational system in Turkey.

References

Adams, J. (2000). Taking Charge of the Curriculum. New York: Teachers College Press.

Arnaud, C. (2004). *Parental education and child's education: A natural experiment*. IZA Discussion Paper No. 1153, Institute for the Study of Labor, Germany.

Atar, H. Y. & Atar, B. (2012). Investigating the Multilevel Effects of Several Variables on Turkish Students' Science Achievements on TIMSS. *Journal of Baltic Science Education, 11*(2), 115-126.

Avalos, B. (1998). School-based teacher development: The experience of teacher professional groups in secondary school s in Chile. *Teaching and Teacher Education, 14* (3), 257-271.

Bolam, R., McMahon, A., Stoll, L., Thomas, S., Wallace, M., Greenwood, A., Hawkey, K., Ingram, M., Atkinson, A. & Smith, M. (2005). Creating and sustaining effective professional learning communities. Research Report 637. London: DfES and University of Bristol.

Brown, L. J., Beardslee, W. H., & Prothrow, D. (2008). *Impact of school breakfast on children's health and learning: An analysis of the scientific research.* Unpublished Manuscript. Harvard School of Public Health. Retrieved June 21, 2013 from

Ceylan, E. & Berberoglu, G. (2007). Öğrencilerin Fen Başarısını Açıklayan Etmenler: Bir Modelleme Çalışması. *Eğitim ve Bilim*, *32*(144), 36-48.

Chang, M., Singh, K., & Mo, Y. (2007). Science engagement and science achievement: Longitudinal models using NELS data. *Educational Research and Evaluation, 13*(4), 349–371.

Chepete, P., (2008). *Modeling of the Factors Affecting Mathematical Achievement of Form 1 Students in Botswana Based on the 2003 Trends in International Mathematics and Science Study. PhD study.* Indiana University Bloomington, IN.

Curcio, G., Ferrara, M., & Gennaro, L. D. (2006). Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews*, *10*, 323–337.

Davis-Kean, P. E. (2005). The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. *Journal of Family Psychology*, *19*(2), 294–304.

Fredericks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*, 59–109.

Hamilton, L. et al. (2003). Studying large-scale reforms of instructional practice: an example from mathematics and science. *Educational Evaluation and Policy Analysis*, *25* (1), 1–29.

Hammouri, H.A.M. (2004). Attitudinal and motivational variables related to mathematics achievement in Jordan: Findings from the third international mathematics and science study. *Educational Research, 46*(3), 214-257.

Hargreaves, A. (2007). Sustainable professional learning communities. In L. Stoll & K. Seashore Louis (Eds.), Professional learning communities: Divergence, depth and dilemmas. Berkshire, England: Open University Press.

Haveman, R., & Wolfe, B. (1995). The determinants of children's attainments: A review of methods and findings. *Journal of Economic Literature, 33*, 1829–1878.

House, J. D. (2000). Relationships between instructional activities and science achievement of adolescent students in Hong Kong: Finding from the third international mathematics and science study (TIMSS). *Studies in Educational Evaluation, 27*, 275–289.

House, J. D. (2008). Effects of Classroom Instructional Strategies and Self-Beliefs on Science Achievement of Elementary-School Students in Japan: Results from the TIMSS 2003 Assessment. *Education*, *129*(2), 259-266.

Istrate, O., Noveanu, G., & Smith, T. M. (2006). Exploring sources of variation in Romanian science achievement. *School Quality and Equity in Central and Eastern Europe*, *36* (4), 475–496.

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

Jones, K. K. & Byrnes, J. P. (2006). Characteristics of students who beneit from high-quality mathematics instruction. *Contemporary Educational Psychology*, *31*, 328–343.

Kaya, S., & Rice, D. (2010). Multilevel effects of student and classroom factors on elementary science achievement in five countries.*International Journal of Science Education* , *32* (10), 1337-1363

Li, M., Ruiz-Primo, M. A., & Shavelson, R. J. (2006). Towards a science achievement framework: The case of TIMSS 1999. In S. Howie & T. Plomp (Eds.), *Contexts of learning mathematics and science: Lessons learned from TIMSS*. London: Routledge.

Lieberman, A. & McLaughlin, M. (1992). Networks for educational change: Powerful and problematic. *Phi Delta Kappan*, *73*, 673-677.

Lomos, C., Roelande, H. H., & Bosker, R. J. (2011). Professional communities and student achievement–A meta-analysis. *School Effectiveness and School Improvement*, *22*(2), 121–148.

Louis, K. S., & Marks, H. (1998). Does professional community affect the classroom? Teachers' work and student work experiences in restructuring schools. *American Journal of Education, 106*, 532–575.

Martin, M. O., & Mullis, I. V. S. (Eds.). (2012). *Methods and procedures in TIMSS and PIRLS 2011*. Retrieved from html http://timss.bc.edu/methods/index.html

Martin, M.O., Mullis, I. V. S., Foy, P., & Stanco, G. M.. (2012). *TIMSS 2011 international results in science*. Chestnut Hill, MA: Boston College. http://timss.bc.edu/timss2011/downloads/T11_IR_Science_FullBook.pdf

McLaughlin, M. W., & Talbert, J. E. (2001). *Professional communities and the work of high school teaching*. Chicago, IL: University of Chicago Press.

McLaughlin, M., and D.J. McGrath, M.A. Burian-Fitzgerald, L. Lanahan, M. Scotchmer, C. Enyeart, L. Salganik (2005). *Student Content Engagement as a Construct for the Measurement of Effective Classroom Instruction and Teacher Knowledge*. Washington, D.C.: American Institutes for Research,

MEB (2005). *İlköğretim fen ve teknoloji dersi (4-5. sınıflar) öğretim programı*. Ankara: Devlet Kitapları Müdürlüğü Basımevi.

Minner, D. D., Levy, A. J., & Century, J. (2009). Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474–496.

Mo, Y., Singh, K., & Chang, M. (2013). Opportunity to learn and student engagement: A HLM study on eighth grade science achievement. *Educational Research for Policy and Practice*, *12*, 3–19.

Morales, J. F.D., & Escribano, C. (2013). Predicting school achievement: The role of inductive reasoning, sleep length and morningness–eveningness. *Personality and Individual Differences*, *55*, 106 – 111.

Mullis, I.V.S., Martin, M.O., Smith, T.A., Garden, R.A., Gregory, K.D., Gonzalez, E.J., Chrostowski, S.J., & O'Connor, K.M. (2003). *TIMSS 2003 assessment framework and specifications*. Chestnut Hill, MA: Boston College.

Munck, M. (2007). Science Pedagogy, teacher attitudes, and student success. *Journal of Elementary Science Education, 19* (2), 13-24.

Newman, F. M., Wehlage, G. G., & Lamborn, S. D. (1992). The significance and sources of student engagement. In F. M. Newman (Ed.), (1992). *Student engagement and achievement in American secondary schools.* New York: Teachers College Press.

Osborne, J. F. & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum.* London: King's College London.

Osborne, J. F., Simon, S. & Collins, S.(2003). Attitudes towards science: A review of literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.

Osborne, J. W. (2000). Advantages of hierarchical linear modeling. *Practical Assessment, Research, and Evaluation, 7*(1), 1-3.

Papanastasiou, E., & Zembylas, M. (2004). Differential effects of science attitudes and science achievement in Australia, Cyprus, and the USA. *International Journal of Science Education*, *26*, 259–280.

Powell, C. A., Walker, S. P., Chang, S. M., & Grantham – McGregor, S. M. (1998). Nutrition and education: A randomized trial of the effects of breakfast in rural primary school children. *American Journal of Clinical Nutrition*, *68*, 873-879.

Raudenbush, S.W., & Bryk, A.S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Newbury Park, CA: Sage.

Saed, S., & Hammouri, H. (2010). Does subject matter matter? Estimating the impact of instructional practices and resources on student achievement in science and mathematics: Findings from TIMSS 2007. *Evaluation & Research in Education*, *23*(4), 287-299.

Schnabel, K. U., Alfeld, C., Eccles, J. S., Köller, O., & Baumert, J. (2002). Parental influence on students' educational choices in the United States and Germany: Different ramifications—same effect*?*. *Journal of Vocational Behavior, 60*, 178–198.

Simpson, R. D., & Oliver, J. S. (1990). A summary of the major influences on attitude toward and achievement in science among adolescent students. *Science Education*, *74*, 1–18.

Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75(3), 417–453.*

Srnith, A. & Wohlstetter, P.(2001). Reform through school networks: A new kind of authority and accountability. *Educational Policy*, *15*, 499-519.

Stemler, S.E. (2001). *Examining school effectiveness at the fourth grade: A hierarchical analysis of the third international mathematics and science study (TIMSS)* (Unpublished doctoral dissertation). Boston College, Boston, MA.

Utley, B. L., Basile, C. G., & Rhodes, L. K. (2003). Walking in two worlds: master teachers serving as site coordinators in partner schools. *Teaching and Teacher Education, 19,* 515-528.

Von Secker, C. (2002). Effects of inquiry-based teacher practices on science excellence and equity. *Journal of Educational Research*, *95*(3), 151–160.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: a meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, *32*, 387–398.

Woltman, H., Feldstain, A., MacKay, J. C. & Rocci, M. (2012). An introduction to hierarchical linear modeling. *Tutorials in Quantitative Methods for Psychology*, *8*(1) 52-69.

Young, D.J., Reynolds, A.J., & Walberg, H.J. (1996). Science achievement and educational productivity: A hierarchical linear model. *The Journal of Educational Research*, *89*(5), 272-278.