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Reliability and Validity of a Malay Translation of the Fennema-Sherman Mathematics Attitudes Scales

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Abstract: The purpose of this study was to establish the reliability and validity of a Malay version of the Fennema-Sherman Mathematics Attitudes Scales (MAS) in a Malaysian context. A Malay version of the Fennema-Sherman MAS was administered to 2380 secondary four students from 29 secondary schools in Malaysia. The reliabilities for all nine scales were sufficient, and confirmatory factor analyses indicated that the nine scales constitute nine separate factors rather than six. As earlier studies have relied on Exploratory Factor Analyses, the use of Confirmatory Factor Analysis (CFA) in this study provided additional support to the factorial validity of the MAS. The construct validity of the scales was further supported by examining hypothesized relationships among the variables.

Key words: Mathematics anxiety; Attitudes toward mathematics; Fennema-Sherman Mathematics Attitudes Scales

Introduction

For the past three decades, there has been continued interest in students' attitudes toward mathematics and in the correlates of these attitudes (McLeod, 1994; Muzzatti & Agnoli, 2007; Sherman & Fennema, 1977; Wigfield & Meece, 1988; Wilkins & Ma, 2003). Hence, there is growing recognition that affective factors play an important role in mathematics education (Ho et al., 2000; Ma & Cartwright, 2003). According to McLeod's theoretical framework (1992), the affective domain is divided into beliefs, attitudes, and emotions that students have toward mathematics. All these three elements have been found to be related to mathematics achievement and are important components of mathematics education. For instance, beliefs regarding one's efficacy have been found to be an important predictor of performance while positive attitudes toward a particular task have been related to

behavioural choices in favour of mathematics (Meece, Wigfield & Eccles, 1990). With regard to emotions, mathematics anxiety has received more attention than any other construct that lies within the affective domain (McLeod, 1992). Various studies have shown that mathematics anxiety is related to poor performance and can disrupt cognitive processing by compromising ongoing activity in working memory (Ashcraft, 2002; Ashchraft & Kirk, 2001; Meece, Wigfield, & Eccles, 1990; Yeo, 2004).

Linnenbrink and Pintrich (2000) have proposed that affective and motivational processes may interact to influence cognitive and behavioural outcomes. For instance, positive emotions, such as the experience of joy in doing a task, may lead to intrinsic motivation for the task, whereas, negative emotions, such as anxiety or boredom, might decrease intrinsic motivation for that particular task (Pintrich & Schunk, 2002). Mecce and colleagues (1990), by integrating self-efficacy and expectancy-value theoretical frameworks of achievement, modeled the reciprocal relations among mathematics anxiety, efficacy beliefs about mathematics, mathematics value perceptions and their links to academic performance. In particular, they found it is "students' interpretations of their achievement outcomes, and not the outcomes themselves that have the strongest effect on students' affective reactions to achievement" (p. 68).

Purpose of this research

However, as much of this research has been conducted in Western (especially North American) populations, there is a need to extend this research to non-Western societies to determine whether there is cross-national generality in regard to the role of affect on students' motivation and performance in mathematics. In Malaysia, the school curriculum posits for good performance in mathematics as a prerequisite for tertiary level studies in science, technology, accountancy, and business. Performing well in mathematics has been entrenched in the minds of secondary school students in Malaysia. Such tremendous pressure to achieve "acceptable" scores may bring about negative attitudes and affect toward the learning of mathematics for a number of students in Malaysia or elsewhere (Marzita, 2002). As a preliminary step in studying the role of mathematics affect in Malaysia, the purpose of this study was to establish the reliability and validity of a Malay version of the Fennema-Sherman Mathematics Attitudes Scales (MAS) in a Malaysian context. A validated MAS with good psychometric properties would be vital for studying the relationships among affective variables in the mathematics domain, especially for Malaysian students who might be experiencing difficulties in learning mathematics.

The Fennema-Sherman Mathematics Attitudes Scales

Mulhern and Rae (1998) stated that the Fennema-Sherman MAS (Fennema & Sherman, 1976) has been widely used to investigate attitudes toward the study of mathematics and the correlates of these attitudes. These scales had been originally designed to research into gender-related differences in mathematics achievement among high school students, but since the seminal studies, the impact of using such scales has been felt in many researchers dealing with mathematics attitudes. In fact, Hyde and colleagues (1990) have stated that the MAS are the "most prominent in the literature on mathematics attitudes and affect" (p.302). Recently, Alkhateeb (2004) found support for the reliability and validity of an Arabic translation of the shortened form of the Fennema-Sherman MAS, while Vezeau and colleagues (1998) provided evidence for the validity of a French version of the MAS.

The complete MAS instrument is composed of nine subscales, each with 12 items. The nine scales include Attitude Toward Success in Mathematics; Mathematics as a Male Domain Scale; Mother, Father, and Teacher scales; Confidence in Learning Mathematics; Mathematics Anxiety scale; Effectance Motivation in Mathematics scale; and Usefulness of Mathematics scale. As reliability is a prerequisite for assessing the validity of a Malay version of the MAS, the first aim of the present study was to examine the reliability of the nine subscales.

A number of researchers (Mulhern & Rae, 1998) have suggested that the items in the MAS may be reduced to six factors rather than nine as suggested by Fennema and Sherman (1976). Mulhern and Rae (1998) found that the following two scales – Confidence in Learning Mathematics, and Mathematics Anxiety – could be collapsed into a Mathematics-Related Affect scale. The Mother and Father scales could be combined into a Parent scale. The Effectance Motivation scale was dropped as a few items from this scale loaded on the Mathematics Affect Scale, a number of items loaded on the Usefulness scale, and a few items did not load on any factor. Hence, the second aim of this study was to test the factor structure of the MAS from data provided by a sample of Malaysian students. In particular, we used Confirmatory Factor Analysis (CFA) to examine whether a nine-factor structure would fit the data better than a six-factor structure.

The use of CFA is also an important step in the validation process of a scale. The bulk of validation studies of the Fennema-Sherman MAS scale have depended solely on Exploratory Factor Analysis (EFA; Alkhateeb, 2004; Melancon, Thompson, & Becnel, 1994; Mulhern & Rae, 1998). The EFA approach has been criticized for having statistics rather than theory determine the structure of a scale, and for not adequately assessing error (Thompson & Daniel, 1996). Hence, CFA is needed to verify these findings as it allows for the testing of a specific, hypothesized

factor structure on the basis of theoretical evidence or substantial past data (Gorusch, 1983).

An important process in establishing the validity of a scale is construct validation. "Construct validation occurs within the context of a theory or set of hypotheses concerning the construct in which we are interested... Only when the observed pattern of relationships is correspondent with predictions based on our understanding of the construct can it be said that the construct validity of the test is supported" (Walsh & Betz, 1995, pp. 66-67). Hence, hypothesized relationships among variables can be studied to support the construct validity of a particular scale. The third aim of the study was to examine the relationships among the various scales of the MAS as a preliminary step in establishing the construct validity of the MAS.

It has been argued that "beliefs about self-capability influence the degree to which students engage in academic tasks, experience anxiety when performing those tasks, and persist when facing challenges and difficulties" (Ma & Cartwright, 2003, p.414). Hence, we hypothesized that Confidence in Learning Mathematics, Attitudes toward Success, Usefulness of Mathematics, and Effectance Motivation would be positively related to one another. In addition, as highlighted earlier, given the effects of confidence and success on mathematics anxiety, we expected a negative relationship between these variables and mathematics anxiety.

Various researchers have shown that teachers (Cooper & Good, 1983; Jussim, 1986; Stipek, 1996) and parents (Mullis et al., 2000) suggest that parents and teachers play an important role in the development of children's belief structures toward mathematics. Hence, it is hypothesized that parent and teacher attitudes would have a positive relationship with all the variables except mathematics anxiety where a negative relationship would be expected.

Method

Participants

The participants in the study were 2380 students (53% girls) from Secondary Four classes. The questionnaires were administered to the students in 29 secondary schools randomly selected from the 67 secondary schools in Penang, Malaysia. The students were from the Science stream as well as from the Arts stream.

Instrumentation

All the subjects in this study completed a translated Malay version of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), using a 5-point Likert–type response format. As the MAS instrument comprised of nine scales, each with twelve items, the students completed answering 108 questions. A sample item for each of the scales is provided in Table 1.

Table 1
Sample Items of the Mathematics Attitudes Scales

Scale	Sample Item
1. Attitude Toward Success in Mathematics (Success)	I'd be proud to be the outstanding student in math
2. Confidence in Learning Mathematics (Confidence)	Generally I have felt secure about attempting mathematics.
3. Effectance Motivation	I like math puzzles.
4. Father Attitude	My father has strongly encouraged me to do well in mathematics.
5. Mathematics as a Male Domain (Male Domain)	Females are as good as males in geometry.
6. Mathematics Anxiety	Math doesn't scare me at all.
7. Mother Attitude	My mother thinks I could be good in math.
8. Teacher Attitude	My teachers have encouraged me to study more mathematics.
9. Usefulness of Mathematics (Usefulness)	I'll need mathematics for my future work.

Fennema and Sherman reported split-half reliabilities ranging from .86 to .93 for all the nine scales of the MAS, while Mulhern and Rae (1998) reported internal reliability coefficients ranging from .83 to .96 for the nine scales. For the present study, the MAS items were scored such that higher scores reflected higher levels of that particular construct. In terms of validity, Betz (1978) found MAS scores to be related to the number of years of high school mathematics taken, mathematics

achievement scores, gender, and test anxiety. Yeo (2004) found that the mathematics anxiety score of the MAS was related to test anxiety and performance on a mathematical problem solving test.

Analyses

Confirmatory factor analyses were conducted to investigate the factor validity of the nine scale structure of the MAS. As a number of researchers have suggested that the items in the Mathematics Attitudes Scales may be reduced to six factors (Mulhern and Rae,1998) rather than nine as suggested by Fennema and Sherman (1976), confirmatory factor analyses were conducted to examine whether the items of the scale would fit a nine factor or six factor structure better. The nested model comparison methodology was used to compare the nine-factor and six-factor structure (Brown, 2006). The nine-factor structure consisted of Attitude Toward Success in Mathematics; Mathematics as a Male Domain Scale; Mother, Father, and Teacher scales; Confidence in Learning Mathematics; Mathematics Anxiety scale; Effectance Motivation in Mathematics scale; and Usefulness of Mathematics scale. In the six factor structure, a Mathematics Affect scale was used to represent the following scales: Confidence in Learning Mathematics, Mathematics Anxiety, and Effectance Motivation; the Parent scale was used to collapse the Mother and Father scale. These analyses were run using the Structural Equation Modeling (SEM) software known as RAMONA which is available in the statistical package, SYSTAT.

Correlational analyses were run to examine the relationships among the various scales of the MAS.

Results

Psychometric properties of the MAS

The internal consistency reliability for the nine scales of the Mathematics Attitudes Scales was generally good. Two of the scales (Confidence and Usefulness) had Cronbach α's greater than .90, and five of the scales had Cronbach α's greater than .80 (Mother, Father, Teacher Attitude, Anxiety, and Male Domain). The rest of the scales had α's greater than .65 (Success, and Effectance Motivation). The Cronbach α's are reported in Table 2.

Table 2
Reliability Coefficients for the Mathematics Attitudes Scales

Scale	Cronbach α
1. Attitude Toward Success in Mathematics (Success)	.65
2. Confidence in Learning Mathematics (Confidence)	.91
3. Effectance Motivation	.76
4. Father Attitude	.88
5. Mathematics as a Male Domain (Male Domain)	.80
6. Mathematics Anxiety	.89
7. Mother Attitude	.83
8. Teacher Attitude	.83
9. Usefulness of Mathematics (Usefulness)	.92

Confirmatory factor analyses

The 9-factor model showed good fit indices (Brown & Cudeck, 1992) – the Root Mean Square Error of Approximation (RMSEA) was 0.054 (90% CI: .053, .055). The RMSEA for the 6-factor model was 0.059 (90% CI: .058, .059). For both the 9-factor, and 6-factor models, all the 108 factor loadings were significant ($p<.05$). However, a comparison of the chi-square statistic indicated that the items fit the nine factor structure significantly better than the six factor structure ($\chi^2(21)= 4391$, $p<.0001$).

Descriptive statistics

The means of the nine subscales are provided by gender in Table 3. Girls scored significantly higher than boys in all the scales except Confidence (F-values can be found in Table 3). There was no significant difference in the Confidence scale. However, except for Male Domain, the effect size measures of the gender differences were generally small. For η^2 as an effect size measure, η^2 = .01, .06, and .14 are considered small, medium, and large effect sizes, respectively (Green & Salkind, 2005).

Table 3

Descriptive Statistics for the nine scales of the Mathematics Attitudes Scale

	Girls	Boys	F-value	Effect Size, η^2
1. Confidence	40.51	40.84	.75	.000
2. Mother Attitude	46.30	45.02	19.17**	.008
3. Father Attitude	47.73	46.46	15.77**	.007
4. Success	45.17	43.36	61.13**	.025
5. Teacher Attitude	41.56	40.14	22.18**	.009
6. Male Domain	46.69	40.83	452.90**	.160
7. Usefulness	49.94	47.19	62.12**	.025
8. Mathematics Anxiety	33.16	32.25	5.98*	.003
9. Effectance Motivation	40.64	38.86	39.62**	.016

*p<.05, **p<.0001

Note: η^2 = proportion of variance in the dependent measure associated with the different groups of children (SSeffect/SStotal).

Correlational analyses

The zero-order correlations among all the nine subscales or factors can be found in Table 4. All the correlations were significant (p<.0001). Mathematics anxiety was negatively correlated with all the other subscales. For example, Confidence was negatively correlated, r(2380)= -.63, p<.0001, with Mathematics Anxiety. Excluding Mathematics Anxiety, all the other subscales were positively correlated with one another. For instance, Confidence was positively correlated with Attitude Toward Success, r(2380) = .27, p<.0001.

Table 4
Zero-order correlation table for the nine scales of the Mathematics Attitudes Scale

	1.	2.	3.	4.	5.	6.	7.	8.	N	M	SD
1.Confidence	-								2379	40.67	9.18
2. Mother Attitude	.42	-							2379	45.70	7.13
3. Father Attitude	.40	.71	-						2374	47.13	7.77
4. Success	.27	.36	.40	-					2380	44.32	5.71
5. Teacher Attitude	.43	.43	.43	.32	-				2380	40.89	7.39
6. Male Domain	.17	.27	.29	.35	.29	-			2380	43.92	7.32
7. Usefulness	.40	.54	.57	.42	.43	.42	-		2380	48.64	8.63
8. Math Anxiety	-.63	-.32	-.30	-.19	-.43	-.11	-.30	-	2380	32.73	9.07
9. Effectance Motivation	.59	.44	.43	.29	.47	.31	.52	-.56	2380	39.80	6.96

All correlations are significant $p<.0001$

Discussion

The purpose of the present study was to validate a Malay version of the Fennema-Sherman Mathematics Attitudes Scales (MAS) in a Malaysian context. The findings provided evidence of good psychometric properties for the Malay version of the MAS. The reliabilities for all nine scales were sufficient, and confirmatory factor analyses indicated that the nine scales constitute nine separate factors rather than six. As earlier studies have relied on Exploratory Factor Analyses (EFA; Alkhateeb, 2004; Melancon, Thompson, & Becnel, 1994; Mulhern & Rae, 1998), the use of Confirmatory Factor Analysis (CFA) in this study helps to provide

additional support to the factorial validity of the MAS. Hence, the results are consistent with Fennema and Sherman's (1976) original conceptualization of nine separate factors. Fennema and Sherman have suggested that the scales can be used as a total package for measuring important attitudes related to mathematics learning, or the scales can be used individually.

The construct validity of the scales was further supported by examining hypothesized relationships among the variables. As hypothesized, Confidence in Learning Mathematics, Attitudes toward Success, Usefulness of Mathematics, and Effectance Motivation were positively related to one another. In addition, these four variables were negatively related to mathematics anxiety.

Confidence in learning mathematics, considered a conceptual forerunner to mathematics self-efficacy, has consistently been found to predict both mathematics performance and mathematics anxiety (Pajares & Miller, 1994). The importance of students' judgments about their capability or self-efficacy has been highlighted by social cognitive theorists such as Bandura (1986) and research has supported self-efficacy's role as an important mediator for all types of achievement behaviour as well as many other types of behaviours (e.g. see reviews by Bandura, 1997; Pajares, 2003; Stajkovic & Luthans, 1998; Robbins et al., 2004).

As hypothesized, parent and teacher attitudes had a positive relationship with all the variables except mathematics anxiety where a negative relationship was found. With items such as "My math teachers think I'm the kind of person who could do well in mathematics", and "My math teachers have been interested in my progress in mathematics", the teacher attitudes scale seem to measure students' perception of their teachers' expectations about their mathematical ability. Hence, this study suggests that teachers' expectations about their students is related to their mathematics affect.

The finding that parents' attitudes were related to students' confidence in mathematics and other attitudes supports research indicating that children construct their own self-perceptions, in part, based on their parents' messages (Jacobs & Eccles, 2000). In fact, research has shown that "parents' perceptions of their children's abilities and their expectations for their children's future successes are related to children's developing perceptions of self-competence" (Bleeker & Jacobs, 2004, p. 107). Bleeker and Jacobs (2004) found longitudinal evidence that mothers' earlier predictions of their children's abilities to succeed in mathematics careers were significantly related to later career choices.

A number of limitations of the study and directions for future work warrant comment. One limitation of this study is the correlational nature of the results -- causal direction cannot be established. Hence, it is possible that mathematics anxiety influences confidence rather than the other way around. Nevertheless, there is longitudinal evidence from other studies that support the primacy of students' judgments of their capabilities (Meece, Wigfield, & Eccles, 1990). The generalizability of the results may be limited as the data were based on one out of the fourteen states in Malaysia. Future research needs to be done in other parts of Malaysia. Nevertheless, a strength of the study is that the data were collected from 27 schools randomly selected from 67 schools in Penang, Malaysia.

In conclusion, this study represents a preliminary step in studying the role of affective factors in mathematics education in Malaysia by validating a Malay version of the MAS. The present findings support the reliability and validity of the Malay version of the MAS for use in a Malaysian context. To further establish the validity of the MAS, future studies can be done to examine the criterion-related validity of the scales, especially with regard to relations between affective factors and mathematics achievement. In addition, research also needs to be done in implementing interventions for teachers and students for reducing negative beliefs, attitudes and emotions toward mathematics. Given the importance of mathematics in today's society, such research would greatly contribute in guiding teachers in alleviating students' anxieties.

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