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Differences of Science Classroom Practices in Low- and High-Performing Schools

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ABSTRACT

This study was carried out to investigate the differences between low- and high-performing schools in the United States based on instructional practices implemented in science classrooms by analyzing TIMSS-2007 data set. Discriminant analysis was conducted to explore the differences between two types of schools. The results revealed that the classified schools were significantly discriminated based on 13 variables (items) related to instructional practices in science classrooms. As a result, whereas students in high-performing schools do more inquiry oriented activities, students in low-performing schools have a tendency to engage more teacher-centered activities. The possible reasons of these results were discussed based on the science classroom practices in the United States.

Key Words: TIMSS-2007, school Effectiveness, Classroom Practices Discriminant Analysis.

INTRODUCTION

International studies such as TIMSS (Trends in Mathematics and Science Study), PISA (Programme for International Student Assessment), and PIRLS (Progress in International Reading Literacy Study) have attracted many researchers' interest all around the world with having fruitful data and their effect on science and mathematics education. Among them, TIMSS (Trends in Mathematics and Science Study) which is a project of IEA (International Association for the Evaluation of Educational Achievement) is one of the most familiar education studies to assess students' science and mathematics achievements in line with the school curricular context in different countries. It has been carried out once every four years and was last conducted in 2011 which involved 63 countries from all around the world (Martin, Mullis, Foy & Stanco, 2011). Generally, TIMSS assessments in science at the eighth grade level were organized based on content and cognitive dimensions. At the eighth grade

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level, the content domain was categorized into the four following content areas: biology, chemistry, physics, and earth science. The cognitive dimension was made to measure students' knowing, application, and reasoning skills (Olson, Martin, & Mullis, 2008).

Understanding the reasons of school difference to students' academic achievement is essential to ensure equity across schools. The results of international studies (TIMSS, PISA, and PIRLS) not only emphasize performance differences among countries but also emphasize performance differences between schools in each country. Investigating the association of the extent of the variation with students attending different schools is one of the concerns of these international studies. For example, PISA 2006 reports revealed that one third of all variation in students' performance was between schools (OECD, 2007). In addition, the importance of schools was also expressed by some studies related to the TIMSS (Schmidt, Jorde, Barrier, Gonzala, Moser, & Shimizu, 1996). Moreover, Bosker and Witziers (1996) revealed that 18% of variance in achievement associated with school difference by conducted a meta-analysis study with a sample of 103 schools.

Because schools provide education, school effectiveness on students' achievement has drawn the attention of many researchers especially after the well-known Coleman report (Coleman, Campbell, Hobson, McPartland, Mood, Weinfield, & York, 1966). The results of the studies based on school effectiveness show some diversity. For example; whereas some of the researchers found little or no evidence of relationship between school factors and students achievement (Hanushek, 1986; 1989), others concluded that the impact of school factors on students' test scores may be substantial (Greenwald, Hedges, & Laine, 1996; Konstantopoulos, 2006). Besides investigating the school effects on students' achievement, school effectiveness research was carried out to increase schools' potential and improve education and especially educational achievement (Creemers & Reezigt, 2005). In addition, some of school effectiveness research was conducted to reveal how schooling impacts students' academic achievement (e.g.,Mortimore, Sammons, Stoll, Lewis, & Ecob, 1988; Rutter, Maughan, Mortimore, Ousten, & Smith, 1979; Teddlie & Stringfield, 1993). Moreover, the characteristics of schools and classrooms which are associated with differences in school effectiveness were emphasized by some of the studies in the literature (Scheerens & Creemers, 1989).

Investigating the features that make some schools more effective is crucial. It was argued that revealing the special characteristics of an effective school, especially the features that could be changed, help authorities to improve underperforming schools by leading them to adopt their features based on the characteristics of effective schools (Luyten, Visscher, & Witziers, 2005). One of the main characteristics of the effective schools is the instructional practices implemented in the classrooms of these schools. It was stated that whereas one type of effective school provide direct instruction to teach students the basic skills, another type of effective school design their instruction based on well rounded curriculum, use student-centered, advanced skill instructional approach (D' Agostino, 2000). In addition, in the high achievement schools, clear and well organized teaching that keeps students actively involved in the learning process and connect to students' background knowledge was encouraged (Papanastasiou, 2008). Van de Grift and Houtveen (2006) also noted that students' performance was improved when the class better organized and students were encouraged to involve actively in the learning process.

Nolen (2003) indicated that one of the significant predictors of both satisfaction and achievement in science is classroom learning environments. The results of her study revealed that classroom characteristics affect students' achievement more than the motivational characteristics. In addition, Odom, Stoddard, and LaNasa (2007) carried out a study to investigate the relationship between instructional practices and students' science achievement.

It was concluded that classroom teaching practices influence students' science achievement. It was argued that whereas implementation of daily life related group experiments and reduction of extensive note-copying during class led students to gain better scores in science. Moreover, positive correlations between student-centered teaching practices and student attitude toward science which is accepted as one of significant predictor of science achievement were reported (Papanastasiou, Zembylas, & Vrasidas, 2004; Kahle, Meece, & Scantlebury, 2000). Furthermore, research on investigating the relationships among instructional practices, attitude toward a subject matter, and science achievement based on international data set have been one of the growing areas in educational research (Papanastasiou, Zembylas, & Vrasidas, 2004; Papanastasiou & Papanastasiou, 2004; Yayan & Berberoglu, 2004; Aypay, Erdogan, & Sozer, 2007, Papanastasiou, 2008).

Lawson, Abraham, and Renner (1989) described two types of fundamental knowledge that could influence school effectiveness: declarative and procedural. Whereas declarative knowledge refers "knowing that," procedural knowledge deals with "knowing how." Declarative knowledge is acquired through a constructive process by using procedural knowledge. Improving procedural knowledge is provided by engaging students in a constructive process to make declarative knowledge more meaningful. Therefore, acquiring procedural knowledge is not only necessary for gaining declarative knowledge but also necessary to meet some requirements of education in globalizing world. For example, acquiring procedural knowledge enables students with a strong foundation for lifelong learning. Science is one of the areas that students have some opportunities to improve their procedural knowledge with the activities implemented in this field. In TIMSS 2007, besides the overall science scores of the students, three different scores such knowing, applying, and reasoning scores of the students were produced based on the related questions for the cognitive dimensions. The questions that assessed students' reasoning skills seem to be appropriate to make interpretation not only of students' reasoning skills, but also convenient for inferring their procedural knowledge and views of nature of science. In addition, there is a strong relationship between United States (US) eighth grade students' science scores and their science reasoning scores in TIMSS 2007. The correlation coefficient was found 0.967 which indicated very high positive relationship between these scores. This high relationship allowed us to make inferences about students' overall science performance besides making inferences about their science reasoning. Therefore, the reasoning scores of the students in TIMSS-2007 were taken into consideration for this study.

Based on the evidence from school effectiveness research and the research on international studies, this article investigates the differences between low-performing schools and high-performing schools in the U.S. based on students' science reasoning scores on TIMSS-2007. Instructional practices implemented in science classrooms were the focus during the investigation of differences between low- and high-performing schools.

METHODOLOGY

a) Sample

TIMSS-2007 included 67 countries all around the world. The target population of TIMSS can be defined as all the fourth and eighth grade students in most of the participating countries. TIMSS-2007 used sample design, named as a two stage stratified cluster sampling, has two stages basically: In the first stage, schools were randomly selected with probability proportional to size, and one or more classes were selected randomly from the relevant grades in sampled schools (Martin, Gregor, & Stemler, 2000; Gonzales & Miles, 2001; Joncas, 2007). As a result of this sample design, 7377 students from 239 schools, included both private and public schools, were sampled at eighth grade level in the U.S. This sample consisted of 3721 girls and 3656 boys.

For the present study, 48 schools, included 1465 students, were included. 24 of these schools were named as low-performing schools and 24 of the schools were named as high-performing schools as a result of their students' science reasoning scores in TIMSS-2007. These schools included 783 boys and 682 girls. The number of the students in low performing schools and high performing schools were 753 and 712, respectively. In this study, namely, schools whose students have high science reasoning scores categorized as high-performing schools, on the other hand schools whose students have low science reasoning scores categorized as low performing schools.

b)Instruments

Students' responses on Student Questionnaire and Science Achievement Test were used for this study. The student questionnaire was administered to gather information about students' background characteristics (e.g. parent's education levels, home resources, language spoken at home), students' self-concept and their attitudes towards science and mathematics , classroom instructional practices related to teaching science and mathematics, students' habits outside of the schools, and students' homework (Martin et al., 2008).

In the Science Achievement Test, there were 94 science items that include four different content domains (Biology, Chemistry, Physics, and Earth Science) and three different cognitive domains (knowing, applying, and reasoning). In the TIMSS-2007 science assessment, IRT (Item Response Theory) scaling methods were used to describe TIMSS achievement measures. Although each student did not respond to all of the items, IRT enabled TIMSS to obtain proficiency scores in science for all students by using multiple imputations or the "plausible values" method. So, five plausible values were generated for each student (Gonzales & Miles, 2001). In addition, the TIMSS-2007 data set not only included five plausible values for science achievement, but also provided five plausible values for each of the cognitive domains such as knowing, applying, and reasoning. In the present study, all of the five overall science reasoning plausible values were used to represent students' science reasoning achievements.

c)Analysis

Discriminant analysis is used to classify individuals into groups on the basis of one or more measures or realize the group differences (Green, Salkind, & Akey, 2000). discriminant analysis was conducted in the present study. Because one of the main aims of the study was to differentiate low-performing schools and high-performing schools with regard to the instructional practices implemented in science classrooms, items related to science classroom practices in the student questionnaire were considered.

In the discriminant analysis, 16 items (variables) related to instructional practices in science classroom were selected from the student questionnaire. These variables were the independent variables of the study. The dependent variable of the study, classified as low- and high-performing schools based on students' science reasoning scores, was defined as school performance. The selected 16 independent variables for first discriminant analysis were the items that represent the frequency of instructional practices implemented in the classroom and rated as "(1) never," "(2) some lessons," "(3) about half the lesson," and "(4) every or almost every lesson." The items were:

1. Make observations and describe what is seeing
2. Teacher demonstrates an experiment or investigation
3. Design or plan an experiment or investigation

4. Conduct an experiment or investigation
5. Work in small groups on an experiment or investigation
6. Read the textbook and other source materials
7. Memorize science facts and principles
8. Use scientific formulas and laws to solve problems
9. Give explanations about what is studying
10. Relate what is learning in science to daily lives
11. Review their homework
12. Teacher give a lecture style presentation
13. Work problems on their own
14. Begin homework in class
15. Have a quiz or test
16. Use computers

Data cleaning procedures was performed after selection of the variables from the TIMSS-2007 United State data set. It was recommended that the missing values can be replaced by mean value if missing values for each variable do not exceed 10% of the total cases in the sample (Tabachnick & Fidel, 2001). Each variable was examined and since the missing values did not exceed the 10% criteria, missing values were replaced by the mean values.

Before conducting the discriminant analyses, all of the schools (239) in the U.S. were ranked from highest to lowest based on their mean values on science reasoning scores. Ten percent of the highest performing schools (24 schools at the top of the list) and 10% of the lowest performing schools (24 schools at the bottom of the school list) were taken for both discriminant analyses. Cases of the other schools were considered as moderately performing schools and excluded from our data set. So, our sample included 48 schools included with 1465 students. The minimum score and maximum score in low-performing schools were 394.16 and 457.26, respectively. On the other hand, the minimum score and the maximum score in high-performing schools were 582.94 and 622.73, respectively. Students' average scores for low-performing schools was 435.62 and students' average score of the high-performing schools was found 592.95.

In the discriminant analysis the stepwise procedure was selected. Wilks' lambda was minimized at each step by adjusting F-to-enter as 1.15 and F-to-remove as 1.00. In addition, Box's M was clicked to check multivariate normality. To understand the multivariate nature of independent variables the univariate analysis of variance was selected. Furthermore, unstandarized discriminant function coefficient, the combined groups plot, residual for each case, and summary table were ticked (Green, Salkind, & Akey, 2000; Geaorge and Mallery, 2006).

RESULTS

As mentioned earlier, discriminant analysis was performed to understand whether there are differences between low-performing schools and high-performing schools with regard to science classroom practices. The discriminant function was gathered by running the discriminant analysis based on classroom practices:

Discriminant Function (Classroom Practices): How well the functions differentiate the groups was determined by examining related eigenvalues: the larger eigenvalues indicate better discrimination, in other words, a strong function is implied by a large eigenvalue (Green, Salkind, & Akey, 2000; George and Mallery, 2006). On the other hand, the canonical correlation indicates the correlation between the discriminant scores and the levels of the independent variables. Canonical correlation is computed based on the eigenvalue associated with the discriminant function: $[\lambda / (1+ \lambda)]$. Canonical correlation value in the output is the square root of this index. A function discriminates well when there is a high correlation. And, the square root of canonical correlation is defined as eta square and is used to understand accounted variance in the dependent variable for the independent variables (Green, Salkind, & Akey, 2000). As indicated in Table 1, an eigenvalue of 0.239 and a canonical correlation of 0.439 were gathered by first discriminant analysis. The eta square, square root of canonical correlation was found 0.192, indicates that 19% variability of scores for the discriminant function were accounted for by the difference among the two groups of schools. Table 1 also represents the results of significance test for the chi-square.

Table 1. *Summary of First Canonical Discriminant Function*

Function	Eigenvalue	% of Variance	Canonical Correlation	Wilks' Lambda	X^2	df	Significance
1	0.239	100	0.439	0.807	279.400	13	0.000

Wilks' lambda and the chi-square value indicate whether the groups significantly differ from each other based on the discriminant function. The discriminant function had Wilks'lambda of 0.80 and $X^2_{(13)}$ = (N = 1465) = 279.4, and $p < 0.05$. These values indicated that there were significant differences between high- and low performing schools based on 13 classroom practices at 0.05 level of significance.

The standardized correlation and correlation coefficient values were for 13 classroom practices in the first discriminant function were presented in Table 2.

Table 2. *Standardized Canonical Discriminant Function and Canonical Discriminant Function Coefficients*

Variables	Standardized Canonical Discriminant Function Coefficients	Canonical Discriminant Function Coefficients
Conduct an experiment or investigation (COEXIN)	.809	.885
Work in small groups on an experiment or investigation (WSMLGR)	.451	.482
Review their homework (REHMW)	.420	.383
Work problems on their own (WORKPRO)	.296	.329
Begin homework in class (BGHWCLA)	.187	.181
Make observations and describe what is seeing (MAKEOB)	.099	.110
Relate what is learning in science to daily lives (RESCIDAIL)	-.135	-.135
Use computers (USECOM)	-.171	-.175
Use scientific formulas and laws to solve problems (SCIFORM)	-.197	-.215
Have a quiz or test (QUIZTEST)	-.324	-.367
Teacher demonstrates an experiment or investigation (DEMOEXP)	-.374	-.394
Read the textbook and other source materials (READBOOK)	-.449	-.512
Design or plan an experiment or investigation (PLANNEXP)	-.451	-.460
Constant		-.338

The discriminant function was written by using standardized canonical discriminant function coefficients. The first discriminant function is written as:

DF1 = 0.809 (COEXIN) + 0.451 (WSMLGR) + 0.420 (REHMW) + 0.269 (WORKPRO) + 0.187 (BGHWCLA) + 0.099 (MAKEOB) – 0.451 (PLANNEXP) – 0.449 (READBOOK) - 0.374 (DEMOEXP) – 0.324 (QUIZTEST) – 0.197 (SCIFORM) – 0.171 (USECOM) – 0.135 (RESCIDAIL)

This function indicates which independent variables differed significantly in discriminating the low- and high-performing schools. The group centroids on discriminant function were presented in Table 3. The values indicate the average discriminant scores for subjects in low- and high- performing schools (George and Mallery, 2006). The relative positions of the categorized schools with respect to the discriminant function were indicated by these centroids (Aypay, Erdogan, & Sozer, 2007).

Table 3. *Functions at Group Centroids*

School Category	Discriminant Function
Low Performing Schools	-0.479
High Performing Schools	0.497

Therefore, it can be concluded that the positively valued discriminating variables are for high performing schools and negatively valued discriminating variables are for low-performing schools. The more allowed and promoted activities in both low- and high performing schools may be derived based on the discriminant function and group centoids.

The classroom activities which were implemented and encouraged more in high-performing schools may be categorized based on DF and group centroids as:

1. Students conduct an experiment or investigation.
2. Students work in small groups on an experiment or investigation
3. Students make observations and describe what they see
4. Students work problems on their own
5. Students reviews their homework
6. Students begin their homework in class

On the other hand, the classroom activities which were implemented and encouraged more in low performing schools can be categorized as:

1. Students read their science textbooks and the other resource materials.
2. Teacher demonstrate an experiment and investigation
3. A quiz or test is frequently administered to students
4. Students use computer in science classes
5. Students design and plan an experiment or investigation
6. Students use scientific formulas and laws to solve problems
7. Students relate their learning in science to their daily lives

Table 4. *Classification Results*

	Predicted Group Membership (%)	
School Performance	(1) Low performing schools	(2)High performing schools
(1) Low performing schools	68.5	31.5
(2)High performing schools	34.4	65.6

67.0% of original grouped cases correctly classified

The classification results of the first discriminant analysis indicate that 68.5% of the students in low-performing schools and 65.6% of the students in high-performing schools were correctly classified (Table 4). How well the discriminant function predicts in the sample is indicated by the classification results (Green, Salkind, & Akey, 2000). Moreover, 67% of the students in the sample (1465 students) were correctly classified on TIMSS-2007 data set for the U.S.

The beta (β) weighs in multiple regression analysis and standardized canonical discriminant function coefficients which indicate the relative influence of entered variables are interpreted in the same way. Variables that positively influenced the dependent variable (school performance) were: conducting an experiment or investigation, working in small groups on an experiment or investigation, making observations, working problems on their own, reviewing homework, beginning the homework in class. The variables negatively influenced the dependent variable (school performance) were: reading science textbooks, demonstrating an experiment and investigation, administering quiz or test to students, using computers in class, designing and planning an experiment or investigation, using scientific formulas and laws to solve problems, relating leanings in science to daily life.

Standardized canonical discriminant function coefficients (Table 2) indicate that the classroom activities that were frequently encouraged in the high-performing schools were: conducting an experiment or investigation (β =0. 809), working in small groups on an experiment or investigation ($\beta = 0.451$), reviewing their homework ($\beta = 420$), working problems on their own ($\beta = 0.296$) beginning homework in class ($\beta = 0.187$), making observation and describing what is their seeing ($\beta = 0.099$). On the other hand, the classroom activities that were frequently implemented in low-performing schools found as: reading the textbooks and other source materials ($\beta = -0.449$), designing and planning an experiment or investigation ($\beta = -0.451$), demonstrating an experiment and investigation by teacher ($\beta = -0.374$), administering quiz or test to the students ($\beta = -0.324$)using scientific formulas and laws to solve problems ($\beta = -0.197$), using computers in science classrooms ($\beta = -0,171$), relating science learning to daily life ($\beta = -0.135$).

The mean values (out of 4) of more frequently implemented activities in high-performing schools were calculated as: conducting an experiment or investigation (M = 3.00), working in small groups on an experiment or investigation (M = 3.14), reviewing their homework (M = 3.00), working problems on their own (M = 3.10) beginning homework in class (M = 2.62), making observation and describing what is their seeing (M = 3.05). On the other hand, the mean values (out of 4) of more frequently implemented activities in low performing schools were found as: the classroom activities that were frequently implemented in low performing schools indicated as: reading the textbooks and other source materials (M = 3.21), designing and planning an experiment or investigation (M = 2.59), demonstrating an experiment and investigation by teacher (M = 2.80), administering quiz or test to the students (M = 3.08), using scientific formulas and laws to solve problems (M = 2.95), using computers in science classrooms (M = 1.94), relating science learning to daily life (M = 2.62).

Based on the results of the discriminant analysis, it can be argued that in science classes at high-performing schools, inquiry-oriented activities or student-centered activities (ex: conducting an experiment or investigation, working in small groups, making observations, working problems individually, reviewing homework) were more often implemented than teacher-centered activities (ex: reading science books, teacher demonstrations, having a quiz or test, using scientific formulas and laws) whereas in science classes at low performing schools, teacher centered activities were used more than inquiry oriented activities.

DISCUSSIONS and CONCLUSIONS

The purpose of the study was to investigate the differences between low- and high-performing schools based on science classroom practices. The schools were classified as low- and high performing school based on students' reasoning scores in TIMSS-2007. The discriminant analysis was conducted and a function was obtained. The discriminant function was carried out based on instructional practices implemented in the science classrooms. The discriminant analysis results showed that low-performing schools differs from high performing schools with regard to science classroom practices (observed variables) based on TIMSS-2007 data for eight grade U.S. students.

As it was indicated previously, the characteristics and the features of effective and high performing schools show some diversity based on the literature (Hanushek, 1986; 1989; Greenwald, Hedges, & Laine, 1996; Konstantopoulos, 2006). Therefore, in this study, instead of putting forward a premise that the effective schools could be characterized like the results of this study and the low performing schools could emulate the characteristics of high-performing schools to become more effective schools, our intention is to expose the characteristics of low- and high-performing schools by focusing especially on students' responses about science classroom practices on student questionnaire in TIMSS-2007.

The discriminant function equation (DF) gathered from the discriminant analysis indicated that low- and high-performing schools were significantly discriminated based on thirteen observed variables related with science classroom practices. The observed variables related to science classroom practices such as: conducting an experiment or investigation(COEXIN), working in small groups on an experiment or investigation (WSMLGR), reviewing homework (REHMW), working problems on their own (WORKPRO) , beginning the homework in class (BGHWCLA), making observations (MAKEOB) contributed significantly in the high-performing school. On the other hand, the observed variables related to classroom practices that contributed significantly in low performing schools were: reading science textbooks (READBOOK), demonstrating an experiment and investigation (DEMOEXP), administering quiz or test to students (QUIZTEST), using computers in class (USECOM), designing and planning an experiment or investigation (PLANNEXP), using scientific formulas and laws to solve problems (SCIFORM), relating leanings in science to daily life (RESCIDAIL).

Odom, Stoddard, and LaNasa (2007) found that whereas doing more group experiments in class positively impact students' achievement, doing extensive note-copying during class caused to decrease students' achievement. Similarly, House (2006) revealed that students who worked together in pairs and small groups and did more experiments in class showed higher science test scores in Japan. In addition, students who work in small groups tended to more often monitor their own progress (Stright & Supplee, 2002). On the other hand, it was found that using computers in science lessons was negatively related to the students' science achievement (House, 2006). However, in another research, it was found that the ways in which usage of computers were also taken into account, although the negative relation between science achievement and use of computer was indicated (Papanastasiou, Zembylas, &Vrasidas, 2004). In other studies (House, 2002; McGehee, 2001), it was reported that using active learning strategies improved students' interest in science and result in higher levels of science achievement. In the literature, similar findings have been reported for various grade level students in different science subject matter (Caccovo, 2001; Yuretich, Khan, & Leckie, 2001). Furthermore, inquiry based science activities that are designed to actively engage students with science processes and their critical thinking skills had positive effects on students' science achievements and their attitudes toward both science and schools (Gibson &

Chase, 2002, Gibson, 1998). And also, it was indicated that laboratory instruction positively influenced students' science knowledge (Freedman, 1997). Stright and Supplee (2002) revealed that self regulatory behaviors of children related to classroom context. Students were not actively involved learning until the assignments were given them to complete in teacher directed instruction. So, it was found that students in the seat work and small group instruction groups monitored their progress more when compared to students in teacher directed instruction. In this study, the instructional practices that were encouraged in high performing schools were inquiry oriented activities (conducting an experiment or investigation, working in small groups on an experiment or investigation, making observations, and working problems on their own). Therefore, our findings seem to support the findings in the literature by indicating most of the activities in high-performing schools are inquiry based activities which leaded high science reasoning performance. In the U.S., high performing schools tend to be high SES, meaning the likelihood of them having more materials to support inquiry learning, as well as teachers who know how to inquiry instruction, is greater. Additionally, the low-performing schools tend to be in lower SES areas which are associated with poverty, high teacher turnover, and crime. Certainly work needs to be done to improve these areas so these students have a better education.

As a result of the present study, inquiry-oriented activities positively contributed to students' science reasoning scores. In other words, inquiry-oriented activities were implemented more in the science classrooms of high performing schools. Eight specific activity structures were stated as more observed activities in Japan which had students whose scores above the international averages on science achievement (Baldi, Jin, Green, & Herget, 2007). These activities specified as "designing experiments by teachers, conducting experiments by students, sharing the results of these investigations, and discussing the investigations in small groups" (Linn, Lewis, Tsuchida, & Songer, 2000). In addition, students were engaged more in the activities related to conducting experiments and investigations had a tendency to acquire high science test scores (House, 2007, 2008). In the literature, there are several studies revealed that inquiry-based instruction leads higher achievement of students (Caccovo, 2001; Yuretich, Khan, & Leckie, 2001; Stright & Supplee, 2002; Freedman, 1997; Von Secker & Lissitz, 1999). In addition, Von Secker (2002) argued that improper and sloppy usage of inquiry based activities may encourage the gap to widen among students. On the other hand, negative relationship between student-centered activities and students' science achievement based on TIMSS data were reported in the literature (Aypay, Erdogan, & Sozer, 2007, Ceylan & Berberoglu, 2007). Improper implementation of these activities in science classes was stated as one of the reasons of this result. In the current study, it can be said from the results that students in the high-performing schools had a tendency to do more inquiry-based activities when compare to the students in low performing schools in the U.S.

The items that were used in science assessment at class, national, and international tests rely generally on multiple choice items which were designed to measure students' scientific knowledge. This assessment technique leads teachers to focus on memorization strategies by neglecting student critical thinking. In addition, these tests are not satisfying enough to measure scientific inquiry which is highly valued in science education (Yeh, 2006). It was indicated that questions focus on how students deal with multiple and conflicting ideas about scientific phenomena, how they develop new ideas, and how they relate new and existing ideas to measure complex science reasoning more accurately (Linn, 1995; Linn & Hsi, 2000). Although TIMSS has made efforts to measure complex reasoning in science, not all of the items assess students' science reasoning because there is a need to align with state and national curriculum standards, to address a broad range of content within a limited testing period, and to use primarily multiple-choice items because of the cost of administration and scoring (Liu, Lee, Hofstetter, & Linn, 2008). However, some of the TIMSS questions were design to measure the aspects of science inquiry based on experimental set-ups or student investigations (Olson, Martin, & Muillis, 2008).

Given the results from this study, we recommend that all schools use inquiry-oriented instruction. This type of instruction may help low performing schools become high performing schools. In textbook adoption years across the country teachers and administrators should look for curricula that support student-centered activities and provide training for teachers to be able to effectively implement such instruction. Special support should be given to low-performing schools that are likely within low SES districts in terms of materials and classroom support to enable teachers to implement the most effective instruction they are able to do in difficult situations.

Because the names and the provenience of the schools were not revealed by the TIMSS-2007, we are not certain about the resource equity of schools that grouped as low- and high-performing schools. However, based on the other studies in the literature (Von Secker & Lissitz, 1999), it can be said that supporting of schools by national, state and local efforts to provide equal opportunities for access laboratory facilities, equipment, and supplies may narrow the gaps among low- and high performing schools. Additionally, many schools in low SES areas do not have teachers who are specially qualified to teach specific science topics, such as physics. As well, some lower SES schools, particularly in rural areas, do not offer a variety of science content courses due to low enrollments, lack of materials, or difficulty in finding instructors. Unequal education opportunities at U.S. schools exist, and strategies for supporting teachers and for providing appropriate instruction for all students need to be found.

Finally, analysis of the TIMSS-2007 U.S. data set revealed major differences between low- and high-performing schools with regard to classroom practices. We recommend that other countries' data set be analyzed to reveal differences between schools with regard to the classroom practices. On the other hand, PISA should be taken into account based on classroom practices for its science, mathematics, and reading subject matters.

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