The Mathematics Educator
2013, Vol. 15, No. 1, 121-135

A Confirmatory Factor Analysis of Attitudes Toward Mathematics Inventory (ATMI)

Aysha Abdul Majeed **I Gusti Ngurah Darmawan** **Peggy Lynch**
The University of Adelaide, Australia

Abstract: Students' attitudes toward mathematics have been known to influence students' participation, engagement, and achievement in mathematics. A variety of instruments have been developed to measure students' attitudes toward mathematics for example Mathematics Attitude Scale (Aiken, 1974), Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), and Attitudes Toward Mathematics Inventory (ATMI) (Tapia & Marsh, 1996). The purpose of this paper is to report the validation of the ATMI instrument. It was administered to 699 Year 7 and 8 students in 14 schools in South Australia. The students responded on a five-point Likert scale. Confirmatory factor analysis (CFA) supported the original four-factor correlated structure based on several fit indices. The validation provided evidence that ATMI can be a viable scale to measure students' attitudes toward mathematics in a South Australian context.

Key words: Attitudes toward mathematics; Attitudes Toward Mathematics Inventory (ATMI); Confirmatory factor analysis; Australia

Introduction

There is an increasing understanding and a growing recognition that in addition to cognitive factors, affective factors play a crucial role in the teaching and learning of mathematics. McLeod's seminal work in the 90s, in particular, led to a new phase of research on affects in mathematics education (Di Martino & Zan, 2011; Goldin, 2000, 2002; Grootenboer & Hemmings, 2007; Malmivuori, 2001, 2006, 2007; Schlöglmann, 2003). McLeod (1992) and his colleagues represented the affective domain as three subdomains: emotions, attitudes, and beliefs. DeBellis and Goldin (1997) added a fourth subdomain of values. In earlier research (e.g. Aiken & Dreger, 1961; Antonnen, 1969; Biggs, 1959; Dutton, 1954; Neale, 1969; Poffenberger & Norton, 1959), "attitudes" was used as a catch-all term. Mathematical affect was considered to comprise basically mathematics anxiety and attitudes toward mathematics (Evans, 2006). The broader and more comprehensive term "affect" is now more commonly used (Clarkson, Bishop & Seah, 2010). In reviewing the literature, Leder and Grootenboer (2005) suggested that attitudes are an intermediary category. Attitudes are more stable than emotions and feelings, but not as stable as beliefs and/or values. Clarkson, Bishop, and Seah (2010) also supported this view and stated that "attitudes are often seen as an intermediate area between extremes" (p.114). Therefore, in the subdomains of affects, beliefs and values appear on one end of the continuum, attitudes somewhat in the middle, and feelings and emotions at the other end. Attitudes have become the focal points of research on affects in mathematics education.

A Literature Review

The literature review that follows explores the subdomain of attitude and considers a variety of definitions provided by researchers in this area of affective domain.

Attitudes toward Mathematics: Meanings

Students' attitudes are developed over a considerably long period of time and have powerful impacts on their effective engagement, participation and achievement in mathematics. Attitudes are not innate but result from experiences and they can be changed. Attitudes are more stable than emotions and feelings, but at the same time they are malleable influences on participation, because attitudes are formed in response to curriculum, teaching practices, and organisational arrangements (Khoo & Ainley, 2005). An early contribution in the study of attitudes toward mathematics was by Neale (1969), who underlined that, "attitude plays a crucial role in learning mathematics and positive attitude toward mathematics is thought to play an important role in causing students to learn mathematics" (p. 631). Neale (1969) defined mathematical attitude as "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activity, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p. 632). This conception of Neale was well recognized and widely acknowledged (e.g. Ma & Kishor, 1997; Zan & Di Martino, 2007), and it was used in this study. Tait–McCutcheon (2008) cited Triandis (1971) and observed that the concept of attitude includes at least three verbs: to think, to feel, and to behave. Thus, students' attitudes toward mathematics affect how well or how often they do it, and how much enjoyment they derive from it (Moenikia & Zahed-Babelanb, 2010).

Many researchers claim that despite the fact that research on attitude, as compared to other subdomain of affects, has the longest history, the term attitude remains an "ambiguous construct" (e.g. Hart, 1989; Hannula, 2002) with an ambiguous theoretical framework (McLeod, 1992; Zan & Di Martino, 2003) that needs to be developed further. Di Martino and Zan (2010) drew on their own work and that of others (Daskalogianni & Simpson, 2000; Leder, 1985; McLeod, 1992; Ruffell, Mason & Allen, 1998) and noted that the many studies of attitudes in mathematics education have not been able to present a clear definition of the construct and those studies that "explicitly give a definition of attitude do not share a single definition" (p.28). Malmivuori (2001) examined two definitions of attitude to draw attention to the inconsistency in defining the construct. One defines understanding of attitude as pupils´ general emotionally toned disposition toward mathematics (Haladyna, Shaughnessy & Shaugnessy, 1983) and the other as a learned predisposition, or a tendency to respond negatively or positively to mathematics (Aiken, 1974). These definitions reflect the inconsistency found in the theoretical backgrounds of the studies. Zan and Di Martino (2003, 2007) pointed out that most studies investigating attitudes have concentrated on designing measurement instruments instead of focusing on the development of a theoretical base. With researchers investing their energy mostly in creation of measurement instruments, it impedes the development of theoretical aspects of the construct. Thus, the development of an adequate theory remains in the background, while construction of instruments occupies the forefront resulting in attitudes defined "implicitly and a posteriori through the instruments used to measure it" (Di Martino & Zan, 2010, p.28). This paper will contribute to the development of a theoretical base by considering the validation of the ATMI instrument.

Despite a general consensus (Hannula, 2002; Malmivuori, 2001, Zan & Di Martino, 2007) on attitude being an ambiguous construct, it would be useful to explore how researchers in the past and present view it. In general, attitudes are defined as "favourable or unfavourable dispositions" toward a given object, person, activity or idea (Rajecki, as cited in Hart, 1989 p.39). Way and Relich (1993) observed that, "although definitions of attitude vary, they generally include the idea that attitudes are learnt, manifest themselves in one's response to the object or situation concerned, and can be evaluated as either being positive or negative"(p. 581). Attitudes are generally considered as having been learnt (White, Way, Perry, & Southwell, 2006), are moderately stable (Ma & Willms, 1999) showing some degree of consistency. Attitudes describe "predispositions toward certain sets of emotional feelings (positive or negative) in particular (mathematical) contexts" (Ma & Willms, 1999, p. 367). McLeod (1992) observed that attitudes are individuals' reactions to negative or positive emotions, with "medium intensity," but with "sufficient stability." These "attitudes may result from the automatizing of a repeated emotional reaction to mathematics" or from "the assignment of an already existing attitude to a new but related task" (McLeod, 1992, p.581).

Instruments used to measure attitudes

Many instruments are available to measure student attitudes toward mathematics. The Fennema-Sherman Mathematics Attitudes Scales (FSMAS) (Fennema &

Sherman, 1976) is the most popular and widely used one in research (Pepin, 2011). Aiken's Mathematics Attitudes Scales (MAS) (Aiken, 1974) has also attracted considerable recognition in mathematics education research. TIMSS 2011 had three attitude scales related to the three motivational constructs: intrinsic value (Students Like Learning Mathematics scale), utility value (Students Value Mathematics scale), and ability beliefs (Student Confidence with Mathematics scale) (Mullis, Martin, Foy, & Arora, 2012). The Attitudes Toward Mathematics Inventory (ATMI) (Tapia & Marsh, 2004) is one of the latest instruments, but it has not enjoyed significant application in research (Chamberlin, 2010). It was chosen for this study because it provides a sharp and distinct focus and identifies four dimensions along which attitudes toward mathematics could be measured.

Attitudes toward Mathematics Inventory (ATMI)

The original ATMI comprised 49 items that measured six domains: anxiety, enjoyment, value, motivation, confidence, and parent/teacher expectations. Scoring was done with a five-point Likert Scale, with response options from "strongly disagree" to "strongly agree." After conducting an exploratory factor analysis using data from a sample of 544 students taking mathematics at a private school in Mexico City, Tapia (1996) combined the confidence and anxiety subscales to form a single factor. An extremely low item-to-total correlation was observed with items on the parent/teacher expectation subscale, so this was also dropped (Tapia, 1996; Tapia & Marsh, 2004). The final scale comprises four subscales and 40 items. The subscales were: *self-confidence, value, enjoyment,* and *motivation*. Positive and negative items were included. Validity and reliability have been established for college students (Tapia & Marsh, 2002) and high school students (Tapia & Marsh, 2004). A confirmatory factor analysis (CFA) conducted by Tapia and Marsh (2002) confirmed the four-factor structure using data from 134 college students from the U.S. Cronbach's alphas were high for the whole scale, ranging from 0.95 to 0.97 (Tapia, 1996; Tapia & Marsh, 2004) and for each subscale: *Self-confidence* (0.95), *Value* (0.89), *Enjoyment* (0.89), and *Motivation* (0.88) (Tapia & Marsh, 2004).

ATMI has a more distinct and cohesive factor structure than that of FSMAS because the subscales of FSMAS include attitudes towards mathematics (Confidence in Learning Mathematics scale; Mathematics Anxiety scale; Motivation in Mathematics scale; and Usefulness of Mathematics scale), perceptions about mathematics as a male dominant learning area (Male Domain scale), and perceptions about parental and teacher support (Mother, Father, and Teacher scales). In this study, the structure of ATMI was also considered in relation to Neale's (1969) definition of attitudes toward mathematics, so that statistical results can be related to the theoretical concerns that lead to the research (Byrne, 2001). The correspondence is shown in Table 1.

Table 1
Subscales of ATMI versus Elements of Neale's Definition

Subscales of ATMI	Elements of Neale's Definition
Self Confidence	A belief that one is good or bad at mathematics
Value	A belief that mathematics is useful or useless
Enjoyment	An aggregated measure of a liking or disliking of mathematics
Motivation	A tendency to engage in or avoid mathematical activities

Despite its stable factor structure (Lim & Chapman, 2012) and strong psychometric properties (Tapia & Marsh, 2004), ATMI has not gained popularity among researchers (Chamberlin & Powers, 2013; Lim & Chapman, 2012). To do so may require further investigations with culturally different samples and a shorter version (Chamberlin & Powers, 2013). This study determined whether the structure of ATMI remained stable with a group of students from South Australia, and provided an option to researchers who are largely dependent on Fennema-Sherman Mathematics Attitudes Scales (FSMAS) when measuring their students' attitudes toward mathematics.

Research Questions

1. Is the ATMI a reliable and a valid instrument to measure students' attitudes toward mathematics in the South Australian context?
2. Does the 4-factor correlated structure of ATMI best fit data from the South Australian sample?

Method

A total of 699 students participated in this study during the first term of the academic year 2012. The dataset was a part of three data points collected for a longitudinal study conducted over the year 2012. The respondents were Year 7 and 8 students in four primary and ten secondary schools in South Australia. Female students formed 59.5% of the sample. The average age of Year 7 students was 11.9 years and that of Year 8 was 12.9 years.

Out of the 40 items of ATMI, only 32 were used. Eight items were omitted. This reduced the instrument to more manageable length without compromising its validity, keeping in mind that lengthy surveys negatively impact on completion rates, particularly, in this case, there was the additional risk of respondent dropouts due to the longitudinal design of the study.

Results and Discussion

The study used confirmatory factor analysis to validate the hypothesized factor structure of ATMI. The ATMI items were treated as observed or measured variables. First, the data were subjected to tests of multivariate normality. The symmetry (skewness) and the flatness (kurtosis) of the distribution ranged from -1.169 to -0.153 and from -0.730 to 1.543 respectively. These satisfy the working guideline that the absolute values of skewness and kurtosis are less than 3 and 8 respectively (Kline, 1998). Missing responses were less than 5%, and to avoid considerable loss in sample size in this multivariate setting and to maintain the consistence of the sample base, missing responses were replaced by the mean values of the corresponding items. Descriptive statistics of the items are given in Table 2, where R indicates negative items, which were reverse scored.

There were five negative items in the *Self-confidence* subscale, and they referred to mathematics causing nervousness, confusion, feeling of dread, dislike of the word mathematics, and being uncomfortable. The positive items relate to student expectation of doing well in mathematics, being able to learn mathematics easily, and being good at solving problems. The means of the nine items suggest that students' self confidence in mathematics was less than desirable and this would influence their learning of the subject.

All the seven items in the *Value* subscale were positively worded. These items referred to mathematics as a worthwhile and necessary domain of learning, having a desire to develop skills in mathematics, and appreciating its value in everyday life and education beyond school. The means, close to and greater than 4, suggest that the students were clearly aware and convinced of the importance of mathematics.

The nine items in the *Enjoyment* subscale referred to enjoying mathematics, the challenge of solving new problems, the comfort level in participating in discussion in mathematics, and feeling of happiness in the mathematics classroom. The students showed an inclination to respond positively to this subscale with means in the range of 3.20 to 3.52, with the exception of item Enj6. Enj6 had the lowest mean, and these students generally did not feel happier in mathematics lessons than in other subjects.

The *Motivation* subscale covered willingness to pursue mathematics beyond the compulsory level. The means ranged from 3.13 to 3.51. In general, these students showed only weak motivation to continue studying it.

Table 2
Descriptive statistics of ATMI items

Label Full	Item Statement	M	SD
Self-Confidence			
1. SlfCon1**R**	Mathematics is one of my most dreaded subjects.	3.28	1.06
2. SlfCon2**R**	My mind goes blank and I am unable to think clearly when working with mathematics.	3.66	1.01
3. SlfCon3**R**	Studying mathematics makes me feel nervous.	3.69	1.07
4. SlfCon4**R**	Mathematics makes me feel uncomfortable.	3.90	0.98
5. SlfCon5**R**	When I hear the word mathematics, I have a feeling of dislike.	3.60	1.19
6. SlfCon6	Mathematics does not scare me at all.	3.50	1.16
7. SlfCon7	I have a lot of self-confidence when it comes to mathematics	3.36	1.07
8. SlfCon8	I am able to solve mathematics problems without too much difficulty.	3.48	0.97
9. SlfCon9	I expect to do fairly well in any mathematics class I take.	3.58	0.94
10. SlfCon10	I am always confused in my mathematics class.	3.70	0.92
11. SlfCon11	I learn mathematics easily.	3.30	1.03
12. SlfCon12	I believe I am good at solving mathematics problems.	3.43	0.98
Value			
13. Val1	Mathematics is a very worthwhile and necessary subject.	4.07	0.90
14. Val2	I want to develop my mathematical skills	4.11	0.86
15. Val3	Mathematics helps develop the mind and teaches a person to think.	4.05	0.83
16. Val4	Mathematics is important in everyday life.	4.21	0.85
17. Val5	Mathematics is one of the most important subjects to study.	4.07	0.91
18. Val6	High school mathematics courses would be very helpful no matter what I decide to study.	3.92	0.88
19. Val7	I can think of many ways that I use mathematics outside of school.	3.95	0.94
Enjoyment			
20. Enj1	I have usually enjoyed studying mathematics in school.	3.28	1.09
21. Enj2**R**	Mathematics is dull and boring.	3.45	1.16
22. Enj3	I like to solve new problems in mathematics.	3.45	1.00
23. Enj4	I would prefer to do an assignment in mathematics than to write an essay.	3.52	1.25
24. Enj5	I really like mathematics.	3.20	1.16
25. Enj6	I am happier in a mathematics class than in any other class.	2.40	1.07
26. Enj7	Mathematics is a very interesting subject.	3.30	1.09
27. Enj8	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in mathematics.	3.38	1.03
28. Enj9	I am comfortable answering questions in mathematics class.	3.52	1.13

Table 2 (continued)
Descriptive statistics of ATMI items

Motivation		M	SD
29. Mot1	I am confident that I could learn advanced mathematics.	3.34	1.13
30. Mot2**R**	I would like to avoid using mathematics in tertiary study.	3.48	0.95
31. Mot3	I am willing to take more than the required amount of mathematics.	3.13	1.09
32. Mot4	I plan to take as much mathematics as I can during my education.	3.51	1.00

It is said that *poetry* has done enough when it *charms*, but *prose* must also *convince*. Indeed, mathematics has to convince and charm students. It is evident from the above results that students in the study were convinced of the value of mathematics but were not charmed enough to find their experience of learning mathematics appealing. They did not enjoy mathematics, did not feel confident when doing mathematics, and were not motivated to pursue further study of it.

Reliability

To assess internal consistency, Cronbach's alpha coefficients for the subscales were estimated using SPSS 19. Very high Cronbach's alpha values were obtained for the overall scale (0.963) and all the subscales: *Self-confidence* (0.928), *Value* (0.909), *Enjoyment* (0.911), and *Motivation* (0.784). These values were larger than the cut-off point of 0.70 for reliability (Hair, Anderson, Tathom, & Black, 2010) and were comparable to the values reported by Tapia and Marsh (2004).

Confirmatory factor analysis

Confirmatory factor analysis (CFA) is often employed to test whether a hypothesized factor structure is supported by the data. The simplest structure is the one-factor model, when the observed variables load onto a single factor (Curtis, 2004), but alternative structures are also tested to find a good model to fit the data. In this study, the four subscales were highly correlated; see Table 3. Hence, a 4-factor correlated model was tested. This model was compared to a single-factor model, a 4-facor uncorrelated model, and a hierarchical model.

Table 3
Correlations among ATMI Subscales

	Value	Enjoyment	Motivation
Self-confident	.513**	.780**	.672**
Value		.637**	.643**
Enjoyment			.784**

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Seven indices are commonly used to examine model fit, and these are shown in Table 4: χ^2 (chi-square), χ^2/df (chi-square with degrees of freedom), GFI (goodness-of-fit index), AGFI (adjusted goodness-of-fit index), CFI (comparative fit index), TLI (Tucker-Lewis index), and RMSEA (root mean square error of approximation).

Table 4
Fit Indices for Four Models

	χ^2	df	χ^2/df	GFI	AGFI	CFI	TLI	RMSEA
4-factor correlated	1828.149	455	4.018	.844	.819	.907	.899	.066
Single factor	3796.864	461	8.236	.633	.579	.775	.758	.102
4-factor uncorrelated	3510.591	461	7.615	.754	.718	.794	.779	.097
Hierarchical model	1852.240	457	4.053	.841	.816	.906	.898	.066

There is disagreement in the literature about the criteria used to establish goodness of fit (Hopko, 2003). Among these criteria are the following. Bentler and Bonett (1980) suggested GFI and CFI of 0.90 and AGFI of 0.80, while Hu and Bentler (1998) noted the value of 0.95 for CFI and GFI. Brown and Cudeck (1992) suggested RMSEA of 0.10 or lower, while Hu and Bentler (1998) required an RMSEA of 0.06. Arbuckle (2009) suggested that GFI, TLI, and CFI should be equal or close to 0.90. As the chi-squared statistic (χ2) is strongly dependent on sample size (Hu & Bentler, 1999), χ^2/df ratios are often used and they should be between 2 to 5 (Byrne, 2001; Darmawan, 2003). The indices shown in Table 4 suggest that the 4-factor correlated model had the best fit with the South Australian data when compared to the alternative models.

The psychometric properties of the ATMI are quite favourable. In Figure 1, the measurement model of ATMI presents the relations between observed variables and latent variables. Boxes are used to represent the observed variables and ellipses for the latent variables. The four factors were highly correlated with correlations ranging from 0.56 to 0.90, which are similar to the values in Table 3.

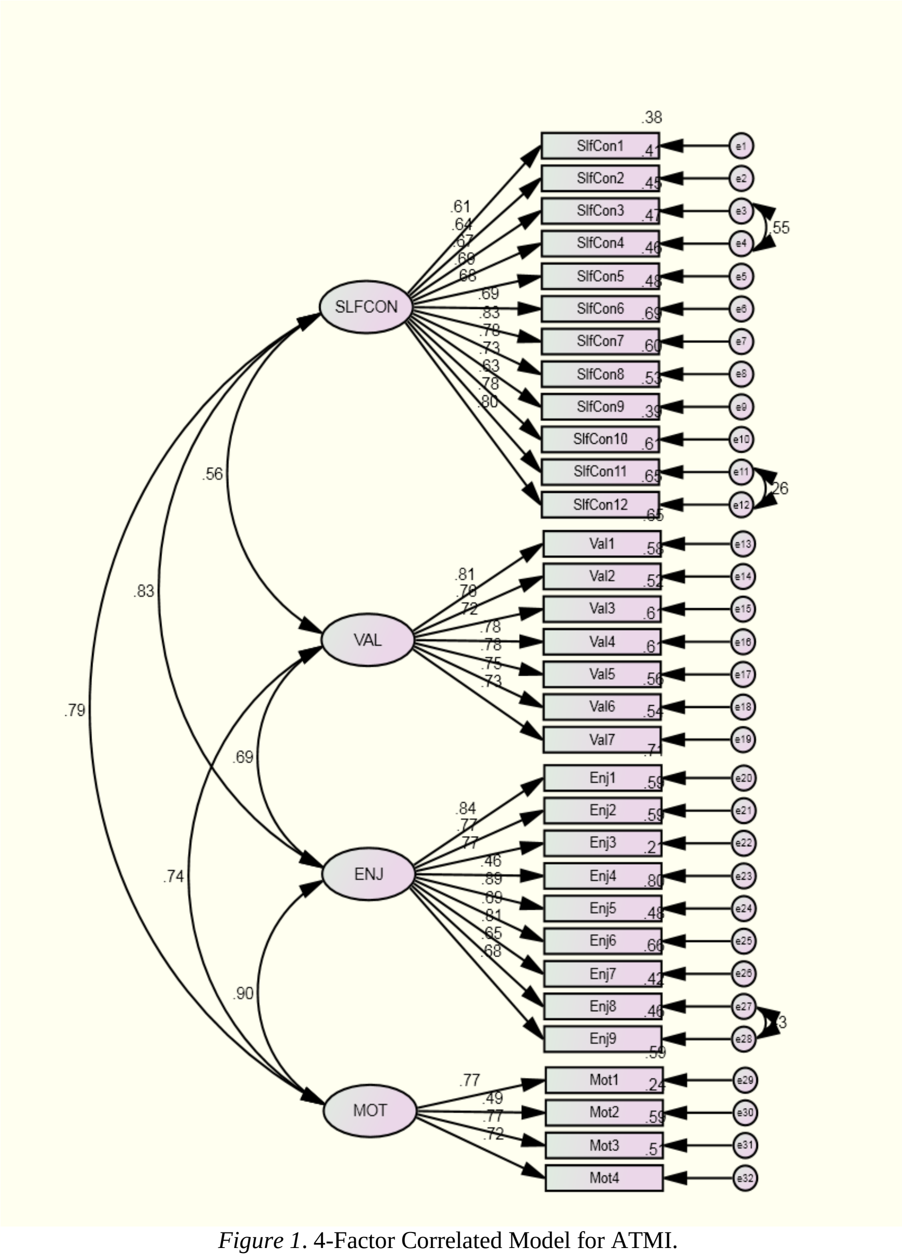

Figure 1. 4-Factor Correlated Model for ATMI.

Factor loadings provide evidence for the extent to which an item relates to the underlying latent factor. The factor loadings shown in Figure 1 were quite high, ranging from 0.62 to 0.90, with exceptions for items Enj4 (0.46) and Mot2 (0.49), which were still higher than the cut-off value of 0.40 commonly used in factor analyses (Hair, Anderson, Tatham & Black, 2010). Thus, all the items functioned in the expected manner and contributed significantly to the measurement of the latent factor. In the 4-factor correlated model (see Fig.1), there were six items with three correlated errors. According to Byrne (2001), correlated errors may reflect "perceived redundancy in item content" (p. 134). Indeed, items 3 (SlfCon3) and 4 (SlfCon4) had similar phrasings, both describing feeling toward mathematics, so that responses to Item 3 might affect responses to Item 4 and vice versa. Similar overlaps in meanings were found between Items 11 (SlfCon11) and 12 (SlfCon12) and between Items 27 (Enj8) and 28 (Enj9). These items may be reviewed with item content retained.

Conclusion

The aim of the paper was to assess the reliability and validity of a shorter version of the ATMI with 12 *Self-confidence*, 7 *Value*, 9 *Enjoyment*, and 4 *Motivation* items. Results of the CFA support a 4-correlated factor model, with very high correlations with one another. The results are also consistent with the factor structure reported by Lim and Chapman (2012), whose sample involved 1601 Singapore students with an average age of 17.9 years. In addition, the items showed good internal consistencies and displayed Cronbach's alphas similar to those obtained for the original ATMI. Thus, this study has validated a shorter version of ATMI for the South Australian context.

For attitude scales to generate meaningful scores, it is necessary to relate these scores to the particular attitude objects (Gardner, 1975). ATMI had measured four definite and distinct attitude objects and it was not a collection of items that may reflect a wide variety of attitudes and perceptions. Furthermore, the reliability and validity estimates for ATMI are stable over many years after its initial administration in 1996 and beyond the initial samples. These considerations provide compelling rationale for its use in future research about attitudes toward mathematics. The ATMI is particularly useful, both for teachers, who want to monitor students attitudes toward mathematics, and for researchers, who often use different instruments in their studies. Using a common instrument may help to replicate research findings. This study is one of a few that evaluate the ATMI for an Australian sample, and the results of this study confirm that it is a promising instrument for measuring students' attitudes toward mathematics across cultures.

References

Aiken, L. R. (1974). Two scales of attitude toward mathematics. *Journal for Research in Mathematics Education*, *5*(2), 67-71.

Aiken, L. R., & Dreger, R. M. (1961). The effect of attitudes on performance in mathematics. *Journal of Educational Psychology*, *52*, 19-24.

Antonnen, R. G. (1969). A longitudinal study in mathematics attitude. *The Journal of Educational Research*, *62*, 467-471.

Arbuckle, J. L. (2009). *AMOS 18 user's guide*. Chicago: Amos Development Corporation.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*, 588-606.

Biggs, J. B. (1959). The teaching of mathematics: II - Attitudes to arithmetic-number anxiety. *Educational Research*, *1*, 6-21.

Brown, M. W., & Cudeck, R. (1992). Alternate ways of assessing model fit. *Sociological Methods & Research*, *21*, 320-258.

Byrne, B. M. (2001). *Structural equation modelling with AMOS*. New Jersey: Lawrence Erlbaum Associates.

Chamberlin, S. A. (2010). A review of instruments created to assess affect in mathematics. *Journal of Mathematics Education*, *3*(1), 167-182.

Chamberlin, S. A. & Powers, R. A. (2013). Assessing affect after mathematical problem solving tasks: Validating the Chamberlin Affective Instrument for Mathematical Problem Solving. *Gifted Education International*, *29*(1), 69-85.

Clarkson, P.C., Bishop, A., & Seah, W.T. (2010). Mathematics education and student values: The cultivation of mathematical wellbeing. In T. Lovat, R. Toomey & N. Clement (Eds.). *International research handbook on values education and student wellbeing* (pp. 111-135). Dordrecht: Springer.

Curtis, D. D. (2004). Comparing Classical and Contemporary Analyses and Rasch Measurement. In S. Alagumalai, D. D. Curtis, & N. Hungi (Eds.) *Applied Rasch measurement: A book of exemplars – Papers in honour of John P. Keeves* (pp. 181-197). The Netherlands: Springer.

Darmawan, I. G. N. (2003). *Implementation of Information Technology in Local Government in Bali Indonesia*. Adelaide: Shannon Research Press.

Daskalogianni, K., & Simpson, A. (2000). Towards a definition of attitude: The relationship between the affective and the cognitive in pre-university students. *24th conference of the international group for the psychology of mathematics education, 3*, 217-224.

DeBellis, V.A., & Goldin, G.A. (1997). The affective domain in mathematical problem solving. In *Proceedings of the Twenty-first Annual Meeting of the International Group for the Psychology of Mathematics Education* (pp. 209-216). Lahti, Finland: University of Helsinki.

Di Martino, P., & Zan, R. (2010). 'Me and maths': Towards a definition of attitude grounded on students' narratives. *Journal of Mathematics Teacher Education*, *13*(1), 27-48.

Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: a bridge between beliefs and emotions. *ZDM: The International Journal on Mathematics Education*, *43*,471-482.

Dutton, W. H. (1954). Measuring attitude toward arithmetic. *Elementary School Journal*, *55*(1), 24-31.

Evans, J. (2006). Affect and Emotion in Mathematical Thinking and Learning. The Turn to the Social: Sociocultural Approaches Introduction: Recent Developments in Research On Affect. In J. Maasz, W. Schloeglmann (Eds.), *New mathematics education research and practice* (pp.203-208). Rotterdam: Sense Publishers.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females. *Journal for Research in Mathematics Education*, *7*(5), 324-326.

Gardner, P. L. (1975). Attitudes to science. *Studies in Science Education*, *2*, 1-41.

Goldin, G. (2000). Affective pathways and representation in mathematical problem solving. *Mathematical Thinking and Learning, 2*, 209-219.

Goldin, G.A. (2002). Affect, meta-affect, and mathematical belief structures', In G. Leder, E. Pehkonen & G. Törner (Eds.), *Beliefs: A hidden variable in mathematics education* (pp. 59-72). Dordrecht: Kluwer.

Grootenboer, P. & Hemmings, B. (2007). Mathematics performance and the role played by affective and background factors. *Mathematics Education Research Journal*, *19*(3), 3-20.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (2010). *Multivariate data analysis* (7th ed.). New Jersey: Prentice-Hall.

Haladyna, T., Shaughnessy, J. & Shaughnessy, J. M. (1983). A causal analysis of attitude toward mathematics. *Journal for Research in Mathematics Education*, *14*(1), 19-29.

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics*, *49*(1), 25-46.

Hart, L. E. (1989). Describing the affective domain: Saying what we mean. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 37-45). New York, NY: Springer-Verlag.

Hopko, D. R. (2003). Confirmatory factor analysis of the Math Anxiety Rating Scale-Revised. *Educational and Psychological Measurement*, *63*(2), 336-351.

Hu, L., & Bentler, P. M. (1998). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1-55.

Khoo, S. T., & Ainley, J. (2005). *Attitudes, intentions and participation: Longitudinal survey of Australian youth*. Victoria: Australian Council for Educational Research.

Kline, R. B. (1998). *Principle and practices of Structural Equation Modelling*. New York, NY: The Guildford Press.

Leder, G. (1985). Measurement of attitude to mathematics. *For the Learning of Mathematics*, *34*(5), 18-21.

Leder, G. C., & Grootenboer, P. (2005). Editorial: affect and mathematics education. *Mathematics Education Research Journal*, *17*(2), 1-8.

Lim, S. Y., & Chapman, E. (2012). Development of a short form of the attitudes toward mathematics inventory. *Educational Studies in Mathematics*, *82,* 145-164.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude towards mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education*, *28*(1), 26-47.

Ma, X. & Willms, J. D. (1999). Dropping out of advanced mathematics: How much do students and schools contribute to the problem? *Educational Evaluation and Policy Analysis*, *21*(4), 365- 83.

Malmivuori, M.L. (2001). The dynamics of affect, cognition, and social environment in the regulation of personal learning processes: the case of mathematics. *Department of Teacher Education, Research Report 172*. Helsinki: Helsinki University Press.

Malmivuori, M.L. (2006). Affect and self-regulation. *Educational Studies in Mathematics*, *63*(2), 149-164

Malmivuori, M.L. (2007). Understanding student affect in learning mathematics. In C.L. Petroselli (Ed.), *Science education: Issues and developments* (pp. 125-149). New York, NY: Nova Science Publishers.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualisation. In D. A. Grouws (Ed.), *Handbook of research on mathematics learning and teaching* (pp. 575-596). New York, NY: Macmillan.

Moenikia, M. & Zahed-Babelan, A. (2010). A study of simple and multiple relations between mathematics attitude, academic motivation and intelligence quotient with mathematics achievement. *Procedia Social and Behavioural Sciences*, *2*, 1537-1542.

Mullis, I.V.S; Martin, M.O., Foy, P. & Arora, A. (2012). *TIMSS 2011 International results in mathematics*. Boston: TIMSS and PIRLS International Study Centre.

Neale, D. (1969). The role of attitudes in learning mathematics. *The Arithmetic Teacher*, Dec, 631-641.

Pepin, B. (2011). Pupils' attitudes towards mathematics: A comparative study of Norwegian and English secondary students. *ZDM: The International Journal on Mathematics Education*, *43,* 535-546.

Poffenberger, T. & Norton, D. (1959). Factors in the formation of attitudes toward mathematics. *Journal of Educational Research*, *52*(5), 171-176

Ruffell, M., Mason, J., & Allen, B. (1998). Studying attitude to mathematics. *Educational Studies in Mathematics*, *35*(1), 1-18.

Schlöglmann, W. (2003) *Affect and cognition: Two poles of a learning process*. Retrieved from http://www.education.monash.edu.au/projects/vamp/schloglmann2001.pdf

Tait–McCutcheon., S. L. (2008). Self-efficacy in mathematics: Affective, cognitive, and conative domains of functioning. In M. Goos, R. Brown, & K. Makar (Eds.), *Navigating currents and charting directions* (pp. 507-513). Brisbane: MERGA.

Tapia, M. (1996). *The Attitudes Toward Mathematics Instrument*. Paper presented at the annual meeting of the Mid-south Educational Research Association, Tuscaloosa, AL (ERIC Reproduction Service No. ED 404165).

Tapia, M., & Marsh, G. E., II. (2002). *Confirmatory factor analysis of the Attitudes Toward Mathematics Inventory.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Chattanooga, TN. (ERIC Document Reproduction Service No. ED 471 301).

Tapia, M., & Marsh, G. E., II. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*(2), 16-21.

Way, J., & Relich, J. (1993). Development of positive attitudes to mathematics: The perspective of pre-service teachers. In B. Atweh, C. Kanes, M. Carss, & G. Booker (Eds.), *Contexts in mathematics education (*pp. 581-586). Brisbane: MERGA.

White, A. L., Way, J., Perry, B., & Southwell, B. (2006). Mathematical attitudes, beliefs and achievement in primary pre-service mathematics teacher education. *Mathematics Teacher Education and Development, 7,* 33-52.

Zan, R., & Di Martino, P. (2003). The role *of* affect in the research on affect: The case of 'attitude'. In M. A. Mariotti (Ed.), *Proceedings of the Third Conference of the European Society for Research in Mathematics*. [CD] Pisa, Italy.

Zan, R., & Di Martino, P. (2007). Attitude toward mathematics: Overcoming the positive/negative dichotomy. *The Montana Mathematics Enthusiast*, *3*, 157-168.

Authors:

Aysha Abdul Majeed [corresponding author; aysha.abdulmajeed@adelaide.edu.au], **I Gusti Ngurah Darmawan**, and **Peggy Lynch**, School of Education, The University of Adelaide, 10 Pulteney Street, Adelaide, Australia, 5005.