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Examining the Effects of Turkish Education Reform on Students' TIMSS 2007 Science Achievements

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Abstract

The purpose of this study is to examine the effects of some of the changes such as student centered learning (i.e. inquiry science instruction), outfitting classrooms with latest technology and computers that the reform movement has brought about on students' TIMSS 2007 science achievements. Two-staged stratified sampling was used in the selection process, in which schools and classes were sampled in the first and second stage, respectively. TIMSS 2007 study were administered to students, teachers and principles in 145 classes in 145 schools. On average, 28 students from each school participated in the study. The results of the hierarchical linear modeling (HLM) analyses indicate that while computer access positively influence students' science achievements, inquiry science instruction negatively influences students' science achievements. Furthermore, it has been found that students' science achievements increase in parallel to an increase in the socio-economic status (SES) of the families, teacher experience and students' self-confidence in learning science. Finally, the effects of inquiry science instruction, self confidence in learning science and gender on TIMSS science achievement have been found to significantly vary among schools.

Key Words

Inquiry based learning, Reform, HLM, TIMSS 2007.

The purpose of the education reform that has been initiated in 2005 is to integrate Turkish education system with the world, to promote using student centered teaching methods and to raise generations who are capable of creative and logical thinking and inquires about the world. In this sense, Turkish education reform shares commonalities with the education reform movement in the United States (Şahin, Işıksal, & Ertepınar, 2010). No doubt that the reform movement has brought about many changes not only for students but also for teachers, administrators, parents and other stakeholders, as well. The future of the reform movement in Turkish education system that has been initiated in 2005, in a sense, will depend on its effects on students' achievements. If the reform movement positively influences students' achievements, it will continue to strengthen, otherwise serious revisions will have to be made. The effect of reform movements on students achievements on large scale assessments needs to be examined (Von Secker & Lissitz, 1999)

Literature review indicate that most of the Turkish studies are conducted using large-scale assessments such as *Trends in Mathematics and Science Study* (TIMSS) that are administered before the implementation of the reform movement in 2005 (Berberoğlu, Çelebi, Özdemir, Uysal, & Yayan, 2003;

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Ceylan & Berberoğlu 2007; Özdemir, 2003; Uzun & Öğretmen, 2010; Yayan & Berberoğlu, 2004). Some studies used *Programme for International Student Assessment* (PISA) data to examine the factors that affect Turkish students' achievements (Anıl, 2009; Demir & Kılıç 2010; Yılmaz, 2009). In addition, many of these studies used mathematics achievement as outcome variable (Akyüz, 2006; Atar, 2011; Sevgi, 2009; Yıldırım, 2006). The purpose of this study is to examine the effects of some of the changes such as student centered learning (i.e. inquiry science instruction), outfitting classrooms with latest technology and computers that the reform movement has brought about on students' TIMSS 2007 science achievements.

Inquiry Based Science Instruction

Education reform in Turkey aimed to bring fundamental changes in classroom practice including transitioning of instruction from teacher centered to student centered. In student centered learning, students play an active role in their learning, by planning their own investigations, questioning, working in groups and learning from each other (Anderson, 1997). In student centered learning teachers serve as a guide rather than a knowledge dispenser.

In science education, inquiry is used to describe a teaching method (i.e. inquiry teaching), a learning method (i.e. inquiry learning) and a way of doing science (i.e. inquiry science) (Anderson, 2002). American National Research Council (NRC, 1996) describes inquiry science as follows:

> *Inquiry is a multi-faceted activity that involves making observations, posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations (p. 23).*

Examination of Turkish science education literature indicates that the number of studies conducted on inquiry science is very limited. Many of these studies focus on teachers' views and beliefs about inquiry science. As an example, Şahin et al. (2010) administered the Teacher Beliefs towards Teaching Pedagogies scale to 197 teachers and found that teachers believed that inquiry science teaching would positively influence the development of students' inquiry skills and facilitate their understanding of science.

There exist many studies abroad that investigate the influence of inquiry science on students' science achievements (Leung, Yung, & Tso, 2005; Von Secker, 2002, 2004; Von Secker & Lissitz, 1999). For instance, using American National Education Longitudinal Study (NELS) data, Von Secker (2002) examined the effect of inquiry science instruction on students' achievement and how this effect was mediated by race, gender, and socioeconomic status. She found that inquiry science instruction positively influenced students' achievements. She also found that the effect of inquiry science instruction differed based on students' SES levels. Leung et al. found similar findings. Non-random selection of the teachers in Von Secker's study was one of the limitations of the study.

TIMSS and PISA Studies

In order to determine the effects of the reform movement initiated in 2005 on Turkish education system, the results of international assessment programs such as TIMSS and PISA administered after 2005 are needed to be examined. However, review of the literature indicates that majority of the researchers, who studied TIMSS, used TIMSS 1999 data in their study (Akyüz, 2006; Berberoğlu et al., 2003; Ceylan & Berberoğlu, 2007; Uzun & Öğretmen, 2010; Yıldırım, 2006). Using structural equation modeling (SEM) these studies identified SES, student centered learning, parents' education level, student confidence in learning and attitudes towards science as factors that effected student achievements. Specifically, student centered instruction have been found to negatively influence Turkish students' science achievements at TIMSS (Berberoğlu et al.; Ceylan & Berberoglu). According to the authors the reason for this might be the quality of student centered instructions. The authors did not think that teachers were ready to put student centered instruction into practice correctly. On the other hand, in some other developing countries such as Jordan, student centered instruction have been found to positively influence students' science achievements (Sabah & Hammouri, 2010).

Studies examining Turkish PISA data indicate that student achievements have been found to vary based on geographic regions (Anıl, 2009). Student achievements in eastern and southeastern regions of Turkey have been found to be lower than that of the western region. In Anıl's study, fathers' educational level has been found to be the best predictor of students PISA science achievements. In another study, Yılmaz (2009) found that students PISA science achievement negatively affected by the number of activities in the classroom.

Finally, studies on TIMSS and PISA data show that factors effecting student achievements differ from one country to another (Papanastasiou & Zembylas, 2004; Shen & Pedulla, 2000; Wilkins, 2004; Yılmaz, 2009) and from one subject area to another (Sabah & Hammouri, 2010). The reason might the difference between the social, cultural backgrounds and, development levels of the countries.

Method

Trends in International Mathematics and Science Study (TIMSS)

Eight grade Turkish students' survey data and science achievement scores on Trends in International Mathematics and Science Study (TIMSS) have been used in this study. TIMSS is one of the projects administered by International Association for the Evaluation of Educational Assessment (IEA). TIMSS is conducted on a four year cycle since 1995. TIMSS content and tested grade levels have gone through several changes since its inception. While TIMSS were administered to 4, 5, 7 and 8 graders in 1995, only 8 graders were tested in 1999. However, beginning in 2003 it was decided TIMSS to be administered only at 4th and 8th grade levels. Turkey participated in the TIMSS study first in 1999 and second in 2007 only at 8^{th} grade levels.

Sample

TIMSS 2007 study was administered to students, teachers and principals in 145 classes in 145 schools. On average, 28 students from each school participated in the study. Two-staged stratified sampling was used in the selection process, in which schools and classes were sampled in the first and second stage, respectively. School sizes were taken into consideration before selecting schools via systematic random sampling (Joncas, 2011). However, no weighing was applied in the selection of classes within a school.

Data Analysis

Hierarchical Linear Modeling (HLM) analysis was used in the analysis of data. HLM is a suitable analysis method particularly in survey research design where multistage sampling is used. HLM analysis is preferred to classical simple regression analysis in dealing with data in nested structure because violations of independence and homoscedasticity assumptions in multistage sampling cause simple regression analysis to underestimate the standard errors and therefore leads to a higher probability of rejection of a null hypothesis (Hox, 2002; Raudenbush & Bryk, 2002). HLM analysis, on the other hand, reduces bias by adjusting the calculated standard errors. Data in the study was analyzed using three HLM models: 1) One-Way ANOVA with Random Effects Model; 2) Random-Coefficients Regression Model and 3) Intercepts-and-Slopes-as-Outcomes Model. All variables but gender were included in the Level 1 and Level 2 analysis as standardized composite scores (Comrey & Lee, 2007) calculated through principal component analysis.

Results

One-Way ANOVA with Random Effects Model

Students overall average science achievement score are found to be 449.42 with a standard error of 5.05. Also, students' overall science achievement has been found to significantly vary among schools ($p< 0.001$). Within school variability and between schools variability has been estimated to be 5636.57 and 2415.16, respectively. Intraclass correlation is calculated as 0.30, which indicates that 30% of variability in science scores is due to differences in mean school science achievement and that remaining 70% due to individual differences.

Random-Coefficients Regression Model

Gender, socioeconomic status (SES), self confidence and inquiry based learning variables are added in the random-coefficients regression model in order to explain the individual differences in the variability of students' science achievement scores. At level 1, gender-science achievement, SES-science achievement, self confidence-science achievement, inquiry based learning-science achievements slope coefficients (Υ) are estimated to be 7.50, 22.48, 32.16, -15.11, respectively. Corresponding p values ($p<0.05$) indicate that the average effect of these variables on science achievement are statistically significant. Effect sizes are found to be 0.10, 030, 0.43 and -0.20, respectively. Effect size of 0.10, for instance, means that male students' science achievements are 0.10 standard deviation higher than that of females.

Adding gender, socioeconomic status (SES), self confidence and inquiry based learning variables into level-1 HLM analysis reduced within-school variability from 5636.57 to 4328.57, which indicates that these variables explain 23% within school variability in students' science scores. Level 2 HLM analysis results indicate that excluding SES (*p.*=0.063). The effect of all student level variables (i.e. gender, self confidence toward science, inquiry based learning) on science achievement significantly varies among schools.

Intercepts-and-Slopes-as-Outcomes Model

In order to further explain the differences in school mean science achievements teacher experience, inquiry based teaching and computer access variables are added to the model. It is found that teacher experience and inquiry based teaching variables has a statistically significant effect on the adjusted school mean science achievements. Effect sizes of 0.02 and -0.14 for teacher experience and inquiry based teaching, respectively indicate that although teacher experiences has statistically significant effect on adjusted school mean science achievement the practical significance of this effect is minimal. Also, the effect size of -0.14 indicate that one standard deviation increase in the inquiry based teaching is related to a 0.14 standard deviation decrease in the adjusted school mean science achievement. Although computer access does not have a statistically significant effect on adjusted school mean science achievement, effect size of 0.21 indicates that its practical effect is noteworthy. Finally, adding teacher experience, inquiry based teaching and computer access variables into the model explains only 9% of between school variability.

Discussion

The purpose of this study is to examine the effects of some of the changes such as student centered learning (i.e. inquiry science instruction), outfitting classrooms with latest technology and computers that the reform movement has brought about on students' TIMSS 2007 science achievements. HLM analysis results indicate that boys outperform girls with respect to science achievement. However, the relevant effect size suggests that even though the effect of gender on science achievement is statistically significant it is of little practical significance. Conversely, although computer access does not have a statistically significant its practical effect on adjusted school mean science achievement is noteworthy. This suggests that enhancing the availability of computers and other technological resources (i.e. internet access, electronic tablets, electronic books) in classrooms may positively influence students' science achievements.

The results of the hierarchical linear modeling (HLM) analysis indicate that while computer access positively influence students' science achievements, inquiry science instruction negatively influences students' science achievements. This may sound surprising at first but it is consistent with earlier research in Turkey and other countries (Berberoğlu et al., 2003; Ceylan & Berberoğlu, 2007; Lavonen & Laaksonen, 2009). One explanation for this negative effect is the scarcity of science teachers who are really prepared to teach science through inquiry (Berberoğlu et al.; Ceylan & Berberoğlu). Another reason may be the way inquiry items stated in TIMSS teacher and student surveys. Similar to PISA survey items (Lavonen & Laaksonen), the TIMSS items regarding inquiry based learning too are focused in the quantity of inquiry related activities not the quality. In the TIMSS survey, students, for instance, were asked to indicate the frequency level of inquiry science related activities such as experimentation, group work, providing explanations but not about their experiences and opinions about them.

Similar to earlier studies it is found that self confidence and socioeconomic status of students have been found to have both statistically and practically significant effect on science achievement (Shen & Pedulla, 2000; Leung, 2002). Shen and Pedulla, for instance, found that self confidence was positively related to science achievement within a country while the relationship was negative cross countries. The authors thought that the negative effect cross countries might be due to lower science and mathematics standards and expectations of students. Turkish students' low achievements on TIMSS (Şişman, Acat, Aypay, & Karadağ, 2011) suggests that educators and policy makers need to revisit the existing standards and their expectations of students so that the revised science standards are more congruent with that of developed countries and provide a better fit for the vision of 2023, the 100th anniversary of the foundation of Turkish Republic. In this regard, educators and policymakers need to set achievable science achievement goals on internationally exams and gradually increase achievement expectations of students.

Finally, one should be cautious about interpreting the findings of this study in regards to outcome of the reform. TIMSS 2007 was administered only two years after the major Turkish education reform. Two years is not enough to determine the real effects of the reform efforts. In order to evaluate the effects of the education reform initiated in 2005 more comprehensively and objectively, Turkish students' science and mathematics achievements on PISA 2010, TIMSS 2011 and other international exams need to be examined.

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