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Examining the Factorial Validity of the Attitudes towards Mathematics Inventory (ATMI) in the United Arab Emirates: Confirmatory Factor Analysis

Ernest Afari

Petroleum Institute, Abu Dhabi, United Arab Emirates
Email Address: ernest.afari@gmail.com

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Abstract: The purpose of this study was to examine the psychometric properties of the Attitudes towards Mathematics Inventory (ATMI) developed Tapia and Martha (2004). Data collected from 269 middle school students in the United Arab Emirates (UAE) were used to validate the questionnaire. A maximum likelihood method of extraction and a varimax rotation with Kaiser Normalization supported a strong factor structure for a 40-item of the ATMI. A confirmatory factor analysis showed a high reliability coefficient for the overall inventory and supported the original four-factor solution. When tested with 3-factor and 4-factor models, the former was found to have the best fit. This study has provided additional support to the factorial validity of the ATMI.

Keywords: Analysis of the Attitudes towards Mathematics Inventory, Confirmatory factor analysis, middle-school students, United Arab Emirates

Introduction

The research into how students' attitudes affect learning of science and mathematics related subjects have been one of the core areas of interest by educators. The development in mathematics education records various attempts in measuring attitudes and determining the associations between behaviour, achievements, career aspirations, gender identity and cultural inclination. Some researchers noted that attitudes can be learned and teachers can encourage and influence the students to like mathematics. But some view that attitude is situated in context and it is much to do with upbringing and environment. The critical role of attitude is well recognized in advancing mathematics education, in particular designing curriculum and choosing powerful pedagogies and nurturing students. Since Thurstone's (1928) seminal work on measuring the attitudes, a steady stream of research papers that describe development and validation of scales appear in scholarly publications. Despite these efforts the progress in this area has been stagnated by limited understanding of the conception about attitude, dimensionality and inability to determine the multitude of variables that made up such concept.

When children start school, their attitude towards learning is derived primarily from their home environment (Lumsden, 1994). However, success or failure in the classroom impacts on these initial attitudes and is shaped by early school experiences which, in turn, impact on subsequent classroom situations (Lumsden, 1994; Reynolds & Walberg, 1992). In addition, students' attitudes are affected by their interactions with their peers (Fishbein & Ajzen, 1975; Reynolds & Walberg, 1992; Taylor, 1992). Positive and negative experiences of school activities produce learned responses which may then impact on students' attitudes as they get older (Dossey, Mullis, Lindquist & Chambers, 1988).

The conceptions, attitudes and expectations of students regarding mathematics and mathematics teaching are considered to be significant factors underlying their school experience and achievement (Borasi, 1990; Reed, Drijvers & Kirschner, 2010). Learning clearly has an affective component and, according to Kind, Jones and Barmby (2007), developing a positive attitude is important for students' achievement. One definition that is commonly used to describe attitudes includes the three components of

E-mail: ernest.afari@gmail.com

cognition, affect and behaviour (Kind et al., 2007; Kruglansky, 2007; Rajecki, 1990). These three components are defined by Reid (2006, p. 4) as: a knowledge about the object, or the beliefs and ideas component (cognitive); a feeling about the object, or the like or dislike component (affective); and a tendency towards action, or the objective component (behavioural).

As Kind et al. (2007) point out, this definition is a sensible view of attitudes because these components are closely linked. For example, we know about mathematics (cognitive) and therefore we have a feeling or an opinion about it (affective) that may cause us to take a particular action (behavioural). Other researchers have suggested that the three components should be treated more independently, and that attitudes should be viewed as basis for evaluative judgements (Ajzen, 2001; Crano & Prislin, 2006). According to Kind et al. (2007) when we have an attitude, we judge something along emotional dimensions, such as good or bad, harmful or beneficial, pleasant or unpleasant, important or unimportant. Crano and Prislin (2006) point out that it is important to notice that these evaluative judgements are always towards something, often called the attitude object. Although some researchers have defined attitudes solely in terms of the affective component (George, 2000; Germann, 1988), Fishbein and Ajzen (1975) viewed attitudes as being formed spontaneously and inevitably, involving the attributes of an object. Attitudes or the affective component of attitudes, therefore, are linked to the beliefs that a person holds (Kind et al., 2007). It is with this in mind that the definition for attitude, used for our study, is the feelings that a person has about an object, based on their beliefs about that object.

Student attitudes toward mathematics

The relationship between achievement in mathematics and attitudes towards mathematics has been studied in many countries in the past. Hemmings and Kay (2010) conducted a study to explore the prior achievement, effort and mathematics attitudes as predictors of current achievement with a sample of Australian secondary school students. They found significant association between mathematics attitudes and achievement among Year 10 students. The authors suggested that the attitude towards mathematics can be a good predictor of mathematics achievement.

In examining the important factors influencing the mathematics achievement of students in middle schools, Choi and Chang (2011) used 12 items questionnaire to measure positive effect towards mathematics, valuing mathematics and self-confidence in learning mathematics. When this measurement was correlated with the Trends in International Mathematics and Science Study (TIMMSS) assessment of approximately 9000 students in the United States, they found that students with positive attitudes towards mathematics were more likely to perform better in mathematics. The attitude towards mathematics questionnaire was also able to detect gender differences. It was found that female middle school students showed significantly less positive attitudes towards mathematics than the male students.

In researching students' attitudes toward mathematics in Estonian and Finnish schools, Piht and Eisenchmidt (2008) conducted a study that involves two groups of students (n = 287) from Estonia and Finland. They found that students' attitudes toward mathematics depend on teaching methods and students' active participation in the learning process. They suggested that creating motivating conditions allow students to have positive attitudes toward mathematics. Students' attitudes towards mathematics influence the extent to which learning outcomes are realised (Reed et al., 2010). It is evident from these studies that measuring students' attitudes towards mathematics can be a useful practice.

Students' attitudes towards mathematics in the United Arab Emirates and the Arab countries

Much of the research on students' attitudes to mathematics has been conducted with Western populations, there is the 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' attitudes and performance in mathematics (Liau, Kassim & Loke, 2007). In the UAE, the school curriculum posits for good performance in mathematics as a prerequisite for higher education in science, technology and business. Also, students are made aware that to participate fully in society, they need to be able to interpret and use mathematics in many different situations. They also need to understand and evaluate ideas and arguments that involve mathematical concepts.

The results of past studies suggest that effective student engagement in mathematics have the potential to translate into efficient learning and improved results (Nicol, 2002; Scherer, 2002; Taylor, Fraser & Fisher, 1997). It is therefore important to ensure that students are interested in their classes, understand the importance of mathematics to their lives, and claim ownership of their own learning (Helal, 2009). It is believed that an inclusive curriculum that gains students' trust and affect will shift the responsibility of learning onto the student, thereby increasing the incentive for him or her to actively pursuing learning (Helal, 2009).

In 2007, Dubai in the UAE participated in the Trends in International Mathematics and Science Study (TIMSS). Helal (2009) examined and interpreted Dubai's 2007 results. About students' affect towards mathematics, Helal (2009) found that among grade 4 students, 81% gave a highly positive response to statements related to their affection for mathematics. This figure drops to 54% at the grade 8 level. More primary school students in the UAE appear to be enjoying the study of mathematics than secondary students. Nearly 25% of all grade 8 students indicated that they dislike mathematics or find it boring. The study by Helal (2009) also indicated that grade 8 students in the UAE hold learning mathematics in lower regard than majority of the Arab countries. This may be due to the existence of poor-quality instruction and learning in some schools within the UAE educational system, and the fact that, on the whole, teaching methods are based on rote memorization (Gaad, Arif & Scott, 2006; Shaw, Badri, & Hukul, 1995).

The study by Helal (2009) also indicated that grade 8 students in the UAE showed less confidence in their mathematical abilities than students in grade 4. Almost 68% of grade 4 students maintained a high confidence in learning mathematics. At the grade 8 level, there was a decline in confidence, as only 51% of the students feel confident in their mathematics learning. Students in grade 8 in other Arab countries, including Bahrain, Egypt, Jordan, Kuwait and Qatar, displayed higher feelings of confidence in mathematics than the UAE.

According to Helal (2009), results show that 10-year-old boys in the UAE showed higher confidence in mathematics learning than boys in other Arab countries. Nearly 70% of grade 4 boys were highly confident in their mathematics learning, compared to 51% in Kuwait, 60% in Qatar and 34% in Yemen. The result is similar for 10-year-old girls in the UAE, where 65% expressed high confidence in mathematics learning ability. This compares to 60% in Kuwait, 63% in Qatar and 36% in Yemen. Among 14-year-old girls, high confidence in mathematics learning ability was registered by 47% in the UAE. This is significantly lower than that of girls in Bahrain (58%), Egypt (52%), Jordan (56%), Kuwait (55%), Qatar (57%) and Saudi Arabia (50%). In comparison, 54% of 14-year-old boys in the UAE registered high confidence in learning mathematics. This is less than the confidence of students in Egypt (57%) and Jordan (59%), but higher than that of students in Bahrain (47%) and Saudi Arabia (44%).

Attitude Instruments

There are many self-report attitude measurement instruments available, for example Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976), Attitudes to Mathematics Survey (White, Way, Perry & Southwell, 2005), Who and Mathematics (Brandell & Staberg, 2008) and Maths and Me Survey (Adelson & McCoach, 2009).

The Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) have been among the most widely-used measures of attitude (Melancon, Thompson & Becnel, 1994). They have been used extensively to investigate attitudes toward mathematics and correlates of these attitudes (Mulhern & Rae, 1998).

The Fennema-Sherman Mathematics Attitude Scales were originally developed to study gender-related differences in mathematics achievement (Mulhern & Rae, 1998). The nine scales are 1) attitude toward success in mathematics; 2) mathematics as a male domain; 3) mother; 4) father; 5) teacher; 6) confidence in learning mathematics; 7) mathematics anxiety; 8) effectance motivation in mathematics; and 9) usefulness of mathematics (Fennema & Sherman, 1976). The scales can be used individually or in sets of two or more (Alexander & Martray, 1989; Drisko, 1993; Stricker, Rock & Burton, 1993) and have been modified for different age groups (Elliot, 1990; Sherman, 1983).

While it has been a popular instrument, the Fennema-Sherman scales have been the focus of little or no reliability or validity research for many years (Suinn & Edwards, 1982). The integrity of the scores produced by the measure had not yet been established conclusively as late as 1988 (O'Neal, Ernest, McLean & Templeton, 1988, November). However, in a 1994 study, Melancon and colleagues (1994) found that the results of the factor analysis was generally favorable with regards to the validity of the scores from the Fennema-Sherman Scales when using primary school teachers as subjects. Because the original instrument takes approximately 45 minutes to administer, Mulhern and Rae (1998) attempted to create a shortened form. They found six clearly identifiable scales. Mother and Father scales was combined to Parent, Anxiety and Confidence became Mathematics-related Affect, and no single factor was clearly associated with the effectance motivation scale (Mulhern & Rae, 1998).

The Test of Science Related Attitudes (TOSRA) was designed to measure seven science-related attitudes among secondary science students: 1) Social implications of science, 2) Normality of scientists, 3) Attitude to scientific inquiry, 4) Adoption of scientific attitudes, 5) Enjoyment of science lessons, 6) Leisure interest in science and 7) Career interest in science (Fraser, 1981). TOSRA has been field tested and applied in numerous studies and has shown to be valid and reliable (Aldridge, Fraser, & Huang, 1999; Fraser, 1981; Fraser, Aldridge, & Adolphe, 2010). Researchers or educators can use TOSRA to monitor student progress toward achieving specific attitudinal goals. While it can be used to assess individuals, it is most effective when used to measure the progress or performance of groups of students. To measure changes in attitudes over time, TOSRA can be used as a pretest and a posttest (Fraser, 1981; Fraser et al., 2010; Martin-Dunlop & Fraser, 2008).

The predecessor to the TOSRA contained only five scales (Social implications of science, Attitude to scientific inquiry, Adoption of scientific attitudes, Enjoyment of science lessons and Leisure interest in science) based on Klopfer’s (1976) classification scheme for attitudinal aims which distinguishes six categories: attitudes to science and scientists, attitude to inquiry, adoption of scientific attitudes like curiosity and open-mindedness, enjoyment of science learning experiences, interest in science apart from learning experiences, and interest in a career in science.

TOSRA is an extension and an improvement of the original battery of scales in four ways. Two new scales were added: Normality of scientists and Career interest in science. The previous battery had required three sets of directions and answering formats and that was simplified so that the TOSRA could be administered with one set of directions and one answering format. TOSRA was structured to contain the same number of items in each scale, whereas the previous format did not. In addition, the field-testing and validation of TOSRA was extended to involve students in years 7–10 rather than only year 7 students as had been the case previously.

While the TOSRA has been used to investigate associations between attitudes and achievement and between gender and attitudes, it has also been used to investigate associations between classroom environment and attitudes (Wong & Fraser, 1996). The TOSRA has been shown to have good internal consistency reliability and discriminant validity. The TOSRA was validated in junior and senior high schools in Australia and in the United States (Khalili, 1987), and can be used to monitor progress in achieving attitudinal aims in specific areas, or to compare groups of students on particular attitudinal dimensions (Fraser, 1981). In a cross-national study of learning environments and attitudes conducted with 1161 students in Australia and Indonesia, the TOSRA was found to be valid and reliable in both its Indonesian and English versions (Fraser et al., 2010).

Several studies have used the TOSRA in a modified form to assess the attitudes of students in a mathematics class or to assess students' satisfaction with their learning environment (Ogbuehi & Fraser, 2007; Raaflaub & Fraser, 2002; Spinner & Fraser, 2005). The modified form is referred to as the Test of Mathematics Related Attitudes (TOMRA). The same seven scales remain but the word 'mathematics' replaces the word 'science' in each item.

Attitudes towards Mathematics Inventory (ATMI)

The Attitudes Towards Mathematics Inventory (ATMI) was designed to assess several underlying dimensions of attitudes toward mathematics (Tapia & Marsh, 2004). The original form had 49 items that assess confidence, anxiety, value, enjoyment, motivation and parent/teacher expectations (Tapia & Marsh, 2004). The ATMI was given to 545 high school students (male and female, grades 9–12) enrolled in mathematics classes. Responses were collected using a Likert-scale format with the following anchors: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. Twelve items were reverse scored. Students were tested at the beginning of the school year and retested four months later (Tapia & Marsh, 2004).

When Cronbach's alpha coefficient was used to test the internal consistency of the ATMI, a coefficient of 0.96 indicated a high degree of internal consistency. Of the 49 items, 40 had item-to-total correlations above 0.50, suggesting that most of the items contributed to the total. After deleting the nine items with an item-to-total correlation lower than 0.50, the value of the alpha coefficient reached 0.97 (Tapia & Marsh, 2004). After factor analysis was conducted on the data, four factors were retained which accounted for 55% of the variance. The four remaining factors were Self-confidence (15 items), Value of mathematics (10 items), Enjoyment (10 items) and Motivation (5 items). The 40-item inventory is estimated to take between 10 and 20 minutes to complete (Tapia & Marsh, 2004).

The ATMI has been used with younger students as well. Tapia and Marsh (2000) measured students' attitudes toward mathematics and identified the underlying dimension of the inventory by testing 262 middle school students in a bilingual college preparatory school (Tapia & Marsh, 2000). Ke (2008) used the ATMI with 160 fifth graders in a study of the application of cooperative, competitive, and individualistic goal structures in classroom use of computer mathematics games. The impact on students' mathematics performance was measured using a standards based mathematics examination and the ATMI was used to assess the impact of the model on mathematics learning attitudes. A college population has also been studied using the ATMI. Tapia and Marsh undertook a study with 134 college-aged American students. Confirmatory factor analysis indicated that the four-factor model held up for American college students (Tapia & Marsh, 2002).

Objectives of the Study

The objectives of the study were to:

1. Examine the reliability and validity of the ATMI in a UAE context.
2. Test the factor structure of the ATMI from data provided by a sample of UAE students.

METHOD

Participants

The participants in this study were 269 middle school students in Grade 6, 7, 8 and 9 with the age ranging from 11 to 14 years old. Out of which 166 (61.7%) were males and 103 (38.3%) were females. The students were randomly selected from three middle schools in the UAE and were asked to complete the questionnaire on paper and it took an average about 30 minutes.

Translation

The questionnaire was originally developed in English. Because all of the participants involved in my study spoke English as a second language, an Arabic translation was created to ensure that they were able to understand the items. The questionnaire was translated into the Arabic language using a standard research methodology of translation, back-translation, verification and modification as recommended by Ercikan (1998) and Warwick and Osherson (1973). Each item was translated into Arabic by a professional translator from the UAE. The next step involved an independent back-translation of the Arabic version into English by a different professional translator, who was not involved in the original translation. Items of the original English version and the back-translated version were then compared by me to ensure that the Arabic version maintained the meanings and concepts in the original version.

Instrumentation

The study examined the 40-item ATMI developed by Tapia and Marsh (2004). The inventory uses 5-points Likert-scale format with 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. Out of the 40 items, 12 are negatively worded. Examples of items are “I am able to solve mathematics problems without too much difficulty” and “I am happier in a mathematics class than in any other class”.

RESULTS

Data Screening

Data were examined for multivariate normality, multicollinearity and outliers before assessing the factor structure of the responses, as recommended by Tabachnick and Fidell (2007). The bivariate correlations, tolerance, and variance inflation values indicated that neither bivariate nor multivariate multicollinearity was present. Because maximum likelihood estimation assumes multivariate normality of the observed variables, the data were examined with respect to univariate and multivariate normality (Teo & Lee, 2012).

Table 1 depicts the descriptive statistics that shows mean, standard deviation, skewness and kurtosis. The mean score ranges from 2.60 to 4.40 and majority of the items for the mean are above the midpoint of 3.00 (87.5%). This indicates that the participants exhibited a strong response for the ATMI. All the standard deviations are above 1.00 and that shows that the spread of item scores are large around the mean. No items showed a skew or kurtosis value greater than the cut-offs of $|3|$ or $|8|$ respectively, recommended by Kline (2010), and this supported the univariate normality in the items. The Mardia’s coefficient is a standard measure of multivariate normality and its value obtained in this study is 217.572. This value is less than the recommended value [p (p + 2); where p = total number of observed indicators; 40(42) = 1,680] by Raykov and Marcoulides (2008), hence the requirement of multivariate normality was satisfied. On these bases, the data for this study was considered adequate for confirmatory factor analysis.

Table 1: Descriptive Statistics of the Items in the ATMI

S/R	Item	Mean	SD	Skewness	Kurtosis
1	Mathematics is a very worthwhile and necessary subject.	4.09	1.944	-.50	-1.30
2	I want to develop my mathematics skills.	4.28	1.841	-.65	-1.01
3	I get a great deal of satisfaction out of mathematics experiments.	4.09	1.837	-.49	-1.25
4	Mathematics helps develop the mind and teaches a person to think.	4.37	1.778	-.72	-.83
5	Mathematics is important in everyday life.	4.42	1.876	-.82	-.87
6	Mathematics is one of the most important subjects for people to study.	4.31	1.914	-.71	-1.05
7	High school mathematics courses would be very helpful no matter what I decide to study.	3.87	1.854	-.27	-1.36

8	I can think of many ways that I use mathematics outside of school.	3.75	1.905	-.16	-1.45
9	Mathematics is one of my most dreaded subjects.	3.20	1.890	.20	-1.40
10	My mind goes blank and I am unable to think clearly when studying mathematics.	3.20	1.867	.202	-1.39
11	Studying mathematics makes me feel nervous.	3.06	1.867	.33	-1.33
12	Mathematics makes me feel uncomfortable.	2.95	1.891	.49	-1.28
13	I am always under a terrible strain in a mathematics class.	2.97	1.829	.36	-1.29
14	When I hear the word mathematics, I have a feeling of dislike.	2.94	1.951	.51	-1.28
15	It makes me nervous to even think about having to do a mathematics experiment.	2.60	1.843	.71	-.99
16	Mathematics does not scare me at all.	3.96	1.996	-.32	-1.49
17	I have a lot of self-confidence when it comes to mathematics	3.58	1.753	-082	-1.24
18	I am able to do mathematics experiments without too much difficulty.	3.80	1.749	-.22	-1.18
19	I expect to do fairly well in any mathematics class I take.	3.84	1.848	-.22	-1.36
20	I am always confused in my mathematics class.	3.28	1.873	.17	-1.42
21	I feel a sense of insecurity when attempting mathematics.	2.90	1.844	.46	-1.15
22	I learn mathematics easily.	3.63	1.815	-.11	-1.37
23	I am confident that I could learn advanced mathematics.	3.64	1.757	-.08	-1.25
24	I have usually enjoyed studying mathematics in school.	3.63	1.819	-.13	-1.33
25	Mathematics is dull and boring.	3.20	1.908	.23	-1.44
26	I like to do new experiments in mathematics.	4.40	1.829	-.70	-.96
27	I would prefer to do an experiment in mathematics than to write an essay.	4.25	1.822	-.62	-1.00
28	I would like to avoid using mathematics in college.	3.28	1.934	.15	-1.50
29	I really like mathematics.	3.65	1.848	-.12	-1.40
30	I am happier in a mathematics class than in any other class.	3.06	1.743	.26	-1.23
31	Mathematics is a very interesting subject.	3.65	1.840	-.11	-1.36
32	I am willing to take more than the required amount of mathematics.	3.37	1.765	.14	-1.23
33	I plan to take as much mathematics as I can during my education.	3.45	1.821	.04	-1.33
34	The challenge of mathematics appeals to me.	3.53	1.767	-.03	-1.26
35	I think studying advanced mathematics is useful.	3.89	1.816	-.31	-1.27
36	I believe studying mathematics helps me with problem solving in other areas.	3.74	1.751	-.10	-1.32
37	I am comfortable expressing my own ideas on how to look for solutions to a difficult mathematics experiment.	3.84	1.727	-.36	-1.05
38	I am comfortable answering questions in mathematics class.	3.87	1.829	-.28	-1.31
39	A strong mathematics background could help me in my professional life.	4.13	1.804	-.59	-1.00
40	I believe I am good at mathematics experiments.	4.14	1.812	-.51	-1.10

Exploratory Factor Analysis

A principal components analysis (PCA) with varimax rotation was conducted on the 40 items to explore the underlying structure of the ATMI. I used three techniques to assist in the decision concerning the number of factors to be retained:

(1) Kaiser's (1960) criterion to retain eigenvalues greater than 1;
(2) Catell's (1966) scree test; and
(3) Horn's (1965) parallel analysis.

Although the Kaiser's criterion and the scree test are well known, parallel analysis is not as widely known but it has been shown to be the most accurate criterion to use in the assessment of the number of factors to retain (Hayton, Allen & Scarpello, 2004; Hubbard & Allen, 1987; Zwick & Velicer, 1986), given that both Kaiser's criterion and Catell's scree test have a tendency to overestimate the number of factors. Using the Kaiser's criterion, only factors with an eigenvalues greater than or equal to 1 are retained. The Catell's scree, however involves plotting each of the eigenvalues of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal. The factors above the break in the plot are retained as these contribute the most to the explanation of the variance in the data set (Pallant, 2007). Parallel analysis is a Monte Carlo simulation technique that aids researchers in determining the number of factors to retain in Principal Component and Exploratory Factor Analysis (Ledesma & Valero-Mora, 2007). Parallel analysis compares the size of the eigenvalues with those obtained from a randomly generated data set of the same size. Those eigenvalues that exceed the corresponding values from the random data sets are retained for further analysis.

Principal components analysis revealed the presence of seven components with eigenvalues exceeding 1, accounting for a total of 58.68% of the variance. An inspection of the scree plot (see: figure 1) revealed a clear break after the third component. Using Catell's (1966) scree test, I decided to retain three components for further investigation.

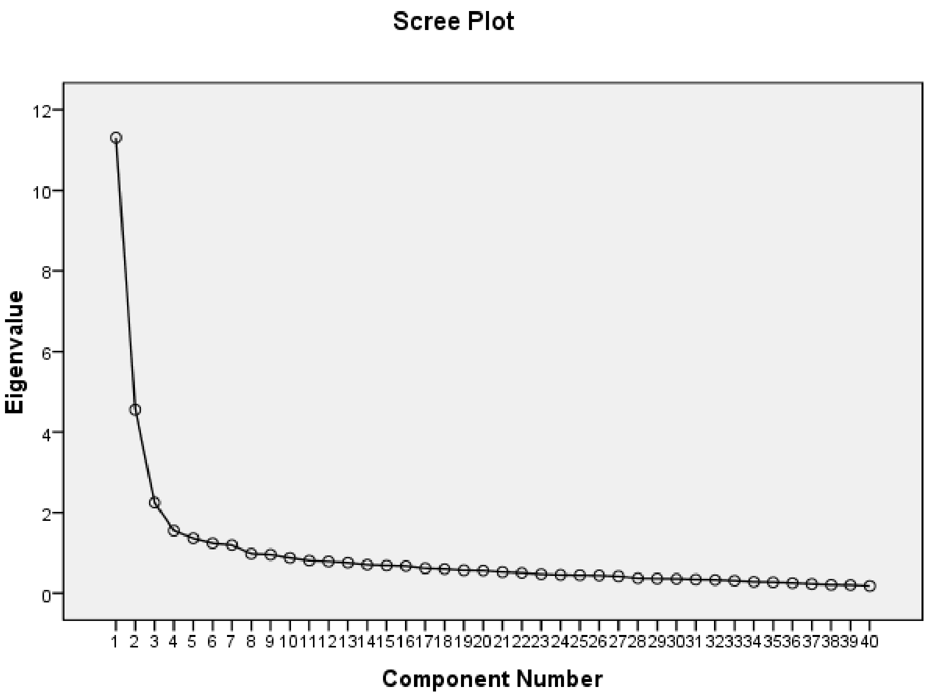

Figure 1: Scree Plot

This was further supported by the results of parallel analysis, using the Monte Carlo PCA for parallel analysis (computer software) developed by Watkins (2000). The results showed only three components with eigenvalues exceeding the corresponding criterion values for a randomly generated data matrix of the same size (40 items × 269 respondents). Details of the eigenvalues generated from the principal components analysis and the criterion values obtained from the parallel analysis are reported in Table 2.

An exploratory factor analysis using principal component and varimax rotation with a forced 3-factor solution was performed. Items with factor loading less than 0.40 were removed from further analysis, as recommended by Hair et al. (2010). The result revealed that a total of 45.29% of the variance, with component 1 contributing 28.27%, component 2 contributing 11.39% and component 3 contributing 5.62% was accounted for by the 40 items. Two items, Item ATMI10 and Item ATMI40 (whose loadings were less than 0.40), were removed from further analysis to improve the factorial validity and internal consistency reliability. Table 3 reports the factor loadings for the remaining 38-item ATMI.

Table 2: Comparison of eigenvalues from principal components analysis and criterion values from parallel analysis

Component number	Actual eigenvalue from principal components analysis	Criterion value from parallel analysis	Decision
1	11.308	1.826	accept
2	4.557	1.724	accept
3	2.249	1.655	accept
4	1.554	1.590	reject
5	1.363	1.530	reject
6	1.242	1.480	reject
7	1.197	1.435	reject

Confirmatory Factor Analysis

Using Confirmatory factor analysis (CFA), I tested the quality of the measurement model. Convergent validity was established by examining the significance of individual item loadings, by means of *t* values. I used several fit indices to measure model fit as recommended by Hair et al. (2010), Harrington (2009) and Kline (2010). According to Brown (2006), fit indices are classified into three categories: (1) absolute fit indices, (2) parsimony indices, and (3) comparative indices. Absolute fit indices measure how well the proposed model reproduces the observed data (Teo, Ursavas & Bahcekapili, 2012). The most common fit index is the model chi-square (χ^2). According Carmines and McIver, 1981, for a model to be assessed as a good fit, the chi-square normalized by degrees of freedom (χ^2/df) should not exceed 3.00. Standardized root mean square residual (SRMR) is another absolute fit index commonly referred to. For the SRMR, value of less than 0.05 would indicate a well-fitting model (Byrne, 2010).

Table 3: Results of the principal component axis and varimax rotation

	Item	1	2	3
ATMI30	I am happier in a mathematics class than in any other class.	**.725**	.229	-.149
ATMI27	I would prefer to do an experiment in mathematics than to write an essay.	**.718**	.158	-.122
ATMI38	I am comfortable answering questions in mathematics class.	**.707**	.173	-.050
ATMI36	I believe studying mathematics helps me with problem solving in other areas.	**.704**	.153	-.021
ATMI32	I am willing to take more than the required amount of mathematics.	**.692**	.235	-.119
ATMI14	When I hear the word mathematics, I have a feeling of dislike.	**.663**	.085	-.109
ATMI23	I am confident that I could learn advanced mathematics.	**.656**	.191	.051
ATMI33	I plan to take as much mathematics as I can during my education.	**.649**	.120	.124

ATMI24	I have usually enjoyed studying mathematics in school.	**.644**	.259	.025
ATMI34	The challenge of mathematics appeals to me.	**.643**	.202	.009
ATMI31	Mathematics is a very interesting subject.	**.631**	.104	.017
ATMI39	A strong mathematics background could help me in my professional life.	**.606**	.211	-.030
ATMI37	I am comfortable expressing my own ideas on how to look for solutions to a difficult mathematics experiment.	**.605**	.179	-.047
ATMI15	It makes me nervous to even think about having to do a mathematics experiment.	**.600**	.221	.018
ATMI25	Mathematics is dull and boring.	**.593**	.346	-.053
ATMI28	I would like to avoid using mathematics in college.	**.547**	.275	-.038
ATMI13	I am always under a terrible strain in a mathematics class.	**.443**	.366	-.042
ATMI11	Studying mathematics makes me feel nervous.	**.431**	.299	.094
ATMI12	Mathematics makes me feel uncomfortable.	**.427**	.328	.044
ATMI29	I really like mathematics.	**.405**	.295	.055
ATMI10	My mind goes blank and I am unable to think clearly when studying mathematics.	**.351**	.328	-.092
ATMI20	I am always confused in my mathematics class.	.248	**.806**	-.095
ATMI19	I expect to do fairly well in any mathematics class I take.	.257	**.759**	-.024
ATMI18	I am able to do mathematics experiments without too much difficulty.	.312	**.718**	.004
ATMI17	I have a lot of self-confidence when it comes to mathematics	.321	**.697**	-.108
ATMI21	I feel a sense of insecurity when attempting mathematics.	.224	**.692**	.046
ATMI16	Mathematics does not scare me at all.	.300	**.653**	.015
ATMI26	I like to do new experiments in mathematics.	.311	**.604**	.001
ATMI22	I learn mathematics easily.	.263	**.602**	-.012
ATMI6	Mathematics is one of the most important subjects for people to study.	-.039	-.070	**.761**
ATMI4	Mathematics helps develop the mind and teaches a person to think.	-.070	.043	**.747**
ATMI2	I want to develop my mathematics skills.	-.075	-.106	**.745**
ATMI5	Mathematics is important in everyday life.	-.100	-.025	**.721**
ATMI3	I get a great deal of satisfaction out of mathematics experiments.	-.088	.015	**.705**
ATMI7	High school mathematics courses would be very helpful no matter what I decide to study.	.041	-.012	**.670**
ATMI8	I can think of many ways that I use mathematics outside of school.	-.103	.060	**.653**
ATMI9	Mathematics is one of my most dreaded subjects.	.130	.052	**.552**
ATMI35	I think studying advanced mathematics is useful.	.018	-.118	**.536**
ATMI1	Mathematics is a very worthwhile and necessary subject.	-.097	.154	**.441**
ATMI40	I believe I am good at mathematics experiments.	.126	-.122	**.330**
Total variance extracted		11.308	4.557	2.249
% variance accounted		28.271	11.392	5.623

The next category of fit indices is the parsimonious indices. It is similar to the absolute fit indices except that it takes the model's complexity into account. An example is the root mean square error of approximation (RMSEA). The RMSEA should not exceed 0.08, although values of less than or equal to 0.05 would indicate a closer approximate fit (Kline, 2010). Finally, comparative fit indices were used to evaluate a model fit relative to an alternative baseline model (Harrington, 2009; Teo et al., 2012). Examples of comparative fit indices include the comparative fit index (CFI) and Tucker-Lewis index (TLI). According to Byrne (2010), Hu and Bentler (1999), and McDonald and Ho (2002), TLI and CFI should both be greater or equal to 0.90.

The results of the CFA of my study showed that all parameter estimates were significant at $p < 0.001$ level, indicated by the t-value (greater than 1.96). The model fit was acceptable ($\chi^2 = 964.184$; $\chi^2/df = 1.668$; TLI = 0.905; CFI = 0.913; RMEA = 0.050; SRMR = 0.056).

Convergent and Discriminant validities

In assessing the convergent validity of the measurement items in relation to their constructs, item reliability of each measure, composite reliability of each construct, and the average variance extracted were examined, as proposed by Fornell and Larcker (1981). The item reliability of the items was assessed by its factor loading onto the underlying construct. As suggested by Hair et al. (2010), an item is significant if its factor loading is greater than 0.50. As reported in Table 4, the standardized factor loadings of all the items were higher than 0.50 ranging from 0.538 (Item ATMI19) to 0.829 (Item ATMI6), with the exception of 4 items (ATMI17, ATMI18, ATMI21 and ATMI25) whose loading were 0.460, 0.488, 0.475 and 0.436, respectively, but were all statistically significant at the $p < 0.001$ level. Thus, they demonstrated convergent validity at the item level.

At the construct level, an alpha of 0.70 and higher was recommended to reflect adequate reliability (Nunnally & Bernstein, 1994). Table 3 shows the reliabilities of all the constructs ranged from 0.811 to 0.924, which were above the minimum value recommended by Nunnally and Bernstein, 1994. The final criterion for convergent validity is a measure of average variance extracted (AVE) for each factor. Fornell and Larcker (1981) and Nunnally and Bernstein (1994) recommended a minimum value of 0.5 for AVE. Results of the analysis showed that the AVE values for two of the factors (Factor 1 and Factor 3) were below 0.5, suggesting that more errors were found in the items than the variance explained by the latent factor structure which these items are associated with (Teo & Lee, 2012).

Table 4: Parameter and reliability estimates of the ATMI

Item	Unstandardized Factor Loading	Standardized Factor Loading	*t*-value	Average Variance Extracted (AVE)	Composite Reliability (CR)
Factor 1				**0.395**	**0.924**
ATMI29	1.000	.730	***		
ATMI24	.929	.692	11.178		
ATMI34	.908	.693	11.144		
ATMI31	.972	.713	14.042		
ATMI23	.882	.677	10.872		
ATMI22	.789	.591	9.423		
ATMI35	.899	.668	10.718		
ATMI36	.900	.692	11.263		
ATMI37	.784	.613	9.805		
ATMI38	.891	.655	10.648		
ATMI30	.739	.572	9.125		
ATMI33	.797	.593	9.463		
ATMI39	.909	.680	10.929		
ATMI32	.791	.607	9.706		
ATMI40	.825	.612	9.908		
ATMI26	.806	.594	9.499		

ATMI19	.736	.538	8.568		
ATMI17	.594	.460	7.497		
ATMI18	.632	.488	7.749		
Factor 2				**0.516**	**0.894**
ATMI6	1.000	.829	***		
ATMI5	.932	.788	14.742		
ATMI4	.852	.760	14.031		
ATMI2	.868	.748	13.720		
ATMI7	.778	.666	11.762		
ATMI1	.831	.678	12.049		
ATMI3	.755	.647	11.437		
ATMI8	.723	.602	10.380		
Factor 3				**0.411**	**0.811**
ATMI13	1.000	.728	***		
ATMI14	1.076	.731	11.337		
ATMI11	1.011	.718	11.133		
ATMI12	1.019	.714	11.079		
ATMI10	.930	.660	10.232		
ATMI15	.840	.610	9.691		
ATMI20	.877	.621	9.614		
ATMI21	.660	.475	7.322		
ATMI25	.626	.436	6.933		

*** This value is fixed at 1.00 in the original solution for identification purposes.
Note: CR is computed by $(\sum\lambda)^2 / (\sum\lambda)^2 + \sum (1 - \lambda^2)$; AVE is computed by $\sum\lambda^2 / \sum\lambda^2 + \sum (1 - \lambda^2)$

The discriminant validity assesses the degree to which constructs differ from each other. In Table 5, the inter-factor correlation matrix showed that Factor 1 and Factor 2 were significantly correlated but Factor 1 and Factor 3 were not significantly correlated and negative. Also Factor 2 and Factor 3 were not significantly correlated and negative. The diagonal elements have been substituted by the square roots of the average variance extracted. The discriminant validity was that the square root of average variance extracted (AVE) for each construct has to be larger than the inter-construct correlation. In Table 5 discriminant validity is said to be adequate for Factor 1 and Factor 3 and also Factor 2 and Factor 3. However, the square root of the average variance extracted (AVE) for factor 1 was lower than the correlation between Factor 1 and Factor 2.

Table 5**:** Inter-construct correlations and square roots of average variance extracted

Construct	Factor 1	Factor 2	Factor 3
Factor 1	**0.628**		
Factor 2	0.694***	**0.718**	
Factor 3	-0.128	-0.102	**0.641**

*$p< 0.05$; **$p< 0.01$
The bold elements in the main diagonal are the square roots of average variance extracted

Model Comparison

The first confirmatory factor analysis explored the three-factor structure of the ATMI (model A). The fit indices for this three–factor model are given in Table 6, from which it can be seen that this model had an acceptable fit to the data (χ^2 = 964.184 , CFI = 0.913, TLI = 0.905, RMSEA = 0.050, SRMR = 0.056). Model B was the four-factor structure of the ATMI. The fit indices for this four–factor model are also given in Table 6, from which it can be seen that this model also had an acceptable fit to the data (χ^2 = 1119.423, CFI = 0.880, TLI = 0.871, RMSEA = 0.058, SRMR = 0.059). Taking into accounts that the fit indices (χ^2, CFI, TLI, RMSEA and SRMR) for the three-factor model exceeded that of the four-factor model, it is reasonable to conclude that the best fitting model is Model A, the three-factor model.

Table 6: Results of Model Comparisons

Model	χ^2	χ^2 /df	**CFI**	**TLI**	**RMSEA**	**SRMR**
A (3-factor)	964.184	1.668	0.913	0.905	0.050	0.0563
B (4-factor)	1119.423	1.904	0.880	0.871	0.058	0.0590

Conculsion

This study presents the confirmatory factor analysis of the ATMI using a sample of (n=269) of middle school students. The results of the study support three-factor solution. The sample data comprises of male (n=166) and female (n=103) making more male students in the sample. The sample size may be small according to the multivariate data analysis which requires participant-to-item ratio of 10:1. Once the reliability and validity of the inventory has been determined, further explorations can be conducted to find out associations with other cognitive variables such as achievement, motivation, self-efficacy and career choice.

ATMI can be used to determine the attitudes of students to examine the enjoyment of and motivation towards the subject matter. The results from the inventory can also indicate the perceived value and self-confidence of the students. The study also shows that the inventory can be used at the younger age. This study contributes to the existing literature on the attitude measurements and the use of self-report questionnaires to determine the psychometric levels of the students. This investigation also shows that although ATMI was designed with undergraduate students, it can also be used with middle school students with high reliability and validity. The study suggests further testing with larger samples and explores association with other variables such as motivation, self-efficacy and career choice.

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