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Examination of Gender Differences on Cognitive and Motivational Factors that Influence 8th Graders' Science Achievement in Turkey

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We examined the influence of several students' cognitive and motivational factors on 8th graders' science achievement and also gender differences on factors that significantly contribute to the science achievement model. A total of 99 girls and 83 boys responded all the instruments used in this study. Results showed that girls outperformed boys on science achievement. Furthermore, regression analyses showed a model including initial conceptual knowledge, scientific reasoning, and utility value of science as independent variables best predicted science achievement. Results also showed girls and boys did not differ on initial conceptual knowledge and scientific reasoning but on utility value of science. Implications for science education were discussed according to the findings.

Keywords: conceptual knowledge, gender differences, science achievement, scientific reasoning, utility value of science

INTRODUCTION

Achievement differences among different student populations have become a concern in science education (National Research Council [NRC], 1996; The Organisation for Economic Co-operation and Development [OECD], 2013). For almost all countries students who have families with higher socio-economic status and who attend high performing schools perform better in science than their peers who do not have these advantages (OECD, 2013). On the other hand, gender science achievement differences have been observed in several countries (OECD, 2013). For instance, this achievement advantage is in favor of boys in Canada and Hong Kong (e.g., Adamuti-Trache & Sweet, 2013; Sun, Bradley, & Akers, 2012) whereas girls have this advantage in Caribbean Islands and India (e.g., Kutnick, 2000; Larson,

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Stephen, Bonitz, & Wu, 2014). From a socio-cultural perspective, roles and stereotypes labeled to boys and girls may vary across different countries which may result in these inconsistent gender achievement differences (Chiu & Chow, 2010).

Turkey is one of the countries where girls perform better than boys in standardized national and international science assessments (Eğitimi Araştırma ve Geliştirme Dairesi [EARGED], 2010; OECD, 2013). Furthermore Bursal (2013) showed that although girls and boys have similar science grades between 4th and 7th grades, girls' science grades are higher than boys at the 8th grade according to classroom-level science assessments.

Several researchers examined students' cognitive (Dogru-Atay & Tekkaya, 2008; Kizilgunes, Tekkaya, & Sungur, 2009; Yenilmez, Sungur & Tekkaya, 2006) and motivational factors (Özdemir, 2003; Yetişir, 2014) that affect their science achievement in Turkey. Besides others sought gender differences for selected variables, i.e., epistemological beliefs (Özmusul, 2012; Topçu & Yılmaz-Tüzün, 2009), metacognition (Topçu & Yılmaz-Tüzün, 2009), and self-efficacy (Karaarslan & Sungur, 2011). Similarly studies conducted in Western and Eastern countries investigated students' cognitive and motivational factors (e.g., Coletta & Philips, 2005; Kaya & Rice, 2010; Liao & She, 2009; O'Reilly & McNamara, 2007) and gender differences on these factors (Barmby, Kind, & Jones, 2008; Breakwell & Robertson, 2001; Cavallo, Potter, & Rozman, 2004; Hong et al., 2013; Larson et al., 2014). However a paucity of study exists in the literature which aimed to investigate student-level variables that affect science achievement and then seek gender differences on those variables in countries where gender science achievement gap has been observed. Since Turkey is one of these countries where gender achievement gap has occurred in favor of girls, we aimed to investigate gender achievement gap and also its relation to students' cognitive and motivational factors in Turkey. Besides we used a conceptual knowledge test that is mostly allocated to physics topics for the assessment of science achievement in particular because we wanted to examine whether girls' science advantage (Bursal, 2013; OECD, 2013) can be extended to physics topics or boys' high school physics advantage (Sencar & Eryilmaz, 2004; Yıldırım & Eryılmaz, 1999) can be generalizable to 8th graders in Turkey. Detection of student-level variables which both affect science achievement and cause a gender difference would help educators and policy makers to address these variables appropriately in science classes for the closure of the gender achievement gap in Turkey. Furthermore results of this study would be informative for researchers who are interested in gender achievement differences and possible factors causing these differences. Following research questions were sought in this study:

- R.Q.1: Is there any achievement gap between 8th grade boys and girls after an education semester that is mostly allocated to physics topics?

State of the literature

- Results of national and international assessments show that girls perform better than boys in science from middle to high school years in Turkey.
- Studies demonstrate that students' initial conceptual knowledge, scientific reasoning, attitudes towards science, epistemological beliefs, and views on student-centered teaching have significant relation with their science achievement.
- Little is known about gender differences on variables that significantly predict science achievement in countries where there is a gender science achievement gap.

Contribution of this paper to the literature

- A regression model including cognitive variables of initial conceptual knowledge and scientific reasoning, and motivational variable of utility value of science best predicted 8th graders science achievement in Turkey.
- 8th grade girls had higher utility value of science scores than boys in Turkey.
- Methodological approach, i.e., detecting student-level variables that contribute to science achievement model and examining gender differences on those variables, used in this study for the examination of gender science achievement difference can be applied in other countries where there is a gender science achievement gap.

- R.Q.2: What is the relationship of 8th graders' initial conceptual knowledge, scientific reasoning, utility value for science, beliefs on theory and data, and views of student-centered teaching with their achievement?
- R.Q.3: Is there any gender difference on variables that significantly predict student achievement?

LITERATURE REVIEW

Gender science achievement difference in Western and Asian countries

Gender science achievement gap varies in Western and Asian countries and also in science disciplines. For instance, boys perform better than girls in Anglo-Saxon countries such as America and Canada (Adamuti-Trache & Sweet, 2013; Louis & Mistele, 2012). However this difference may result largely due to physics advantage of boys (Cavallo et al., 2004; Preece, Skinner, & Riall, 1999). On the other hand, the picture is different in Asian countries. Girls outperform boys on chemistry and physics in India (Larson et al., 2014). However boys score higher than girls on science in Hong Kong (Sun et al., 2012). These gender science achievement gap differences can be explained by different gender roles expected from boys and girls (Chiu & Chow, 2010) and different socialization experiences of boys and girls with science both of which depend on cultural norms (Adamuti-Trache & Sweet, 2013).

Gender science achievement difference in Turkey

After a review of the literature, we recognized that results of the studies related to gender achievement difference can be examined for general science, a specific science discipline, and a specific topic in Turkey. To begin with, analyses of the international assessments show girls perform better than boys in science from middle school to high school years (EARGED, 2007, 2010; OECD, 2013; Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü, 2013). In addition, analyses of the national assessments show a similar advantage of girls over boys (Bursal, 2013; EARGED, 2009). Furthermore, Bursal (2013) demonstrated that gender effect on general science achievement widens as the grade level increases.

On the other hand, gender achievement difference changes according to science disciplines. For instance, studies show that boys perform better than girls in high school physics (Sencar & Eryilmaz, 2004; Yıldırım & Eryılmaz, 1999). Particularly, Sencar and Eryılmaz (2004) showed that this difference can change according to question format. That is, authors found that boys scored higher than girls on practical question items, i.e., questions related to daily life, but not on theoretical items. However other studies showed that girls outperform boys on biology related topics such as respiration and photosynthesis (Alparslan, Tekkaya, & Geban, 2003; Yenilmez et al., 2006). On the other hand, girls' achievement advantage may not be generalized to all biology topics such as genetics (Dogru-Atay & Tekkaya, 2008).

Student-level variables that affect science achievement across different countries

We will summarize research findings related to the relation of students' selected cognitive, i.e., initial conceptual knowledge, scientific reasoning, and epistemological beliefs, and motivational factors, i.e., attitudes towards science and views on science teaching, with their science achievement. To begin with, O'Reilly and McNamara (2007) showed that American high school students' prior science knowledge influences their science achievement in school and in state-wide tests. Similarly Johnson and Lawson (1998) demonstrated that prior biology knowledge affect student achievement in biology courses in USA. However Johnson and Lawson

(1998) also found that students' scientific reasoning explains more of the variance in their biology achievement than prior knowledge does. Significant influence of scientific reasoning on students' science achievement was replicated in studies conducted in USA (Coletta & Phillips, 2005; Lawson, Banks, & Logvin, 2007) and in Taiwan (Liao & She, 2009). On the other hand, Elder (1999) demonstrated that students' epistemological beliefs relate to their science learning in USA. In terms of motivational factors, Martin, Mullis, Foy, and Stanco (2012) found that students' attitudes towards science influenced their science achievement after analyzing TIMMS 2011 international data. On the other hand, Kaya and Rice (2010) showed that student perception of inquiry in their science classes is positively related to their science achievement in Singapore however this relationship was negative in USA and Australia.

Student-level variables that affect science achievement in Turkey

There are several studies conducted in Turkey which analyzed the effect of initial conceptual knowledge, scientific reasoning, and epistemological beliefs on science achievement. For instance, Yenilmez et al. (2006) analyzed the relation of 8th graders' scientific reasoning and initial conceptual knowledge with their achievement. According to the results of this study, both variables predicted students' achievement. Similar to the results reported in Yenilmez et al. (2006), Dogru-Atay and Tekkaya (2008) found that 8th graders' scientific reasoning predicts their science achievement. In addition to these variables, Topçu and Yılmaz-Tüzün (2009) found that 4th to 8th grades' epistemological beliefs significantly contributed their science achievement. Similarly, Kizilgunes et al., (2009) showed student learning approach mediated the relation between epistemological beliefs and achievement.

On the other hand, several studies investigated the influence of attitudes towards science and views on science teaching on science achievement. To begin with, Yetişir (2014) showed that while students' attitudes towards science positively relate to their science achievement, their engagement in science lessons have no relation. However author also found that class average engagement had a significant relation. On the other hand, Özdemir (2003) analyzed 3rd TIMMS Turkish 8th graders' data for examining the influence of selected variables on science achievement. It was found that students' rating of inquiry level frequency in their science classes related to their achievement in a negative direction. On the contrary, their rating of teacher-centered activities frequency in their science classes positively related to their achievement. On the other hand, author found a strong relation between student self-perception of their performance in science and their achievement. However, this study found no relation between students' achievement and their level of science enjoyment. In another study, Ceylan and Berberoğlu (2007) investigated 1999 TIMMS data for examining the relation of students' attitudes towards science and the teaching method type in their classes with their science achievement. Authors found that both students' attitudes towards science and their rating of the frequency of student-centered activities in their science classes have negative correlation with their science achievement. On the contrary, their rating of the frequency of teacher-centered activities has a positive relation with their achievement according to findings.

Results of the reviewed literature are consistent with the influence of initial conceptual knowledge, scientific reasoning, and also epistemological beliefs on science achievement in Turkey. Yet while Kizilgunes et al. (2009) assessed students' epistemological beliefs in science, Topçu and Yılmaz-Tüzün (2009) assessed their epistemological beliefs in general. We think that it would be better examine student epistemological beliefs in science to pinpoint the contribution of domain specific

epistemological beliefs on science achievement. On the other hand, results of Yetişir (2014) and Ceylan and Berberoğlu (2007) are inconsistent for the contribution of students' attitudes towards science to their science achievement. After an elaboration on the scales used for assessing this variable in both studies, we recognized that Yetişir (2014) selected 20 items which consisted of items assessing students' interest in science, utility value for science, and ability beliefs in science. However, Ceylan and Berberoğlu (2007) performed principal factor analyses to identify the factors in TIMMS student questionnaire. As a result, authors grouped 4 items under students' attitudes towards science which mostly assessed students' interest in science. We assume that other subscales of attitudes towards science, i.e., utility value and ability beliefs, may be more important in predicting science achievement. Further, we assume that if Ceylan and Berberoğlu (2007) had used these subscales, they would have obtained different results.

Both Ceylan and Berberoğlu (2007) and Özdemir (2003) found that students' evaluation of inquiry frequency in their science classes has negative relation with their science achievement. Since student-centered approaches have been stressed recently by policy makers in Turkey (Milli Eğitim Bakanlığı [MEB], 2006), we assume that science class environment and students' evaluation of their science class environment would have changed accordingly through that time.

Although variables that affect to science achievement have been examined in the literature, little has been done to examine the gender differences on those variables in Turkey. For instance, a study by Topçu and Yılmaz-Tüzün (2009) found that students' metacognition and epistemological beliefs affect 4 to 8th graders' science achievement. Besides, authors examined if boys and girls differ on these variables. Authors found that girls outperformed boys on both metacognition and epistemological belief scales. Our research aim was similar to Topçu and Yılmaz-Tüzün (2009) in that first we investigated variables that predict science achievement. Then we examined gender differences on those variables. Apart from Topçu and Yılmaz-Tüzün (2009), we examined other variables such as initial conceptual knowledge, scientific reasoning, utility value for science; frequency of student-centered activities, and epistemological beliefs related to scientific theory and data that we taught can make an effect on science achievement.

METHOD

Research context

This research took place in three schools in a suburban region of an industrial city in Turkey. Duration of the study was one semester of a school year, i.e., 4 months. A total of 17 8th grade science classes participated in this study. After a list-wise deletion according to study dependent variables and independent variable, 182 8th grade students remained in the final sample. 99 of these students were girls and 83 of these were boys. 7 science teachers participated in the study. 5 of these teachers were male and the other two were female. These teachers' science teaching experience ranged between 10 to 15 years. Student-centered teaching approaches in science education have been encouraged by policy makers (MEB, 2006) in Turkey. However teachers of these schools mostly applied teacher-centered instruction during the study because their teaching performance was mostly evaluated by their student success on a state-wide exam that is used to place students in high schools.

Study variables

Conceptual knowledge

This test measured student conceptual knowledge related to sound, heat and temperature, matter states and heat, electricity in our life, and natural processes units. This test was administered as pretest to assess student initial conceptual knowledge and as posttest to assess student science achievement related to aforementioned topics. Several items were selected from different student study books. Other items were constructed by the first author. A total of 17 multiple-choice items were included in the test. Content validity of the test was established in a previous study by Acar (2015). Students' responses were coded as 1 if they answered an item correct and as 0 if they answered an item wrong. Accordingly, posttest administration of the test yielded .76 (n = 182) cronbach's alpha estimate of internal consistency.

Scientific reasoning

Scientific reasoning test was administered at the beginning of the semester. This test was initially developed by Lawson (1978). A modified version of this test (Lawson, 2000) was used in this study. There were questions about conservation of mass, control of variables, correlational reasoning, probabilistic reasoning, proportional reasoning, and hypothetical reasoning in this version. There were a total of 12 two-tier multiple choice items in the test. Each two-tier had content and a reasoning question. Particularly, the content question was about a reasoning skill and the reasoning question was about a justification to the content question. Turkish translation of the test was done by the first author and an English Language expert from Teaching English as a Second Language department edited any vague statement. Student responses were coded as 1 if they answered both content and reasoning question correct. They were coded as 0 in any other circumstance. This test was administered at the beginning of the semester. Cronbach's alpha estimate of the internal consistency yielded a score of .61 (n = 182).

Beliefs on theory and data

This questionnaire was administered at the beginning of the semester. It was developed by Leach, Millar, Ryder, & Sere (2000) to assess student views on scientific theory and data. Authors are affected by the theoretical perspective that students' epistemological beliefs are context-dependent. Therefore they developed this questionnaire to assess students' beliefs on scientific theories and data. There were 7 pairs of statements which were written as summaries of opposing philosophical stances (Leach et al., 2000). Although Leach et al. (2000) used a different method for coding student responses to this questionnaire (e.g., data focused, radical relativist, and theory and data related reasoning), student responses on each item can be grouped under absolutist or relativist view on theory and data. That is to say, if a student has a relativist view he/she would open to consider different data sources and theoretical perspectives in a scientific issue. On the other hand, if a student has an absolutist view he/she would think that there is only one correct data source and theoretical perspective that explains a scientific issue. The first author of this paper grouped the items according to this criterion. That is to say, if a student agreed with the statement of "In analyzing a given data set, it is quite reasonable for different scientists to use different theoretical perspectives", this response was coded as relativist view. On the other hand, if a student agreed with the other statement of the same pair, i.e., "In analyzing a given data set, there is only one theoretical perspective which it is reasonable for scientists to use", this response was coded as absolutist view. Then, an expert from science education department was asked to recode the items according to the same criterion. After this

process, it was found that both codings were consistent for all pairs. Finally this questionnaire was translated to Turkish and the English Language expert edited any vague statement. Thereafter, this questionnaire was administered at the beginning of the spring semester. Consequently, internal consistency estimate of Cronbach's alpha was found as .47 (n = 182).

Utility value of science

Students responded to this questionnaire at the beginning of the semester. 4 Likert-type items that assess students' utility value of science were selected from "Your views on Science" subsection in PISA student questionnaire (OECD, 2006). Items were about the importance of science such as "Advances in <broad science and technology> usually improve people's living conditions" and "<Broad science> is important for helping us to understand the natural world" (OECD, 2006; p. 13). These items were presented to the second author of this paper for examination of the content validity. He stated that the items were about students' value they give for science. Following a study by Kind, Jones and Barmby (2007), we named this questionnaire as utility value of science. Specifically Kind et al. (2007) found after factor analyses that utility value of science is a subscale of attitudes towards science.

All the items were in positive direction so if a student selected *strongly agree*, it was coded as 4 and if he selected *strongly disagree*, it was coded as 1. Turkish translation of the questionnaire was done by the first author and the English Language expert edited any vague statement. This questionnaire was administered at the beginning of the semester. Cronbach's alpha was computed as .61 (n = 182).

State of student-centered teaching

This questionnaire was administered at the beginning of the semester. Therefore students responded to this test before they received instruction on the science topics of the semester, e.g., sound and heat and temperature. 4 Likert-type items were selected from the subsection of "Teaching and Learning Science" in PISA student questionnaire (OECD, 2006) to assess the frequency of student-centered teaching activities done in science classrooms. Following were the examples of the items: "Students are given opportunities to explain their ideas"; "Students spend time in the laboratory doing practical experiments" (p. 28). The second author of this paper stated that the items were assessing student views about student-centered activities in their science classroom.

Since all the items were in positive direction, a maximum score of 4 was coded for *in all lessons* and a minimum score of 1 was coded for *never or hardly ever*. Translation of this questionnaire was done by the first author and the English expert edited any vague statement. This questionnaire was also administered at the beginning of the semester. Cronbach alpha was found as .57 (n = 182).

Data analyses

First we performed Analysis of Variance (ANOVA) to compare boys' and girls' achievement scores. We examined Levene's statistic for the homogeneity of variance assumption. Levene's statistic showed this assumption was met ($F(1, 180) = 2.43$, $p = .121$). Then we performed regression analysis on achievement scores to detect the predictor variables. We examined Variance Inflation Factor (VIF) of each independent variable for checking collinearity assumption. Each VIF value was between 1.00 and 1.50 which was far below the critic value of 10 (Marquaridt, 1970) indicating collinearity assumption was not violated.

Finally, we performed a Multivariate Analysis of Variance (MANOVA) on initial conceptual knowledge, scientific reasoning, and utility value of science to examine if boys and girls differ on these variables. We examined homogeneity of variance and covariance of dependent variables, i.e., initial conceptual knowledge, scientific

reasoning, and utility value of science, across girls and boys. Levene's Test showed that error variances of initial conceptual knowledge (F (1, 180) = 2.03, p = .156), scientific reasoning (F (1, 180) = 2.07, p = .152), and utility value of science (F (1, 180) = 1.01, p = .316) were similar across each gender. On the other hand, Box's M resulted in 14.76 which had a p value of .025. This indicates that covariance matrices for dependent variables were not same for boys and girls. However Keselman, Carriere, and Lix (1993) stated that equal sample size designs are quite robust against the violation of this assumption. Since sample size for each gender is quite similar in the present study, we assume that violation of homogeneity of covariance assumption would not affect MANOVA results that much.

RESULTS

ANOVA was performed on achievement scores to examine a possible gender effect. Gender was the independent variable in this analysis. Result showed that girls (M = 8.80, SD = 3.82) scored higher than boys (M = 7.42, SD = 3.42) on this measure (F (1, 180) = 6.44, p = .012).

We computed Pearson product-moment correlations between study dependent variable, i.e., achievement, with independent variables, i.e., students' initial conceptual knowledge, scientific reasoning, utility value of science, beliefs on theory and data, and their views on the state of student-centered teaching in their science classes. Results can be seen in Table 1. As can be seen, students' initial conceptual knowledge, scientific reasoning, utility value of science, and beliefs on theory and data had significant correlations with their achievement.

We performed step-wise linear regression analyses to pinpoint the variables that best predict achievement. Initially, we entered student initial conceptual knowledge to the first model. This model significantly predicted achievement (F (1, 180) = 24.26; p = .000) explaining 12% of the variance. Then we added scientific reasoning

Table 1. Correlations of dependent and independent variables

	1	2	3	4	5	6
Achievement (1)	1					
Pre Conceptual Knowledge (2)	.35***	1				
Scientific Reasoning (3)	.29***	.31***	1			
Utility value of science (4)	.24**	.17*	.07	1		
Beliefs on theory and data (5)	.17*	.16*	.07	.17*	1	
State of student-centered teaching (6)	-.05	.09	.13	.30***	-.04	1

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

Table 2. Step-wise linear regression analyses for predicting achievement

Model	Standardized Beta	t	p	R^2
1				
Prior Knowledge	.35	4.9	.000	.12
2				
Prior Knowledge	.28	3.90	.000	.16
Scientific Reasoning	.20	2.80	.006	
3				
Prior Knowledge	.25	3.52	.001	.19
Scientific Reasoning	.20	2.78	.006	
Utility value of science	.18	2.64	.009	
4				
Prior Knowledge	.24	3.33	.001	.20
Scientific Reasoning	.20	2.76	.006	
Utility value of science	.17	2.43	.016	
Beliefs on theory and data	.09	1.29	.199	

Table 3. Descriptive statistics of the variables that significantly contributed to the model

	Conceptual Knowledge		Scientific Reasoning		Utility Value of Science	
	M	**SD**	**M**	**SD**	**M**	**SD**
Girls	6.01	2.37	1.49	1.38	13.55	1.61
Boys	5.76	1.90	1.55	1.78	13.01	1.51

in the second model. This model again significantly predicted achievement (F (2, 179) = 16.50, p = .000) explaining 16% of the total variance. For the third model, we added utility value of science to the previous independent variable set. In this case, this model explained 19% of the total variance in the achievement (F (3, 178) = 13.68, p = .000). Finally, we added beliefs on theory and data. This time, the model explained 20% of the total variance (F (4, 177) = 10.72, p = .000). However t statistic related to model 4 presented in Table 2 showed that relationship between this variable and achievement was not significant. In summary, model 3 best explained 8th graders' science achievement with each independent variable significantly contributing to the model. According to this model, students' prior knowledge best predicted 8th graders science achievement. Then their scientific reasoning and utility value of science were best predictors respectively.

For the examination of gender differences on variables that significantly contributed to the model, we performed MANOVA. Descriptive statistics can be seen in Table 3. Gender was the independent variable in this analysis. The result showed that girls and boys did not differ on the set of dependent variables (Wilks' λ was utilized, F (3, 178) = 1.91, p = .130). Follow-up ANOVA results showed while boys and girls did not differ on initial conceptual knowledge (F (1, 180) = 0.60; p = .438) and scientific reasoning (F (1, 180) = 0.06; p = .801), girls scored higher than boys on utility value of science scale (F (1, 180) = 5.26; p = .023).

DISCUSSION

We will discuss our findings related to gender science achievement difference, the variables that predicted science achievement and gender differences on those variables respectively. First of all, we found that girls' science advantage over boys can be generalizable to physics topics for 8th graders in Turkey. This finding is in alignment with the previous research findings which showed that girls score higher in science than boys in the middle school years in Turkey (Bursal, 2013; EARGED, 2009). However this result may seem to contradict with Sencar and Eryilmaz's (2004) and Yıldırım and Eryılmaz's (1999) findings regarding boys advantage over girls in high school physics. Specifically, Sencar and Eryilmaz (2004) showed that boys score higher than girls on practical items i.e., questions related to daily life, but not on theoretical items. Although conceptual knowledge items used in the present study were mostly physics questions and practical, contrary to the expectation, we found girls' advantage over boys. We assume that boys' advantage in physics may start in later grades where physics content gets more abstract.

Students' initial conceptual knowledge, scientific reasoning, utility value for science, and beliefs on theory and data had significant correlations with their achievement. On the other hand, only initial conceptual knowledge, scientific reasoning, and utility value for science contributed to the regression model that best predicted 8th graders' science achievement. Previous research also found the significant influence of students' initial conceptual knowledge (O'Reilley & McNamara, 2007; Yenilmez et al., 2006) and scientific reasoning (Dogru-Atay & Tekkaya, 2008; Johnson & Lawson, 1998). On the other hand, Yetişir (2014) found that student composite score on attitudes towards science contribute to science achievement. The present study showed utility value of science, which is one of the

constructs of attitudes towards science (Kind et al., 2007; Martin et al., 2012), also predicts science achievement significantly.

In analyzing variables that affect 8th graders' achievement related to respiration and photosynthesis, Yenilmez et al. (2006) found that student scientific reasoning best predicts their achievement and then prior knowledge. Although we found that both variables influence science achievement, the significance order was different from Yenilmez et al.'s (2006). We interpret this mismatch as the relative significance of scientific reasoning and initial conceptual knowledge for explaining achievement in respiration and photosynthesis and achievement for physics topics used in this study. That is to say, we think that scientific reasoning may be more important in predicting achievement related to respiration and photosynthesis than predicting achievement in physics topics. Future research should be carried out on this issue to obtain more concrete results.

Neither 8th graders' beliefs on theory and data, nor their views on the state of student-centered activities in their science class contributed to the science achievement model in the present study. However, Topçu and Yılmaz-Tüzün (2009) found that domain-general epistemological beliefs contributed to 8th graders' science achievement. Specifically, authors used Schommer-Aikins, Duell, and Hutter's (2005) epistemological beliefs questionnaire in which students are asked about speed of learning, studying of a lesson, their beliefs in authorities, and certainty of knowledge in a decontextualized manner. Therefore this questionnaire has not been used specifically to assess student epistemological beliefs related to science. We assume that domain-general epistemological beliefs may have more influence in predicting science achievement than domain-specific epistemological beliefs which were assessed in the present study. On the other hand, although results of the present study showed that students' evaluation of inquiry frequency for their science classes had negative correlation with their science achievement, this result was not significant. Given the previous research findings of the significant negative relation between this variable and science achievement (Ceylan & Berberoğlu, 2007; Özdemir, 2003), our results are encouraging for student-centered teaching implemented in Turkey. More clearly, we assume that instructional time devoted for student-centered activities may have increased and/or quality of them may have developed from the time of implementations of previous researches which prevented negative significant contribution of this variable to science achievement in the present study.

Among the variables that influence science achievement, we found that girls outperform boys on only utility value of science scores. That is, girls had more positive attitudes towards utility value of science than boys. This finding can be explained by their different learning style. That is to say, Stark and Gray (1999) found that girls prefer more teacher-centered activities such as teacher demonstrations and writing about science and boys prefer more student-centered activities such as discussion in groups and problem solving. In addition, Cavallo et al. (2004) found that girls use less meaningful learning approaches than boys. Expository science instruction still mostly used in Turkey may be more suitable for girls' learning style and as a consequence they may develop better attitudes towards science (Topçu and Yılmaz-Tüzün, 2009). Allocating more space in science activities such as connecting science teaching to real life and student discussion of ideas with their peers may develop credibility of science among boys (Jocz, Zhai, & Tan, 2014). Consequently these more positive attitudes may affect boys' science achievement positively. Indeed Acar (2014) found that argumentation instruction where students are required to argue between different alternatives helps to prevent the widening of gender science achievement gap. On the contrary, Acar (2014) also showed gender achievement gap in traditional instruction does not close. In sum, if we want to create class environment that provides equal learning opportunities for each

gender, we should ignore teacher-centered teaching approaches and provide more space for student discussion and connecting science to real life situations in science classrooms. On the other hand, our result regarding girls' advantage of utility value of science, which significantly influenced science achievement, cannot be generalized to other countries where gender factor plays a role in science achievement because boys and girls may encounter with different socialization experiences with science in these countries (Adamuti-Trache & Sweet, 2013). However researchers can follow our methodological design to detect gender effect. That is, they can first detect the variables that affect science achievement in those countries. Afterwards they can examine gender differences on those variables.

Limitations

There are several methodological concerns with the present study. First, we used limited number of cognitive and motivational factors to predict 8th graders' science achievement. We would have used other important cognitive and motivational variables such as metacognition and self-efficacy. Second, instruments other than conceptual knowledge test had cronbach's alpha reliability coefficients that were below .70 which is accepted as the boundary of a reliable instrument in social sciences. More clearly scientific reasoning, utility value of science, and state of student-centered teaching scales had cronbach's alpha measures near .60. Scientific reasoning test has a well-established reliability both for English and Turkish versions (Ates & Cataloglu, 2007; Kwon & Lawson, 2000; Liao & She, 2009). We assume that student motivation may have been low during this test administration which may have reduced the inter item correlation. On the other hand, both utility value of science and state of student-centered teaching scales consisted of four items. This may be a reason why we got lower reliability alpha coefficients for these scales because cronbach's alpha is sensitive to the number of items in a scale, i.e., a scale with large item pool may result in higher cronbach alpha even though item inter-correlations were low and vice versa (Cortina, 1993). In fact, previous researchers also found reliability coefficients below .70 for these scales when they analyzed Turkish data in Third International Mathematics and Science Study (Ceylan & Berberoglu, 2007; Özdemir, 2003). On the other hand, we should interpret low reliability coefficient of beliefs on theory and data scale in particular because it was below .50. Since Topçu and Yılmaz-Tüzün (2009) found that general epistemological beliefs affect science achievement and girls' advantage on this variable, we specifically aimed to examine the effect of science specific epistemological beliefs on science achievement and gender differences on this variable. However, low reliability of this instrument threatens its validity. Future research should examine the ways to improve the reliability of this questionnaire or use other questionnaires which assess science specific epistemological beliefs with well-established reliabilities.

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REFERENCES

Acar, Ö (2014). *Cinsiyet değişkeninin argümantasyon ve geleneksel öğretim metotlarının kullanıldığı sınıflardaki öğrencilerin fen öğrenimine olan etkisinin incelenmesi*. Paper presented at 1. International Eurasian Educational Research Congress, İstanbul, Turkey. Retrieved from http://ejercongress.org/pdf/Congress.pdf.

Acar, Ö (2015). Examination of science learning equity through argumentation and traditional instruction noting differences in socio-economic status. *Science Education International, 26*(1), 24-41.

Adamuti-Trache, M., & Sweet, R. (2013). Academic effort and achievement in science: Beyond a gendered relationship. *Research in Science Education, 43*, 2367-2385.

Alparslan C., Tekkaya, C., & Geban, Ö. (2003). Using the conceptual change instruction to improve learning. *Journal of Biological Education, 37*(3), 133-137.

Ates, S., & Cataloglu, E. (2007). The effects of students' reasoning abilities on conceptual understandings and problem-solving skills in introductory mechanics. *European Journal of Physics, 28*, 1161-1171.

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education, 30*(8), 1075-1093.

Breakwell, G. M., & Robertson, T. (2001). The gender gap in science attitudes, parental and peer influences: Changes between 1987-88 and 1997-98. *Public Understanding of Science, 10*, 71-82.

Bursal, M. (2013). Longitudinal investigation of elementary students' science academic achievement in 4-8th grades: Grade level and gender differences. *Educational Sciences: Theory & Practice, 13*(2), 1151-1156.

Cavallo, A. M. L., Potter, W. H., & Rozman, M. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics, 104*(6), 288-300.

Ceylan, E., & Berberoglu, G. (2007). Factors related with students' science achievement: A modeling study. *Education and Science, 32*(144), 36-48.

Chiu, M. M., & Chow, B. W. Y. (2010). Culture, motivation, and reading achievement: High school students in 41 countries. *Learning and Individual Differences, 20*, 579-592.

Coletta, V. P., & Philips, J. A. (2005). Interpreting FCI scores: Normalized gain, preinstruction scores, and scientific reasoning ability. *American Journal of Physics, 73*(12), 1172-1182.

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology, 78*(1), 98-104.

Dogru-Atay, P., & Tekkaya C. (2008). Promoting students' learning in genetics with the learning cycle. *The Journal of Experimental Education, 76*(3), 259-280.

Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı. (2007). *PISA 2006: Uluslararası öğrenci değerlendirme programı ulusal ön rapor*. Ankara: Earged.

Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı. (2009). *ÖBBS 2008: İlköğretim öğrencilerinin başarılarının belirlenmesi: Fen ve teknoloji raporu*. Ankara: Earged.

Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı. (2010). *Uluslararası öğrenci değerlendirme programı PISA: 2009 ulusal ön rapor*u. Ankara: Earged.

Elder, A. D. (1999). *An exploration of fifth-grade students' epistemological beliefs in science and an investigation of their relation to science learning.* Unpublished doctoral thesis, The University of Michigan, Ann Arbor.

Hong, J. C., Lu, C. C., Wang, J. L., Liao, S., Wu, M. R., Hwang, M. Y. et al. (2013). Gender and prior science achievement affect categorization on a procedural learning task. *Thinking Skills and Creativity, 8*, 92-101.

Jocz, J. A., Zhai, J., & Tan, A. L. (2014). Inquiry learning in the Singaporean context: Factors affecting student interest in school science. *International Journal of Science Education, 36*(15), 2596-2618.

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

Karaarslan, G., & Sungur, S. (2011). Elementary students' self-efficacy beliefs in science: Role of grade level, gender, and socio-economic status. *Science Education International, 22*(1), 72-79.

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

Keselman, H. J., Carriere, K. C. & Lix, L. M. (1993). Testing repeated measures hypotheses when covariance matrices are heterogeneous. *Journal of Educational and Behavioral Statistics, 18*(4), 305-319.

Kind, P., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education, 29*(7), 871-893.

Kizilgunes, B., Tekkaya, C., & Sungur, S. (2009). Modeling the relations among students' epistemological beliefs, motivation, learning approach, and achievement. *The Journal of Educational Research, 102*(4), 243-256.

Kutnick, P. (2000). Girls, boys and school achievement: Critical comments on who achieves in schools and under what economic and social conditions achievement takes place-a Caribbean perspective. *International Journal of Educational Development, 20*(1), 65-84.

Kwon, Y. J., & Lawson, A. E. (2000). Linking brain growth with the development of scientific reasoning ability and conceptual change during adolescence. *Journal of Research in Science Teaching, 37*(1), 44-62.

Larson, L. M., Stephen, A., Bonitz, V. S., & Wu, T. F. (2014). Predicting science achievement in India: Role of gender, self-efficacy, interests, and effort. *Journal of Career Assessment, 22*(1), 89-101.

Lawson, A. E. (1978). The development and validation of a classroom test of scientific reasoning. *Journal of Research in Science Teaching, 15*(1), 11-24.

Lawson, A. E. (2000). *Classroom test of scientific reasoning*. Retrieved 01 Jan. 2008 < http://www.public.asu.edu/~anton1/LawsonAssessments.htm>.

Lawson, A. E., Banks, D. L., & Logvin, M. (2007). Self-efficacy, reasoning ability, and achievement in college biology. *Journal of Research in Science Teaching, 44*(5), 706-724.

Leach, J., Millar, R., Ryder, J., & Sere, M. G. (2000). Epistemological understanding in science learning: The consistency of representations across contexts. *Learning and Instruction, 10*, 497-527.

Liao, Y. W., & She, H. C. (2009). Enhancing eight grade students' scientific conceptual change and scientific reasoning through a web-based learning program. *Educational Technology & Society, 12*(4), 228-240.

Louis, R. A., & Mistele, J. M. (2012). The differences in scores and self-efficacy by student gender in mathematics and science. *International Journal of Science and Mathematics Education, 10*, 1163-1190.

Marquaridt, D. W. (1970). Generalized inverses, ridge regression, biased linear estimation, and nonlinear estimation, *Technometrics, 12*, 591-612.

Martin, M. O., Mullis, I. V. S., Foy, P., & Stanco, G. M. (2012). *TIMSS 2011 international results in science*. Chestnut Hill: TIMSS & PIRLS International Study Center.

Milli Eğitim Bakanlığı. (2006). *İlköğretim Fen ve Teknoloji Dersi (6, 7 ve 8. sınıflar) Öğretim Programı*. Ankara: Talim ve Terbiye Kurulu Başkanlığı.

National Research Council. (1996). *The national science education standards*. Washington, DC: National Academy Press.

O'Reilly, T., & McNamara, D. S. (2007). The impact of science knowledge, reading skill, and reading strategy knowledge on more traditional "high-stakes" measures of high school students' science achievement. *American Educational Research Journal, 44*(1), 161-196.

Özdemir, E. (2003). *Modeling of the factors affecting science achievement of eighth grade Turkish students based on the third international mathematics and science study-repeat (TIMMS-R) data*. Unpublished master dissertation, The Middle East Technical University, Ankara.

Özmusul, M. (2012). Upper primary school students' views towards scientific knowledge: An analysis for information literacy. *Elementary Education Online, 11*(3), 629-645.

Preece, P. F. W., Skinner, N. C., & Riall, R. A. H. (1999). The gender gap and discriminating power in the national curriculum key stage three science assessments in England and Wales. *International Journal of Science Education, 21*(9), 979-987.

Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving beliefs, and academic performance of middle school students. *The elementary School Journal, 105*(3), 289-304.

Sencar, S., & Eryilmaz, A. (2004). Factors mediating the effect of gender on ninth-grade Turkish students' misconceptions concerning electric circuits. *Journal of Research in Science Teaching, 41*(6), 603-616.

Stark, R., & Gray, D. (1999). Gender preferences in learning science. *International Journal of Science Education, 21*(6), 633-643.

Sun, L., Bradley, K. D., & Akers, K. (2012). A multilevel modelling approach to investigating factors impacting science achievement for secondary school students: PISA Hong Kong sample. *International Journal of Science Education, 34*(14), 2107-2125.

The Organisation for Economic Co-operation and Development. (2006). *OECD programme for international student assessment 2006: Student questionnaire*. Retrieved on 17-October 2013, at URL: http://pisa2006.acer.edu.au/downloads.php.

The Organisation for Economic Co-operation and Development. (2013). *PISA 2012 results: Excellence through equity: Giving every student the chance to succeed (Volume II)*. PISA, OECD publishing.

Topçu, M. S., & Yılmaz-Tüzün, Ö. (2009). Elementary students' metacognition and epistemological beliefs considering science achievement, gender and socioeconomic status. *Elementary Education Online, 8*(3), 676-693.

Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü. (2013). *Pisa uluslararası öğrenci değerlendirme programı: Pisa 2012 ulusal ön rapor*u. Ankara: Yeğitek.

Yenilmez, A., Sungur, S., & Tekkaya, C. (2006). Students' achievement in relation to reasoning ability, prior knowledge and gender. *Research in Science & Technological Education, 24*(1), 129-138.

Yetişir, M. İ. (2014). The multilevel effects of student and classroom factors on the science achievement of eight graders in Turkey. *Education and Science, 39*(172), 108-120.

Yıldırım, U., & Eryılmaz, A. (1999). Effects of gender, cognitive development and socioeconomic status on physics achievement. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 15*, 121-126.

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