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Original Paper

Authenticating Factor Analysis of Attitude towards Mathematics Inventory (ATMI) in Thailand

Hareesol Khun-inkeeree[1*] & M. S. Omar Fauzee[2]

[1] Walailak University, NakhonSiThammarat Province, Thailand

[2] Universiti Utara Malaysia, Malaysia

[*] Hareesol Khun-inkeeree, Walailak University, NakhonSiThammarat Province, Thailand

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Abstract

The study examine the psychometric properties of Attitudes towards Mathematics Inventory (ATMI) in the Thai context. To achieve the objective set by the authors, 259 students from 10 different primary schools in Nakhon Si Thammarat province, Thailand were selected. Furthermore, a forty items ATMI questionnaire having four scales that is, 15 items measuring self-confidence, 10 items measuring value, 10 items measuring enjoyment, and 5 items measuring motivation from the study of Khine and Afari (2014) was adapted. The questionnaire adapted was translated to Thai language by expert English Thai lecturer. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were carried out to ascertain the factorability of the correlation matrix. That ATMI can be a viable scale to measure students' attitudes toward mathematics in Thai context.

Keywords

Attitudes toward Mathematics, Attitudes towards Mathematics Inventory (ATMI), verifying factor analysis, Nakhon Si Thammarat province, Thailand

1. Introduction

There is a growing trend of technological advancement in various forms across different human endeavors. This is evident in the usage of sophisticated electronic gadgets such as cell phones, medical facilities and scientific exploratory activities (Tate, Lyons, & Valle, 2015). The observations in today's world had also increased the level of addressing mathematical problem-solutions in the academic circle particularly in enhancing the level of students' understanding and mastering of the mathematical concepts. To achieve this, mathematics teachers have also intensified their knowledge and expand their scope of learning in their curriculum activities (Thorsteinsson & Page, 2015). The objective of using electronic gadgets is aimed at assisting students to develop a positive mindset and attitude towards mathematical problem-solving. Although, for the past thirty years, researchers have been investigating how to develop the mind and attitude of students towards mathematics (Belbase, 2013; Johnson, 2012; Kutaka et al., 2018; Kay, 2015).

The relevance of mathematics across various disciplines cannot be overemphasized because it contributed a lot to problem-solving and analytical issues. Mathematics is extensively utilized in areas such as economics, education business, medicine, biology, engineering, computer science, and sociology (Battistoni, 2017; Bucciarelli & Kuhn, 2018; Maloney, Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Additionally, mathematics is a vital tool needed in everyday life to enhance the level of awareness and consciousness without being deprived of one's rights (Maloney & Beilock, 2012). Living in a fast-growing economy adequate information dissemination is paramount for effective communication because technology usage keeps advancing. To meet up the pace of technological advancement propelled through scientific discovery, countries across the globe recognized the need to develop the mental capacity and attitude of the student towards the culture of learning and applying mathematical knowledge in their everyday life activities. Studies by Wang and Eccles (2014) does indicate that most students perceived mathematics as a problematic subject. Although, there has been a remarkable improvement in elementary mathematics at the lower educational stage in recent times, yet, the concern for effective implementation of the educational program has become the focus of educators in the academic environment. More so, one of the educational goals is to develop a positive mindset of students in embracing mathematics as a prerequisite in addressing daily encounters (Hattie, Fisher, Frey, Gojak, Moore, & Mellman, 2016). Thus, it is widely believed that the students' attitudes towards a particular subject will affect their level of performance in that subject (Lee & Hannafin, 2016; Lo & Hew, 2017; Griffin, 2015).

2. Background of Study

The Thai system of education consists of 12 years of compulsory education: 6 years of "Prathom" (primary education, P1 to P6) and 6 years of "Mattayom" (secondary education, M.1 to M.6) as per the policy laid out by Thai Ministry of Education. This system resulted from the educational reform of the 1999 National Education Act. It emphasized on organizational structures, decentralization of administration, and student-centered teaching practices (Ministry of Education, 2008).

Furthermore, the Thai education mathematics curriculum was updated in the year 2018. The curriculum inculcates flexibility to integrate the knowledge, experiences, and culture of the Thai community. As a result, the curriculum is consistent with the learning standards of each core subject. In the Thai National Curriculum, self-learning strategies, thinking skills, and moral development are cauterized teaching and learning activities.

An essential part of the Educational Reform is that educational institutes were decentralized to play a major role in curriculum development. The centralized role was restricted only to determining the standards and to develop students' attitudes. The Basic Educational Curriculum as spelled out in 2001; this was followed by the revision of the core curriculum of Basic Education in 2008. The curriculum became standard-based, giving more attention to students' quality rather than the curriculum contents. With this, teachers' innovativeness was mandated and they were charged to support students' learning process of thinking. According to the Basic Education Core, the expected competencies among students, with a special focus on Mathematics, deals with the skills in communication, thinking, problem-solving, applying life skills, and technological application in teaching approaches is more important.

The awareness and understanding of these approaches are advantageous to teachers by employing different strategies to teach mathematics, thereby creating a balance of teaching and learning mathematics with regards to students' expectations within the academic environment. Such a balance is seen to enhance the techniques used in teaching mathematics in a strategic way through which students will develop high-quality experiences.

Thai Education system lays tremendous emphasis on Mathematics as the basis for overall learning development. The learning of Mathematics imparts many skills that contribute to the development of the human mind. It trains the learner to think methodically and rationally, analyze various types of situations, anticipate and plan, make decisions and solve problems (Coghlan & Brannick, 2014). Mathematics also serves as a tool that facilitates the gaining of knowledge related to science and technology. Mathematical skills and knowledge are indeed essential to enhance the standard and quality of living in the modern era.

There are three levels of Mathematics Curriculum in school:

1) Intended curriculum which is derived from the school administrators' perspectives.

2) Implemented curriculum which is derived from the teachers' perspectives.

3) Attained or realized curriculum which is derived from the students' perspectives (Inprasitha, 2004; Khonkarn, 2006).

3. Problem Statement

The learning areas in the study of mathematics are designed to enable students to acquire mathematical skills and knowledge to their utmost potential. These include numerical concepts and sense of perception; percentage and ratio; and system, properties, and operation and application of real numbers. It was realized that the mathematics curriculum cannot be found in textbooks, reports, or documents because it occurs and continues in the classroom which is the structural unit of Mathematics (Inprasitha, 2004; Khonkarn, 2006). The guidelines of the National Council of Teachers of Mathematics (2000) suggest that teachers should establish the standard for class discussion. The groundwork for Mathematics learning is that students should be good listeners who respect and value others' opinions whether or not they are agreeable. The responsibility to ensure this in the classroom was also given to the teacher (Khan, 2011). Recognizing the importance of Mathematics learning as outlined above, the

Ministry of Education of Thailand (2001, 2008) stated that students in Thailand were expected to learn how to associate knowledge of Mathematics with other sciences. With this government of Thailand had over the years enhance the education curriculum. Yet, the performance of Thai students is nowhere found to meet up with the expected outcome (Asian Correspondent, 2019). Some of the factors identified to contribute to these low-performance observations include lack of personnel, that is, less teaching staffs Puncreobutr and Rattanatumma (2016) as well as the behavior of teachers and students towards learning mathematics (Yasar, Çermik, & Güner, 2016).

Concerning this, the initial focus of this study is to examine the relationship between students' attitudes toward performances in mathematics. However, as literature have it, there exist oceans of studies regarding the intended objective (Bofah & Hannula, 2015; Karjanto, 2017; Yáñez-Marquina & Villardón-Gallego, 2016). Nevertheless, deeper insights into earlier studies reveal that although there are several studies investigating attitudes towards performances, there exist no agreeable measurement in this regard (Byrne, 2001; Chamberlin, 2010; Mata, Monteiro, & Peixoto, 2012; Mohamed & Waheed, 2011; Tapia & Marsh, 2004) specifically, among studies primary school students in Thailand's context. Hence, the authors find it critical to develop a universal attitudinal instrument viable enough to cater for attitude stability towards learning and performing in mathematics.

4. Purpose and Objective of Study

Considering the low performance of Thai students in mathematics, the main objective of this study is to examine the stability of the Attitude toward Mathematics Inventory (ATMI) scale concerning student's performance in mathematics. The study will therefore provides alternative approach to researchers in measuring student's attitudes towards mathematics by followed the objectives to determine the reliability and validity of instruments to measure students' attitudes toward mathematics in Thailand context.

4.1 Review of Literatures

Attitudes are predispositions of individuals towards a particular object, thing or situation based on past experiences over time. Nevertheless, attitude can influence by imagined circumstances, although attitudes are more stable than emotions but, at the same time, it can influence the level of participation. Winter and O'Raw (2010) noted that attitudes are formed in response to educational background, teaching practices and organizational structure. Attitude can either be seen as being positive or negative. A positive emotional disposition towards a particular subject is a function of a positive attitude to that subject while a negative attitude towards a particular subject emanates from negative emotional dispositions (Mata et al., 2012).

Attitude is conceptualized by different authors based on individual dispositions towards a subject. According to Mata, Monteiro, and Peixoto (2012), students' attitude towards mathematics is propelled by certain factors such as beliefs experiences, which could be changed over time. Buttressing the relevance of individual experience, social interactions among students is paramount within the context of mathematical discuss as it becomes a central issue. Likewise, Fraser and Kahle (2007) identified in their study that learning process within a designated environment among pair group significantly impact on student attitude. This is also reflected in the level of performance and achievement by the student which is reflected in their overall scores. Additionally, Mohamed and Waheed (2011), in their study on understanding attitude and influences in relation to differences amongst students on their development, identified three factors that play significant role on students; factors associated to students themselves (for instance, achievement in mathematics, anxiety, self-efficacy and self-concept, motivation and experiences at school); factors associated with school-teacher and students relationship and teaching skills such as teachers knowledge on mathematics, availability of teaching materials, beliefs and organization of teaching environment. Finally, they also identified factors such as family background and societal influences students' development and achievement towards mathematics. These imply that the level of students' attitudes and performances towards the assimilation of studying mathematical is a function of environmental, social and emotional influences on the individual's psychological makeup that reflects the way the students view mathematics as either being positive or negative.

Positive attitude builds self-confidence and enhances the level of student achievement and vice versa. Positive attitude thus is crucial in the willingness of students to accept, learn, assimilate and achieve remarkable results in mathematics. The aim of this study, therefore, is its contribution to the development of a theoretical base through the validation of the ATMI instrument.

4.2 Background of Instruments Used to Measure Attitudes

There are various instruments to measure the level of student's attitudes towards mathematics. However, the most popular and widely used instrument used in research is the Fennema-Sherman Mathematics Attitude Scales (FSMAS) (Sachs & Leung, 2013). Another instrument that has also attracted considerable attention in mathematics education research is the Aiken's Mathematics Attitude Scales (MAS) (Aiken, 1976). Likewise, the TIMSS 2011 which has three attitude scales that are related to the three motivational constructs that evaluate the intrinsic value of students namely, utility value, the belief, and ability of students towards mathematics scale. More recently, another scale that has received attention is the Attitude towards Mathematics Inventory ATMI by Tapia and Marsh (2004), though this has not gained much ground in its application in research (Chamberlin, 2010). Nevertheless, this scale was adopted in this study because of its clear and distinct application and identification of the four dimensions that measure the level of attitude towards mathematics among students.

Attitudes Toward Mathematics Inventory (ATMI) scale originally is used for measuring various items in different fields. It consists of 49 different items that measure six domains namely; anxiety, enjoyment, value, motivation and parent/teachers' expectations (Asante, 2012). Assessment of scores was done using a five-point Likert scale with response options ranging from "strongly disagree" to "strongly agree". Tapia (1996), combined the level of confidence and anxiety of students as a single factor influencing student's attitudes towards mathematics. This result was derived after analysis of data after using the exploratory factor from a sample of 544 students offering mathematics in a private school. The result obtained shows a relatively low item-to- total correlation with items on the parent/teachers' expectation subscale which depicts a non-significant relationship of the two items, hence was rejected (Tapia, 1996; Tapia & Marsh, 2004).

Also, another scale comprising of four subscales which include self-confidence, value, enjoyment, and motivation; 40 items including the positive and negative items. Tapia and Marsh (2002) in their study conducted at different times established the validity and reliability test for both college students and high school students respectively (Tapia & Marsh, 2004). Subsequently, a Confirmatory Factor Analysis (CFA) was conducted using data obtained from 134 college students from the U.S to affirm the four-factor structure as identified by Tapia and Marsh (2002). The Cranach's alphas derived for the whole scale is within the range of 0.95 to 0.97 (Tapia & Marsh, 2004). While for each sub-scale self-confidence, value, enjoyment, and motivation have 0.95, 0.89, 0.89, and 0.88 respectively on the scale value (Tapia & Masrh, 2004). One of the advantages of the ATMI is its distinctive and consistent characteristics embedded in the factor structure and its ability to measure a variety of constructs or items which other scales like the Fennema-Sherman Mathematics Attitude Scales (FSMAS) do not possess (Byrne, 2001). These items 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).

Despite the consistency in the structure of the ATMI scale and robust psychometric characteristics, its popularity and usage amongst scholars are still low (Lim & Chapman, 2012; Tapia & Marsh, 2004; Chamberlin & Powers, 2013; Lim & Chapman, 2012). The need for researchers to further explore the ATMI scale from various perspectives using different cultural samples and a smaller version is expedient in creating more awareness on the usage of the ATMI scale (Chamberlin & Powers, 2013). This study, therefore, determined the stability of the ATMI scale when applied among a group of students in Thailand. It also aimed at providing an alternative to researchers who are solely in measuring the attitude of students towards mathematics.

5. Methodology

This study was conducted using a quantitative approach in which questionnaires were randomly distributed to 295 primary school students across 10 primary school in in Nakhon Si Thammarat province, Thailand. The questionnaire was used as an instrument to examine the students' attitudes towards mathematics in primary school in the Nakhon Si Thammarat province, Thailand.

Data Collection Method, the instrument background. In addition to the application of the ATMI in this study, the structure of the ATMI was also examined in relation to the objective of the present study. This illustration is highlighted in Table 1 below.

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

The questionnaire was translated into the Thai language by an expert Thai lecturer who specializes in teaching the English language. Responses were collected using the Likert-scale anchors: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree were used (Tapia & Mash, 2004). Kramarski and Gutman (2006), suggested that that the reliability of the pretest is 0.71 and the reliability of the posttest is 0.86 in the analysis of Cronbach's Alpha. Therefore, the reliability and discriminatory power of both tests used in the study were good. The details of the ATMI showed in Table 2.

Sample of Study, total of 295 students participated in this study during the second term of the academic year 2019. The dataset was a part of three data points collected for a longitudinal study conducted over the year 2019. The respondents are 295 students 10 primary schools in Nakhon Si Thammarat province, Thailand. The Attitude toward Mathematics Inventory (ATMI) was employed to evaluate different underlying perspectives of students' attitudes toward mathematics (Tapia & March, 2004). Forty items of ATMI consists of four scales: 15 items of self-confidence, 10 items of value, 10 items of enjoyment, and 5 items of motivation (Khine & Afari, 2014). The whole set of the questionnaire is shown in Table 2.

Table 2. Factor Analysis Result of Self-Confidence

Items	Loadings
SC3	.447
SC9	.877
SC10	.835
SC11	.802
SC12	.814
SC13	.794
SC14	.843
SC15	.683
Eigenvalues	1.826
Percentage (%) of variance explained	35.78
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.871

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Bartlett's Test of Sphericity	Approx. Chi-Square	1977.683
	Df	105
	Sig.	.000

As seen in Table 3, the KMO measuring the sampling adequacy yielded a value of .706 which is above the threshold value of .6 as suggested by Kaiser (1974) and the Bartlett's test of sphericity was significant (Chi-square=647.667; df=45, p<.001). Therefore, the five items loading between .574 and .720 are said to be valid and reliable in measuring value.

Table 3. Factor Analysis Result of Motivation

Items		**Loadings**
VA2		.574
VA3		.588
VA4		.691
VA7		.669
VA8		.720
Eigenvalues		2.83
Percentage (%) of variance explained		28.29
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.706
Bartlett's Test of Sphericity	Approx. Chi-Square	647.667
	Df	45
	Sig.	.000

Table 4 also revealed that with the KMO value been .655 which is above .6, the Eigen value above 2 and the Bartlett's test of sphericity significant (Chi-square=443.371; df=45, p<.001); all the four items loadings between .447 and .770 are said to be valid in measuring enjoyment.

Table 4. Factor Analysis Result of Enjoyment

Items		Loadings
ENJ3		-.653
ENJ8		.713
ENJ9		.770
ENJ10		.447
Eigenvalues		2.44
Percentage (%) of variance explained		24.43
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.655
Bartlett's Test of Sphericity	Approx. Chi-Square	443.371
	Df	45
	Sig.	.000

As seen in Table 5, the items loading between .554 and .73 which is above the threshold value of .4 as suggested by Straub et al. (2004), the Eigen value is 2.16, KMO is .696 which are all greater than the threshold value of .6 for KMO and 1 for Eigen value and the Bartlett's test of sphericity is significant. Therefore, it can be concluded that the four items in Table 5 is valid in measuring motivation.

Table 5. Factor Analysis Result of Motivation

Items		Loadings
MOT1		.731
MOT2		.580
MOT3		.554
MOT4		.621
Eigenvalues		2.16
Percentage (%) of variance explained		43.19
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.696
Bartlett's Test of Sphericity	Approx. Chi-Square	229.430
	Df	10
	Sig.	.000

Furthermore, reliability test was carried out to ascertain the consistency of an instrument used and according to Sekaran (2003), it is one of the indicators of goodness of measure. The degree of inter-correlations among items were by internal consistency through Cronbach alpha coefficients (Zikmud & Babin, 2012). According to Nunnally (1978), Cronbach alpha value of .6 is generally considered sufficient but a value of .7 and above is more desirable. Therefore, as shown in Table 6, all the Cronbach alpha value for self-confidence, value, enjoyment and motivation are .837, .757, .787 and .723 which are above the acceptable value of .6. Thus, items used for measuring these variables are considered reliable.

Table 6. Reliability Coefficients of the Variables

S/NO	Variable	No of items	Cronbach alpha
1.	Self-confidence	8	.837 (.859)
2.	Value	5	.757 (.846)
3.	Enjoyment	4	.787(.818)
4.	Motivation	4	.723(.803)

In other to determine the factors or items that measures a variable, Principal Component Analysis (PCA) with varimax rotation as suggested by Meyers et al. (2006) was carried out on the variables of the study to ascertain convergent validity. According to Tabachnick and Fidell (2007), it is common to use a guideline for a lower limit on item factor loadings to determine whether to delete or retain items. Principal component analysis was conducted and absolute value below .4 was suppressed. This was in line with the threshold value of 0.4 as suggested by scholars in social science studies (Straub, Boudreau, & Gefen, 2004). Tables 2-5 are the factor loadings for self-confidence, value, enjoyment and motivation respectively. As seen in Table 2, the loadings are within the range .447 to .877. The KMO value is .871, eigenvalue of 1.826 and the Barttlet's test of sphericity is significant having $p<.05$. Therefore, the eight items are valid in measuring self-confidence.

6. Discussion

Considering the objectives set at the beginning of this study which was to verify if the items developed by Khine and Afari (2014) can be adapted and use to examine students' attitudes towards mathematics in Thailand. The empirical findings reveal that the items adapted yielded a positive anticipated result. Considering the observed results, the authors conclude that these instruments can be used in the context of Thailand to investigate the students' attitudes towards mathematics.

Therefore, it can be concluded from the study's findings that self-confidence, Value, Enjoyment and Motivation are reliable and valid in measuring the attitude of student's towards mathematics in Thailand context. This study contributes to the body of knowledge and academic domain due to its relevance on how to evaluate the level of students' attitude and performances towards Mathematics. It also identifies those factors that can hinder or enhance the approach and techniques of teachers' in accessing students' performances in the classroom. The limitation of the study is its scope in location and student's level in school. The study therefore recommends future study by using other locations and students' level in school.

7. Limitation of the Study

Despite the robust findings in this study, as per the instrument verified, the authors acknowledged that to allow generalizability of the findings, the samples employed in this study must be widen. That is, samples from other Thaioland's province must be investigated.

Furthermore, the authors suggested future studies to consider other variables such as peer group study, learning environment, curriculum contents needed more attention from scholars in context of Nakhon Si Thammarat province of Thailand.

8. Recommendations

Based on the findings, the following researchers can come up with some suggestions related to the stress management of Seberang Perai Utara primary schools in Penang. These proposed proposals are considered appropriate to reduce the stress of schoolwork in general.

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