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Gender Differences in Science Performance among Iranian Students in TIMSS 2007

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Abstract: This study investigates the differences between male and female among 8th grade Iranian students in science performance of the Trend International Mathematics and Science Study (TIMSS 2007). Changes in the average percent scores for science performance indicated a descending trend for both genders in the past few TIMSS cycles. Female students generally outscored male students in science, in particular, similar results were found for 8th grade Iranian students in TIMSS 2007. A total of 3981 8th grade students (1786 girls and 2195 boys) from Iran who participated in TIMSS 2007 were studied on their response to students' questionnaire of TIMSS 2007. This study also explored the underlying constructs of students' questionnaire items of TIMSS 2007 based on gender. Principal Component Analysis was performed to determine underlying constructs among the students' questionnaire items. The results of principal component analysis showed that 21 items from the questionnaire were loaded into six factors for both genders with slight differences on the loadings. The underlying constructs were identified as students' self-concept on efficacy-intrinsic motivation, extrinsic motivation, active and passive learning, self-defence and positive attitude on school climate.

Key words: *TIMSS, science performance, gender differences.*

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I. INTRODUCTION

Student achievement in both mathematics and science is well documented in the Trend International Mathematics and Science Studies (TIMSS). Iran is one of the countries that have participated in TIMSS over the past four cycles (1995 to 2007) with particular focus on 8th grade students. Studies on Iranian students' mathematics and science achievement based on TIMSS (Kiamanesh, 2004, 2006; Kiamanesh & Mahdavi-Hezaveh, 2008) are limited, especially with regard to relative variables. In order to examine similarities and differences on the effects of school-related variables on students' science performance for Iran, this study addressed gender differences in science performance among Iranian 8th graders in TIMSS 2007.

In TIMSS 2007, the differences in achievement between male and female 8th grade students were negligible in about one-third of the countries under study. In the remaining countries, female students outscored their male counterparts (Mullis & Martin, 2008). On average, science achievement for female students was higher than male students across all the TIMSS 2007 countries by 6 points. Female students had higher average science achievement than male students in 14 countries, while male students had higher achievement than female students in 11 countries (Martin et al., 2008). The nine countries that showed a decrease from 1995 to 2007 in average achievement for male students included Cyprus, the Czech Republic, Iran, Japan, Norway, Romania, Scotland, Singapore, and Sweden. A further four countries, namely Chinese Taipei, Hungary, Malaysia, and Thailand (as well as the province of Quebec, Canada) showed a decrease from 1999 levels, and a further seven countries a decrease from 2003 (Botswana, Egypt, Hong Kong SAR, Israel, Korea, the Palestinian National Authority, and the United States) (Martin et al., 2008; Sahranavard & Hassan, 2012).

There are a number of studies pointing to a correlation between students' science performance and gender differences (Bacharach, Baumeister, & Furr, 2003; Chang, 2008; Dimitrov, 1999; Preckel, Goetz, Pekrun, & Kleine, 2008; Von Secker, 2004). According to Chang (2008), for instance, gender differences in self-concept and science values do not parallel diminishing differences in actual achievement; when students' achievement levels are controlled, science self-concept and values are more highly related to science achievement for high achievers. At the lower level of achievement, female students' average performances are better than their male counterparts and show smaller score variation. At the upper level, male students outperform female students with a larger score variance. In addition, male students outnumber female students in the

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top 25% for science performance (Chang, 2008). No matter the direction of gender differences at each quarter, male students show higher self-concept of ability and subjective science values. On the whole, it can be said that gender influences science achievement, with male students generally performing better than female students in the subject (Bacharach, et al., 2003; Dimitrov, 1999; Von Secker, 2004).

In addition, researchers have debated about other factors which may influence students' performance, such as self-concept (efficacy-intrinsic motivation), extrinsic motivation, active and passive learning, self-defence and positive attitude (school climate) in relation to gender differences (Chang, 2008; Dimitrov, 1999; Preckel, et al., 2008). Preckel, et al. (2008) assert that in both ability groups, male students earned significantly higher test scores, but there were little or no gender differences in grades. Female students scored lower on measures of academic self-concept, interest, and motivation. Gender differences were larger in gifted than in average-ability students. Ability group differences for self-concept and interest were only found for male students, in favour of the gifted. Results support the assumption that gender differences in self-concept, interest, and motivation in mathematics are more prevalent in gifted than in average-ability students.

However, as shown in Table 1 below, Iranian female students' superiority in TIMSS 2007 has shown a diminishing trend for male students:

Table 1. TIMSS 2007 Average science achievement by gender in Iran

Female students		***Male students***		***Difference*** **(absolute value)**
Percent of students	**Average scale score**	**Percent of students**	**Average scale score**	
49 (1.7)	443 (5.6)	51 (1.7)	429 (6.0)	14 (7.9)

(Source: Martin, et al., 2008)

II. PURPOSES OF THE STUDY

Studies show that a number of different factors are correlated with science performance (Awang & Ismail, 2006; Mokshein, 2002). To determine the gender influence on these factors among 8th grade Iranian students respectively, the present study addresses the following questions.

1. Is there any difference in mean score of items in student questionnaire of TIMSS 2007 based on gender among Iranian 8th grader?
2. Is there any difference in factor loading of items in student questionnaire of TIMSS 2007 based on gender among Iranian 8th grader?

III. SIGNIFICANCE OF THE STUDY

One of the most remarkable findings of TIMSS 2007 regarding Iranian 8th graders is that male students' science achievement scores have shown a significant decline, while female students' scores have shown a significant improvement when compared to the scores of TIMSS 2003, 1999 and 1995. The superiority of Iranian male students' in TIMSS 1995, 1999 and 2003 is reversed in TIMSS 2007. Therefore, this study is significant because it aims at identifying factors that may affect science achievement differently in male and female students. By doing so, this study can pave the way for further comprehensive research on gender differences in science.

IV. METHODOLOGY

The data for this study was obtained from 3981 8th grade Iranian students who participated in TIMSS 2007 (see Table 2 below). The average age of the sampled students at the time of testing was at least 13.5 years. The data analysed in this study is related to the students who took the 2007 science achievement test

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Table 2. Frequency of gender in the study

	Female students	*Male students*	*Total*
Frequency	1786	2195	3981
Percent	44.9	55.1	100.0

To investigate students' science performance between male students and female students based on some student-related variables, the study first examined the underlying structures of the items in the student questionnaire, based on past research. From the student questionnaire, 21 items were analysed using principal components extraction factor analysis followed by the Varimax rotation procedure. The sample comprised two different groups (female and male students) and to meet the assumption of homogeneity of samples in the factor analysis, the data were analysed for these groups separately. The KMO and Bartlett's test of Sphericity was used to test of the hypothesis that the correlation matrix is an identity matrix and that the variables are independent. The KMOs yielded values of .799, .769, and .806, and Bartlett's tests of Sphericity in measure of Chi-square yielded 11853.033, 5293.184, and 6480.719 for the female and male student groups respectively. The results showed that values of Chi-square were significant at $p<.001$ for all groups, and therefore, the hypothesis of the correlation matrix is an identity matrix was rejected. Since past studies have designated a KMOs statistics value between .8 and .9 to be great (Colman & Pulford, 2006; Field, 2005; George & Mallery, 2003), it was thus concluded that the factor analysis was an appropriate procedure to analyse the variables. Then, to determine the number of factors to be extracted, two conventional criteria, eigenvalue and Scree test, were used. First, based on the eigenvalues, only factors that had an eigenvalue of 1 and/or greater were considered as independent factors, after which the result of the first criteria was examined based on the Scree test. The Scree plot indicated that all the factors that had an eigenvalue equal to 1 and/or greater on the plot also had a greater eigenvalues, therefore between two criteria there were consistency. As a result, variables with factor loadings of .40 and greater were considered as criteria combination to the variables. It is worth noting that the factors determined have been named based on previous research evidence (Kiamanesh, 2005; Kiamanesh & Mahdavi-Hezaveh, 2008; Mullis, Martin, Gonzales, & Chrostowski, 2004; Papanastasiou, 2008).

V. DATA ANALYSES

In the present study, the independent samples *t* test was utilized to investigate students' gender differences based on items regarding science items, based on variables of the study in the TIMSS 2007 student questionnaire. In addition, an exploratory factor analysis was also used. The results are listed in the following section.

VI. RESULTS

The results of *t* test are shown in Table 3.

Table 3. Students' average percent for different items by gender

Items	***Female students***		***Male students***			
	Mean	***SD***	***Mean***	***SD***	***t***	***P***
I usually do well in science.	1.67	.725	1.73	.746	-2.441	.015
I enjoy learning science.	1.57	.775	1.67	.816	-3.471	.000
I learn things quickly in science.	1.83	.807	1.93	.836	-3.738	.000
I like science.	1.61	.837	1.68	.890	-2.595	.010
I need science to learn other school subjects.	2.25	.864	2.34	.921	-2.945	.003
I need to do well in science to get into the university of my choice.	1.72	.896	1.80	.915	-2.850	.004
I need to do well in science to get the job I want.	1.83	.949	1.91	.968	-2.614	.009

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How often do you make observations and describe what you see?	1.80	.836	1.93	.997	-4.463	.000
How often do you watch the teacher demonstrate an experiment or investigation?	1.44	.767	1.51	.949	-2.946	.003
How often do you design or plan an experiment or investigation?	2.39	.994	2.44	1.047	-1.517	.129
How often do you conduct an experiment or investigation?	1.89	.871	2.17	.886	-9.523	.000
How often do you work in small groups on an experiment or investigation?	1.98	.959	2.44	.700	-14.306	.000
How often do you use scientific formulas and laws to solve problems?	1.79	.871	1.82	.801	-1.114	.266
How often do you listen to the teacher give a lecture-style presentation?	1.34	.728	1.35	.890	-.467	.641
I like being in school.	1.37	.665	1.54	.658	-7.494	.000
I think that students in my school try to do their best.	1.69	.776	1.92	.413	-8.448	.000
I think that teachers in my school want students to do their best.	1.14	.494	1.26	.431	-6.934	.000
In school during the last month, was something of yours stolen?	1.86	.349	1.78	.326	6.260	.000
Were you hit or hurt by other students?	1.85	.360	1.75	.467	7.503	.000
Were you made to do things you didn't want to do by other students?	1.89	.309	1.88	.949	1.405	.160
Were you made fun of or called names?	1.85	.359	1.68	1.047	12.790	.000

The independent samples *t* test was carried out to compare the means of female and male students in the items of the student's questionnaire TIMSS 2007. Based on data obtained, most observed differences were significant, except five items which showed little or no significant differences ("I usually do well in science", "How often do you design or plan an experiment or investigation?", "How often do you use scientific formulas and laws to solve problems?", "How often do you listen to the teacher give a lecture-style presentation?", and "Were you made to do things you didn't want to do by other students?"). An inspection of the two means suggest that male students obtained higher scores on the TIMSS 2007 student questionnaire compared to female students, except on three items ("In school during the last month, was something of yours stolen?", "Were you hit or hurt by other students?", and "Were you made to do things you didn't want to do by other students?"), indicating that female students got higher scores on the TIMSS 2007 student questionnaire items compared to male students.

The results of principal component analysis are summarized in Table 4.

Table 4. The identified factors with the items and their factor loadings

Factors	***Items***	***Loading***		
		Total	***Female***	***Male***
Self-concept (efficacy-intrinsic motivation)	I usually do well in science.	.792	.740	.721
	I enjoy learning science.	.786	.748	.764
	I learn things quickly in science	.764	.790	.787
	I like science.	.731	.789	.783
Active learning	How often do you conduct an experiment or investigation?	.722	.724	.709
	How often do you work in small groups on an experiment or investigation?	.715	.694	.720
	How often do you design or plan an experiment or investigation?	.694	.678	.715
	How often do you make observations and describe what you see?	.580	.633	.526
Extrinsic motivation	I need to do well in science to get the job I want.	.863	.880	.850
	I need to do well in science to get into the university of my choice.	.857	.874	.834
	I need science to learn other school subjects.	.541	.518	.559
Self-defence	Were you hit or hurt by other students?	.714	.678	.739
	Were you made fun of or called names?	.695	.661	.717
	Were you made to do things you didn't want to do by other students?	.602	.582	.609
	In school during the last month, was something of yours stolen?	.489	.475	.459
Positive	I think that students in my school try to do their best.	.694	.662	.705

attitude (school climate)	I like being in school.	.688	.700	.681
	I think that teachers in my school want students to do their best.	.597	.588	-
Passive learning	How often do you listen to the teacher give a lecture-style presentation?	.696	.773	.576
	How often do you watch the teacher demonstrate an experiment/ investigation?	.651	.676	.661
	How often do you use scientific formulas and laws to solve problems?	.480	-	.557

As can be seen in Table 4, the 21 items based on factor loading above .40 were retained and loaded into six factors— students' self-concept on efficacy-intrinsic motivation, extrinsic motivation, active and passive learning, self-defence and positive attitude on school climate. There were gender differences only on two items that were loaded into six factors observed in this study. First, on one hand, the item "How often do you use scientific formulas and laws to solve problems" was not loaded with the other items into factor that was identified as passive learning for female. Second, on the other hand, the item "I think that teachers in my school want students to do their best" not loaded with other items into factor that was identified as passive learning for male students.

VII. DISCUSSION AND CONCLUSION

Most studies on the relationship of gender and student achievement show that male students in general tend to perform better than female students do (Chang, 2008; Preckel, et al., 2008). However, there are other studies that show no significant difference in science achievement between male and female students, and several others that show female students outperforming male students in science. Nonetheless, several other studies also show male students outperforming female students in science achievement (Beaton et al., 1996; Erickson & Farkas, 1991; Martin et al., 2000).

Therefore, the findings of this study provided more evidence on the puzzling issues of gender differences on science performance. Based on data from the items students' questionnaires on science TIMSS 2007, male and female among 8th grade Iranian students were examined. The results of t-test showed that there were significant gender differences of the mean score in the majority of the items. However, the result of the principle component analysis showed minor differences of the item loadings. Out of 21 items, 6 underlying constructs were identified for both genders. Nevertheless, in general the loadings for the items students' questionnaires on science of TIMSS 2007 for female are higher than male students. In conclusion, there are differences between female and male students' science performance in TIMSS 2007. However, how influential the identified factors on students' science performance are yet to be determined in further investigation.

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