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The Investigation of Construct Validity of TIMSS 2003 Student's Questionnaire among 8th Grade Malaysian Students

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Abstract This study is aimed to investigate the construct validity of TIMSS 2003 student's questionnaire among 8th grade Malaysian students' performance in science. Data from 5314 eighth-grade students (3071 male and 2243 female, in the age 14.3 years old) from Malaysia who participated in the Trends in International Mathematics and Science Study (TIMSS) 2003 were analysed for this study. Principal component analysis was performed to determine underlying constructs among items on the TIMSS 2003 student's questionnaire. Factor analysis showed that the 16 items from the questionnaire were distributed among four factors for the groups under study. The overall findings showed that attitudes towards science and students' science self-concept were important factors based on the variance on science achievement. Attitudes towards school and family background were also significant factors on the variance on science achievement but their effects were less than the first three factors.

Keywords: TIMSS 2003 student's questionnaire, construct validity, Malaysian students

Introduction

Student science performance has received a great deal of attention among researchers in education.This attentionstems from the importance of science in students' future educational paths and incontinuing to develop an innovative and creative society. Previous studies have identified factors that influence student performance in science from various countries. Notable among these studies is the Trends in International Mathematics and Science Study (TIMSS), which documents student achievement in both mathematics and science. Malaysia wasa participating country in the last two cycles of TIMSS,in 1999 and 2003 at the eighth-grade level (Beaton, et al., 1996; Martin, et al., 1997; Martin, Mullis, Foy, & Olson, 2008; Mullis, et al., 2000; Mullis, et al., 2008). Malaysia participated in the last three cycles of TIMSS, from 1999 to 2007, at the eighth-grade level.

These studies consider student-specific and school-related factors that may have impacts on student performance. In a study of data from TIMSS 1999, Mokshein (2002)

found that self-concept of science ability, as well as awareness of the social implications of science, gender and home educational resources were significantly related to Malaysian students' achievement, but students' attitudes towards science and parents' educational level were not significantly related to science achievement. Kiamanesh (2004) reported that some school-related variables, such as students' science self-concept, awareness of the role of science in society and future career options, are fostered to some degree by the educational system and may be directly influenced by school interventions. Although variables like family background are not under the control of educational systems, they are worthy of investigation because they may indirectly influence both student performance and school interventions. Kiamanesh (2004) also found that science self-concept, view of science in the world, home background, belief in the importance of science and external motivation had significant influences on eighth-grade Iranian students' science achievement, while neither the students' attitudes towards science nor the home-school interface had a significant influence. Mettas et al. (2006) reported a significant relationship between students' self-beliefs and attitudes and science achievement. Research findings indicate a strong positive relationship between students' science performance and the accessibility of educational resources (a dictionary, a personal study desk, and a computer) at home among countries that have participated in TIMSS studies (Beaton, et al., 1996; Martin, Mullis, & Chrostowski, 2004; Martin, et al., 2008; Martin, et al., 2000). There is also a positive relationship between parents' educational level and students' science achievement in eighth grade (Beaton, et al., 1996; Davis-Kean, 2005; Feinstein, Duckworth, & Sabates, 2004; Martin, et al., 2008; M. O. Martin, et al., 2000; Nordtveit, 2005). Research findings have shown that in most countries, home schooled students with more books have higher proficiency in science (Beaton, et al., 1996; Martin, et al., 2004; Martin, et al., 2008).

Science knowledge among its citizens is critical to Malaysia's goal of becoming a developed nation by the year 2020, and knowledge of science is paramount to this goal. The importance of science and technology is officially documented in the government blueprint as articulated by the Malaysian Prime Minister (Mohamad, 1993): "*one of the nine challenges in the actualization of the Vision 2020 is to establish a scientific and progressive society - a society that is innovative and forward-looking, one that is not just a consumer of technology but also a contributor to the scientific and technological civilization of the future"* (as sited by Mokshein, 2002, p. 5). However, despite important gains, Malaysia remains only slightly above the international average in science achievement based on TIMSS 2007 and still lags behind other fast-growing Asian nations, such as Singapore and Taiwan. In each of the last four cycles of TIMSS (1995 to 2007), Singapore was the top-performing country in both mathematics and science. In 1995, it was the top performer in mathematics at both the fourth- and eighth-grade levels and in science at the eighth-grade level. In 1999, it led in mathematics at the eighth-grade level and was out performed by just one scale-score point by Chinese Taipei in science at the eighth-grade level. In 2003, it was again the top performerin both mathematics and science at both grade-levels, and most recently in 2007, it outperformed all other participating countries in science at both the fourth- and eighth-grade levels (Beaton, et al., 1996; Martin, et al., 1997; Martin, et al., 2008; Martin, et al., 2000; Mullis, et al., 1997; Mullis, Martin, Gonzales, & Chrostowski, 2004; Mullis, et al., 2000; Mullis, et al., 2008). Results of the TIMSS 2003 study rank Malaysia below many other countries in this international evaluation of student achievement (Martin, et al., 2004; Mullis, et al., 2004).

Malaysia is a multicultural country with three major ethic groups: Malay, with 58% of the population; Chinese, withapproximately 30%; and Indian, with 10%; the remaining 2% is made up of various other ethnic groups (Dixon, 2005; Malaysia, 2004; Wong, Kaur, Koay, & Jamilah, 2008). The results of TIMSS 1999 showed that Malaysian students performed slightly but insignificantly below the international average in life science and chemistry. Malaysians performed above the international average in all other categories, including environmental science, earth science and physics, but these differences were only significant for environmental science. On the average, Malaysian students in both TIMSS 1999 and 2003 achieved performance scores above the international average in life science, chemistry, physics, earth science and environmental science by 11, 19, 26, 16, and 27 scale-score points, respectively. However, Malaysians scored considerably higher than the international average in the five content areas in TIMSS 1999 and 2003 on average (See Appendix 1).

The TIMSS 2007 data are not yet available for secondary analysis. While limited descriptions have been given of Malaysian students' performance in mathematics and science based on previous TIMSS data (Awang & Ismail, 2006; Mokshein, 2002), analysis of the factors influencing student achievement in mathematics, and particularly in science, have been limited. To help fill this gap, this paper attempts to identify these factors and to evaluate the effects of school-related variables on students' science performance in Malaysia.

There is a great deal of evidence that student performance in science is influenced by contextual variables, such as a student's attitude towards science, science self-concept, family background, aspirations for further education, attitude towards school, school environment, leisure time and so on (Beaton, et al., 1996; Kiamanesh, 2004; Martin, et al., 1997; Martin, et al., 2004; Martin, et al., 2008; Mettas, et al., 2006; Mokshein, 2002). This study focused on three important student-related factors that can be directly impacted by school, such as attitude towards science, science self-concept, and attitude towards school, as well as two other factors that may have an indirect influence, i.e., family background.

Based on the above mentioned and importance of the factors in academic achievement, this study generalized this information to specifically Malaysian eighth-grade students. Some studies obtained similar results and others were different. The importance of some student-related variables is examined by investigators (Kabiri & Gharbi, 2009; Kiamanesh, 2004). The present study aimed at evaluating the construct validity ofthe TIMSS 2003 student's questionnaire using a Malaysian. Also, this study determined whether, TIMSS 2003 student's questionnaire is a valid instrument for the assessment of student-related factors among 8th grade Malaysian students' performance in science.Therefore, this scale would provide a tool for any future TIMSS studies.

We made use of the TIMSS database and applied factor analysis. In the next section, we explained the data used. Section 3 outlines the empirical approach. We discussed the results in Section 4. Finally, Section 5 concludes with the main findings and some final remarks.

Previous Research Conducted on TIMSS in Science

Studies have shown that a large percentage of Malaysian students display a highly positive attitude towards science (Martin, et al., 2000). Although internationally there is a positive correlation between students' self-concept in learning science and their eighth-grade science scores, the relationship between these two factors at the country level is more complex. Reports indicate that relatively few students (21% or less) in several high performing

countries, including Singapore, Japan, Hong Kong, Chinese Taipei, and Korea, had high levels of self-concept in science (Martin, et al., 2004; Martin, et al., 2000). Researchers comparing science achievement among Singaporean and Japanese eighth-grade students based on TIMSS 1999 pointed out that a higher percentage of Singaporean than Japanese students indicated that they liked science (91.9% compared with 56.1%). Based on TIMSS 1999 data, Mokshein (2002) found that self-concept in learning science, awareness of the social implications of science, gender and home educational resources were significantly related to Malaysian students' achievement, but students' attitudes towards science and parents' education levels were not significantly related to science achievement. Researchers have indicated that students' self-beliefs and attitudes are significantly related to science achievement (Mettas, et al., 2006). Janjetovic and Malinic (2004) have shown positive correlations between family variables and self-concept. Hammouri (2004) examined achievement in the 1999 TIMSS-R data (TIMSS Repetition data) at the student level. He investigated factors affecting perceptions of the importanceof math (self, maternal and peer items) and attribution of success in math (two items) in addition to the TIMSS Positive Attitude and self-concept indices. Parental expectations for their children's future careers reflected gender typing. Male students were encouraged to pursue technical careers in the hard sciences while female students were directed towards careers in literature (O'Connor-Petruso & Miranda, 2004).

Research findings indicate that there is a strong positive relationship between students' science performance and the availability of educational resources (dictionaries, a personal study desk, and a computer) at home in the countries that participated in the TIMSS (Martin, et al., 2004; Martin, et al., 2000). There is a positive relationship between parents' educational level and students' science achievement in eighth grade (Davis-Kean, 2005; Feinstein, et al., 2004; Nordtveit, 2005). Additionally, research has shown that in most countries, home study students with more books had higher levels of achievement in science (Martin, et al., 2004). Researchers have shown that boys generally scored significantly higher in science than girls (Beaton, et al., 1996).

Method

Participants

The data for the present study included student-related variables from 5314 eighth-grade students (3071 girls and 2243 boys) from Malaysia, with a mean of 14.3 years old, who participated in TIMSS 2003.

Measure

In the TIMSS 2003 Student Questionnaire, students were asked about their home environments and school experiences, and their attitudes toward mathematics and science. At the eighth grade, three indices were constructed representing three aspects of students' attitudes toward mathematics and science: positive affect, self-confidence, and valuing the subject. The eighth grade also included an index of time students spend on homework in mathematics and science and an index of students' perceptions of being safe in school (Martin & Preuschof, 2008). TIMSS student questionnaire includes 39 items. Each student in the sampled eighthgrade TIMSS classes completed a Student Questionnaire(Erberber, et al., 2008).

Procedure

Data for this study came from the Third International Mathematics and Science Study (TIMSS) 2003 conducted by the International Association for the Evaluation of Educational Achievement (IEA).The study is designed to illustrate trends in eighth-grade mathematics and science achievement in an international context with the participation of almost fifty countries, including Malaysia. The present study uses the science achievement data from Malaysia for the 2002 school year.

Data Analysis

Our analysis first examined at the underlying structure of the items on the student questionnaire. Based on methods used in previous research, the 16 items from the student questionnaire were analysed using principal components extraction factor analysis followed by a Varimax rotation procedure. Because the sample was composed of two different groups (girls and boys) and to meet the assumption of homogeneity of samples in factor analysis, the data were analysed for these groups separately. The KMO and Bartlett's Sphericity tests were used to test the hypothesis that the correlation matrix was an identity matrix and the variables were independent. The results showed that chi-square values were significant at $p<.001$ for all groups; therefore, the hypothesis of the correlation matrix as an identity matrix was rejected. Authors have argued that KMO statistics values between.8 and .9 are high (Colman & Pulford, 2006; Field, 2005, p. 650; George & Mallery, 2003, p. 256). Thus, it was concluded that factor analysis was an appropriate procedure for analysing the variables. To determine the number of factors to be extracted, two conventional criteria, eigenvalue and scree test, were used. First, only factors with eigenvalues of 1 or greater were considered as independent factors, and the result of the first criteria was examined with the scree test. The scree plot confirmed the eigenvalues of 1 or greater for all factors considered to be independent, indicating consistency between the two criteria. As a result, variables with factor loadings of .40 or greater were considered to be a criteria affecting multiple variables. The factors determined to be appropriate for extractionare based on the evidence from previous research (Kiamanesh, 2005; Kiamanesh & Mahdavi-Hezaveh, 2008; Mullis, et al., 2004; Papanastasiou, 2008).

Results

The results of factor analysis are summarized in Table 1. As shown in Table 1, the 16 items with factor loadings above .40 were identified and grouped according to four factors. Some items were grouped differently for girls than for boys. For Malaysian girls, the item "I think that most teachers in my school care about the students" were grouped under the attitude towards school factor ratherthan the attitude towards science factor. The item "Science is not one of my strengths" was included with the other items under the students' science self-concept factor for Malaysian boys.

Table 1
Extracted Factors with the Survey Items and Their Factor Loadings

Factors	Items	Malaysia Factor Loadings	
		Girls	Boys
Attitude towards Science	I need to do well in science to get the job I want.	.798	.781
	I need to do well in science to get into the university of my choice.	.780	.735
	I would like a job that involves using science.	.776	.745
	I think learning science will help me in my daily life.	.659	.656
	I enjoy learning science.	.634	.636
	I would like to take more science in school.	.643	.697
	I need science to learn other school subjects.	.610	.626
Attitude towards School	I think that most teachers in my school care about the students.	.807	.777
	I think that most teachers in my school want students to do their best.	.748	.745
	I think that most students in my school try to do their best.	.646	.640
	I like being in school.	.600	.626
Students' science self-concept	Science is more difficult for me than for many of my classmates.	.781	.760
	Sometimes when I do not initially understand a new topic in science I know that I will never really understand it.	.718	.721
	Science is not one of my strengths.	.707	.696
Family background	What is the highest level of education completed by your father (or stepfather or male guardian)?	.893	.902
	What is the highest level of education completed by your mother (or stepmother or female guardian)?	.893	.901

Table 2
The Variance in Malaysian Students' Science Achievement Accounted for by Each Factor

Factors	Rotation Sums of Squared Loadings			
	Girls		Boys	
	% of Variance	Cumulative %	% of Variance	Cumulative %
Attitude towards science	22.567	22.567	22.188	22.188
students' science self-concept	13.401	35.968	13.175	35.364
Attitude towards school	11.419	47.387	11.105	46.469
Family background	10.009	57.396	10.258	56.727

Table 2 shows the percentage of variance explained by each factor and the total variance explained by all factors for male and female Malaysian students. The factors explained 57.395%, and 56.727% of the variance of the items for Malaysian girls and boys, respectively. These overall factors could explain 0.66% variance on the variables for Malaysian girls than boys, respectively.Attitude towards sciencehad the largest explained variance for girls and boys. Student's science self-conceptwas the second greatest factor for girls and boys. The remaining factors contributed almost equally for both boys and girls.

Discussion

This study was designed to investigate the construct validity of TIMSS 2003 student's questionnaire in science among Malaysian eighth-grade students.

Factor analysis showed that four factors explained the highest proportion of the variance among the 16 items for both genders (59.91%).

The four factors explained slightly more variance in science performance among boys than among girls (16% and 15%, respectively). Although the pattern of factors was approximately equal for boys and girls, attitude towards science and students' science self-concept explained 2.1% and 1.37% more variance, respectively, for boys than for girls. In contrast, family background and attitude towards school, explained 1.18%, .80%, and 59%, more variance, respectively, for girls than boys.Results show that attitude towards science and students' science self-concept was the factors that most influenced the variance in science achievement for Malaysian students. Family background and attitude towards school were also significant, though their effects were considerably less important than the other three factors. The present findings show both similarities and differences in comparison with previous studies. For example, Mokshein (2002) found that self-concept in learning science, awareness of social implications of science, gender and home educational resources explained a low proportion (13%) of variance in Malaysian students' science achievement based on TIMSS 1999. She also concluded that parents' education level and attitude towards science did not significantly affect on the variance in Malaysians students' science achievement. Similarity, Kiamanesh (2004) found that attitude towards science among Iranian eighth-grade students did not significantly affect science achievement; in contrast, the findings of the present study suggest that students' attitude towards science is one of the most important factors affecting science achievement.

In summary, the percentage of Malaysian students who agreed that science was very important did not change significantly between TIMSS 1999 and TIMSS 2003 (from 43% to 42%). The percentage of students who slightly agreed with this statement significantly decreased from 1999 to 2003 (51% to 44%), and the percentage who disagreed with the question significantly increased from 1999 to 2003 (from 5% to 13%). That is, the overall percentage of Malaysians who agreed with the statement significantly decreased over four years. The percentages of students who slightly agreed with the statement were similar those for students who disagreed, with values from 1995, 1999 and 2003 significantly increasing (10%, 13% and 17%, respectively). The percentage of students who placed science education at the high, medium and low levels of importance in 2003 were 73%, 25% and 2%, respectively. This index shows that learning science has become more highly valued among Malaysian students. However, a significant correlation has been shown between students' value of science education and their level of science achievement (Martin, et al., 2004).

Students' science self-concept was a less important factor for Malaysian boys, than girls. The percentage of students who reported a high level of science self-concept (38%) was lower for Malaysian students than the international average while the percentage of Malaysian students reporting a low level of science self-concept (14%) was higher than the international average). Forty-eight percent of Malaysian students reported a medium level of science self-concept. The results showed a positive relationship between this index and students' science scores (Martin, et al., 2004).

At the international level, Malaysian students who indicated that they had a computer and a study desk at home achieved higher scores in science than those who did not. Only 57% and 87% of Malaysians reported having a computer and a study desk at home, respectively (Martin, et al., 2004). International performance in science was positively correlated with computer use, particularly among eighth-grade students, and this result was similar for Malaysians. Only 26% of Malaysian students reported using a computer both at home and school. Twenty-six of Malaysians reported using a computer at home but not at school, and 24% reported using a computer and used at school but not at home eleven

percent of Malaysians reported no use of a computer (Martin, et al., 2004). Findings for students internationally showed a positive correlation between the number of books at home and science achievement. This pattern was also found for Malaysian students. Among Malaysian students only 5% reported having more than 200 books at home, 9% reported having between 101 and 200 books at home, and 28% reported having between 26 and 100 books at home (Martin, et al., 2004).

Attitude towards school had less of an impact on science achievement for Malaysian students. Family background was a more significant factor for girls. Several researchers have reported that family background, including family income, and parents' education directly and indirectly influence students' school performance (Davis-Kean, 2005; Feinstein, et al., 2004; Nordtveit, 2006). Parents with higher levels of education may spend money differently than those with lower education, and thus, they may be better able to protect their children from the effects of poverty or to derive greater developmental advantages from their higher incomes (Feinstein, et al., 2004). Parents' participationin their children's education has long been acknowledge as a key factor in children's success at school (Khong & Ng, 2005). Researchers have demonstrated that parental involvement in their children's education can have a variety of effects including higher grades and graduation rates, better attendance, more regular completion of homework, more positive attitudes and behavior in school and greater higher rates of enrollment in post-secondary education (Henderson & Berla, 1994, cited in Khong & Ng, 2005).

The present study shows that each of four factors explain 15.5% of the variance in science performance for Malaysian students who participated in TIMSS 2003. The remaining variance in science performance may be influenced by other factors not investigated in this study. As shown in Appendix 1, there is a gap between Malaysian students' science achievement in TIMSS 1999 and 2003. The results of the present study show that attitudes towards science and students' science self-concept are relatively low for Malaysian students, but this difference is not remarkable. Thus, there are other important factors influencing Malaysian students' science performance that require further investigation.

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Appendix 1

Average Students' Science Achievement by Content Areas at 8th Grade in Malaysia on TIMSS 1999 and 2003 Compare with the International Average (from: Mullis et al., 2000; 2004)

Contents Areas		Malaysia	International average
Life Science	1999	479	488
	2003	504	474
Chemistry	1999	485	488
	2003	514	474
Physics	1999	494	488
	2003	519	474
Earth Science	1999	491	488
	2003	502	474
Environmental Science	1999	502	488
	2003	513	474