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Adaptation and Validation of Students' Attitudes Toward Mathematics to Indonesia

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Annotation. In this study, it is aimed to psychometrically evaluate of students' attitudes toward mathematics inventory in secondary education (ATMSE). The validity of the model's four-factor structure was evaluated using confirmatory factor analysis (CFA). Reliability values for the four subscales ranged between 0.79 and 0.89 both consistency reliability using Crbα and composite reliability using ω. ATMSE is a viable instrument for assessing students' attitudes toward mathematics in Indonesia.

Keywords: *attitudes toward mathematics, confirmatory factor analysis, secondary school students.*

Introduction

The goal of mathematical education is to foster positive attitudes toward mathematics (ATMs). There are concerns about factors that possibly yield achievements and cultural differences in attitude among students. Success in mathematics is based on several influencing factors, such as the characteristics of students (attitude and creativity), students' environment (culture/ethnicity), and teachers. In the last two decades, the relevance of ATM education has been emphasized in systematic research in the context of social psychology under the assumption that affective and cognitive factors play a role in learning mathematics (Dutton, 1951; Hannula et al., 2016). Although attitude study has a lengthy history, there is no clarity on exactly what an attitude is and how an attitude may be identified.

Research on ATM has been conducted extensively, highlighting the close relationship between attitude elements and successful mathematics performance (Davadas & Lay, 2017; de-la-Peña et al., 2021; Karjanto, 2017; Tok, 2015; Van Praag et al., 2015; White et al., 2018). Particularly, Kartowagiran & Manaf (2021) performed an interesting meta-analysis with longitudinal modeling, showing that the positive attitudes of students toward mathematics learning have a significant influence. However, there were sample size limitations; the collected sample did not represent the student population. Moreover, (Barkoukis et al., 2008) showed that the drop-out rate of students correlates with their ATMs.

Lipnevich et al. (2011) studied students' perception of mathematics to predict ATMs achievement and provided data on reliability and validity. Osborne et al. (2003) also showed that pupils' ATMs have economic consequences for their futures, hypothesizing that students who have abandoned mathematics will earn less on the job market than students who did not. However, their study was limited by the lack of an instrument to measure the motivation aspect. Moreover, several scholars have noted that issues about the psychometric impact of evaluation instruments have been raised recently (Fabian et al., 2018; Kiwanuka et al., 2017; Lim & Chapman, 2013; Ren & Smith, 2018; Yáñez-Marquina & Villardón-Gallego, 2016). Further, researchers (e.g., Moliner & Alegre, 2020; Nedaei et al., 2019; Primi et al., 2020) have expressed dissatisfaction with the absence of appropriate instruments for assessing mathematics attitudes.

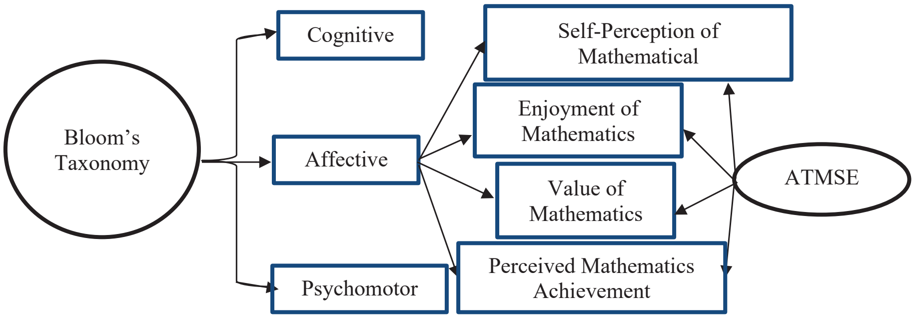
The relevance of developing such instruments is to assess mathematics achievement and personality variables (Tapia, 1996). The rationale for the popularity of Fennema-Sherman mathematics attitudes scales (FSMAS) by Fennema & Sherman (1976) over ATM inventory (ATMI) by Tapia (1996) might be because FSMAS was first developed, and no alternative instrument meant to evaluate mathematics attitudes had been adequately tested for validity and reliability between FSMAS and ATMI creation and testing. Thus, ATMI may require a longer time to achieve popularity than its predecessor. This lack of popularity might also be because only samples from Mexico or US have been used to test ATMI; thus, a culturally diverse sample is required to explore the characteristics of ATMI. Most other existing instruments are based on western samples and require a significant amount of time to operate. The objective of this study is to develop and validate a variant of ATMI (Tapia, 1996; Tapia & Marsh, 2004)-ATMI in secondary education (ATMSE)-on an Indonesian sample space. Particularly, the major contributions of this study are: (a) adapting an instrument known as the ATMI questionnaire in Indonesia using data collected from a sample of secondary school students from several Indonesian schools and (b) performing reliability and validity analyses on the ATMI questionnaire.

Theoretical Background

The concept of students' attitudes relates to mathematics education and mathematics, which are the basis of success in their learning experiences (Di Martino & Zan, 2010; Reed et al., 2010). There is no doubt that learning has an affective component. The affective domain is related to values, enjoyment, self-perceptions, and attitudes. Bloom (1956) argued in his taxonomy of educational objectives that the affective domain includes how we handle things emotionally, such as feelings, appreciation, values, enjoyment, enthusiasms, and attitudes. The conceptual model of ATMSE is shown in Figure 1.

One commonly used definition of attitudes includes the three components: cognitive, affective, and psychomotor (Bloom, 1956). It is the domain in the Indonesian curriculum where the most precise definitions of objectives can be found, phrased as descriptions of student behavior (Arrafi, 2021).

Figure 1
The Model of ATMSE. Adapted From Bloom (1956)



Self-perception of mathematics

Measuring secondary students' mathematical self-perceptions is crucial because students with low self-esteem may avoid tasks that require mathematics, whereas those who believe they are capable will enroll in additional mathematics courses and demonstrate a greater interest in solving mathematics problems. Students' self-perceptions as learners encompass both their mathematical self-efficacy and self-concept in mathematics. Bandura (1997) and Bandura & Ramachaudran (1994) defined mathematical self-perceptions as follows: self-perception in mathematics is a person's perception of self as a mathematical learner, including beliefs about his/her ability to learn and to perform well in mathematics. Adelson & McCoach (2011) stated that mathematical self-perceptions consider students' "attitudes, feelings, and perceptions" regarding their mathematical abilities. In addition, they stated that mathematical self-perception involves perceptions of a student about his/her ability to learn and do mathematics. Examples of actual items in ATMI are as follows: (1) I am really good at math; (2) Math comes easily to me; and (3) Math is very hard for me.

Value of mathematics

The concept of values and valuing has long been recognized as important in school education, particularly moral education programs, but its importance in the teaching and learning of specific school topics is relatively new. Bishop (1988) introduced the concept of values in mathematics and mathematics education and then expanded it to include progress and control, mystery and openness, rationalism and objectivism, and other concepts. A person's internalized values, regarding convictions, are the things that are important and worthwhile in his/her eyes (Seah, 2018).

In mathematics, value is a belief in the usefulness or inutility of mathematics (Adelson & McCoach, 2011; Tapia & Marsh, 2004). In the above listed concepts, mathematics was referred to as a worthwhile and necessary domain of learning, the desire to improve one's mathematical abilities was expressed, and the importance of mathematics in everyday life and education outside the classroom were recognized. When the average score is approximately 4 or greater, the students are fully aware and convinced of the importance of mathematics, a point is awarded for each item on this subscale, and the total score is used to determine the importance of mathematics in students' lives. Examples of actual items taken from ATMI are: (1) I am good at math; and (2) Mathematics is interesting (Mutohir et al., 2018).

Enjoyment of mathematics

Recent educational research has begun to examine the role of positive emotions in mathematics success. The enjoyment of mathematics reflects the affective dimension of attitude (Kiwanuka et al., 2017). Enjoyment is the positive activating emotion associated with a particular subject that is particularly appealing to an individual (Van der Beek et al., 2017). It has been discovered through extensive research that there is a moderate to strong positive relationship between mathematical pleasure and academic achievement in a subject area. Fisher et al. (2012) discovered a positive concurrent relationship (ranging from 0.39 to 0.63) between preschoolers' mathematics abilities and their early mathematics interest, which included enjoyment. For eighth-grade students, Frenzel et al. (2007) also discovered a positive correlation between mathematics achievement and enjoyment (values ranging from 0.39 to 0.66) in mathematics.

Particularly, the degree to which students enjoy solving mathematics and attending mathematics classes has been measured in terms of the enjoyment of mathematics (Lim & Chapman, 2013; Ma & Kishor, 1997; Thorndike-Christ, 1991). Mathematics enjoyment can be defined as an aggregated measure of one's liking or disliking of mathematics (Palacios et al., 2014; Tapia & Marsh, 2004). This subscale measures how much students enjoyed mathematics, solving new problems, participating in mathematics discussions, and feeling happy in the mathematics classroom. This subscale comprises 12 items used to determine the level of enjoyment that students experience for mathematical concepts and operations. The following are examples of enjoyment items: (1) Doing math is easy for me; and (2) I feel comfortable doing math problems (Palacios et al., 2014).

Perceived mathematics achievement

Perceived competence or achievement in mathematics is essential to promote successful learning. The perception of learning is an integral part of creating, maintaining, and helping pupils to achieve learning objectives. With greater success, the perceived usefulness of mathematics is regarded as the key to achieving what students plan (Liao et al., 2019). Perceived mathematics achievement is defined as students' perceptions of their abilities as learners and their capacity to complete mathematical tasks successfully. This perception may correspond to reality to a greater or lesser extent, but it is a significant source of motivation for students in any case (García et al., 2016). Further, the perceived mathematics achievement is administered to assess perceived mathematics on the part of students' mathematical persistence and subsequent enrollment in future courses (Güner & Çomak, 2014; Tapia, 1996; Thorndike-Christ, 1991). This subscale comprises seven items, which are described in detail below. In the actual inventory, two of these items were found to be true: (1) My friends think that I am successful at Maths; (2) I am sure I will be successful in math class (Yaşar, 2014).

Assessment tools for measuring ATMSE

There have been numerous field reports of assessment tools developed to measure ATMs over the past four decades, e.g., FSMAS (Fennema & Sherman, 1976), ATMI (Tapia, 1996), ATMI in the UAE (Afari, 2013), and Short form of "Mathematics Attitude Scale" (Yaşar, 2014) (see Table 1 for more details).

FSMAS instrument comprises nine scales, each with 12 items. The name of each scale and the dimension it measures include mathematics usefulness as the mother scale, mathematics as a male domain scale, teacher's scale as the father scale, attitude toward success in mathematics scale, confidence in learning mathematics scale, effectance motivation scale in mathematics, and mathematics anxiety scale (Fennema & Sherman, 1976). A 5-point Likert-format instrument used for 10th- and 11th-grade students showed internal consistency reliabilities ranging between 0.86 and 0.93 (Cronbach's alpha) (Fennema & Sherman, 1976). Since the pioneering studies, many researchers focusing on mathematics attitudes have noticed the influence of employing such scales, which were originally intended to evaluate gender-related differences in mathematical achievement among high school students (Liau et al., 2007; Mulhern & Rae, 1998). Recently, some scholars have criticized the psychometric characteristics of assessment tools, which agrees with the criticism of FSMAS (Mulhern & Rae, 1998; Suinn & Edwards, 1982). Mulhern & Rae (1998) argued that rather than the nine scales proposed by the developers of FSMAS, the scales could be reduced to six (i.e., attitude toward success in mathematics, mathematics as a male domain, parents' attitudes, teacher attitudes, mathematics-related effect, and mathematics usefulness). Further, Suinn & Edwards (1982) argued that, although FSMAS is a widely used instrument, research on the reliability or validity of its scales is inadequate.

ATMI is one of the newest instruments in this field, and it measures students' ATMs in various manners (Chamberlin, 2010). Tapia & Marsh (2004) developed ATMI as a cost-effective and efficient alternative to previous mathematics attitudes scales. As originally written, ATMI comprised 49 items based on five scales, including value (Klein, 1985), anxiety (Hauge, 1991; Terwilliger & Titus, 1995), motivation (Dossey, 1994), and confidence (Thorndike-Christ, 1991). According to a 5-point Likert scale, the responses range from "strongly disagree" to "strongly agree" (Tapia, 1996; Tapia & Marsh, 2004). Using data from a high school sample, exploratory factor analysis was performed to combine the confidence and anxiety subscales into a single factor, which resulted in the creation of a single factor. In addition, owing to the subscale's extremely low item-to-total correlation, items on the parent/teacher expectation subscale were eliminated. Their 49-item questionnaire comprised 40 items: 10 enjoyment, 5 motivation, 15 self-confidence, and 10 value items. Cronbach's alpha was high (0.97 with a standard error of measurement of 5.67); therefore, the measurement tool had good internal consistency.

Afari (2013) developed an ATMI questionnaire focusing on students' attitudes toward a subject matter to determine whether they are interested in and motivated by the subject matter. After reading a paper, middle school students from the UAE were asked to rate it on a five-point Likert scale. After being tested using confirmatory factor analysis (CFA), the four factors (40 items) were divided into three factors (36 items): factors 1 (19 items), factor 2 (8 items), and factor 3 (9 items). The reliability of the questionnaire was measured using Cronbach's alpha coefficient, which ranged from 0.811 to 0.924. Yaşar (2014) studied ATMs and discovered that a short form of "Mathematics Attitude Scale" could be used to measure the mathematics attitudes of high school students more accurately using fewer mathematics attitude items. The scale used was a five-point Likert scale with 35 items divided into four categories (i.e., enjoyment; fear, anxiety and distress; place and importance of mathematics in life; and perceived mathematics achievement). Cronbach's alpha reliability coefficient for each scale ranged from 0.82 to 0.89, whereas the general Cronbach's alpha reliability was estimated to be 0.956.

The above findings lend support to the construct validity as a measurement of ATMs. However, there is a paucity of research into mathematics attitudes in Indonesia, particularly in the context of secondary education. Recent studies have revealed that there is an urgent need for research in this area, particularly for students with low and average mathematics achievement abilities (A et al., 2021; Tamur et al., 2020).

Table 1
Instruments of ATM

Study	Instrument	Number of items	Psychometric properties
(Aiken Jr & Dreger, 1961)	Math Attitude Scale	20 items (10 negative attitudes and 10 positive ones)	EFA (for test–retest (N = 310)
(Dutton & Blum, 1968)	Attitudes toward arithmetic with a Likert-type test	27 items between positive and negative feelings about arithmetic	The reliability of the scale by the Spearman–Brown test-retest formula, was 0.84 (N = 346)
(Alken, 1974)	Two scales of ATM (enjoyment/E and value/V)	21 items (Scale: 11 E and 10 V items)	EFA; Cronbach's alphas for E and V scales were 0.95 and 0.85, respectively (N = 190)
(Fennema & Sherman, 1976)	FSMAS	9 scales were developed: the success in mathematics, masculinity, mother (M), father (F), teacher, confidence in learning mathematics, mathematics anxiety, effectance motivation, and mathematics usefulness	EFA Split-half reliability (for the subscales): 0.86–0.93 (N = 1,600)
(Tapia & Marsh, 2004)	ATMI	40 item with 4 scales: 10 enjoyment, 15 self confidence, 5 motivation, and 10 value items	EFA and CFA; Cronbach's alpha for each dimension ranged from 0.88 to 0.95. Cronbach's alpha for the 4 scales was 0.97. Test–retest reliability for each dimension was within 0.70–0.80. Moreover, test–retest reliability for the 4 scales was 0.89 (N = 545)
(Michaels & Forsyth, 1977)	The use of an instrument to measure certain ATMs	4 subscales, including security with mathematics (S), enjoyment of word problems (EW), appreciation of the utility of mathematics (U), and enjoyment of pictorial problems (EP).	EFA Spearman-Brown Reliability: S =.61, U = 0.51, EP =.78, and EW =.78 (N = 299)

Study	Instrument	Number of items	Psychometric properties
(Sandman, 1980)	Mathematics attitude inventory	48 items in 6 subscales: perception of mathematics teachers, anxiety toward mathematics, value of mathematics in society, self-concept in mathematics, enjoyment of mathematics, and motivation in mathematics.	EFA Cronbach's alpha for 6 scales: 0.68–0.89 (N = 5,034)
(Arrebola & Lara, 2010)	ATM for students in compulsory secondary education	37 items divided into 7 factors: 3 positive self-concept, 7 affective component, 5 negative self-concept, 3 cognitive component, 13 behavioral component, 2 expectancy of accomplishment, and 2 demotivation toward the study of mathematics 2 items	EFA and CFA Cronbach's alpha coefficient was 0.923 (N = 236)
(Lim & Chapman, 2013)	A short version of ATMI	There are 19 items in total, divided into four subscales: 5 enjoyment of mathematics, 5 value of mathematics, 4 motivation, and 5 self-confidence in mathematics.	CFA Cronbach's alpha coefficient was 0.93 Test–retest reliability = 0.75 (N = 1,601)
(Yaşar, 2014)	Short form of "Mathematics Attitude Scale"	19 items in total, divided into 4 subscales: 6 enjoyment items, 4 role of mathematics in life items, and 4 perceived mathematics success items, and 5 items each for fear, anxiety, and distress.	EFA and CFA. Cronbach's alpha values for components ranged between 0.82 and 0.89. Cronbach's alpha value for the four-point scale was 0.956 (N = 1,801)

Note: EFA: exploratory factor analysis; CFA: confirmatory factor analysis ATM in Indonesia

Recent research on ATMs has primarily focused on western populations (Liau et al., 2007). As a result of cross-continental generalizations about the relationship between student attitudes and mathematics achievement, there is an urgent need to extend the research to nonwestern societies. Attitude development in Indonesia follows the applicable curriculum, namely the 2013 curriculum. It aims to produce Indonesian students who are productive, creative, innovative, and effective by strengthening integrated attitudes, skills, and knowledge (Kementerian Pendidikan dan Kebudayaan, 2014; A & B, 2022). In this curriculum, students must not only perform well in mathematics but also comprehend and evaluate mathematical concept-based ideas and arguments.

Several prior studies suggest that students who engage in mathematics learning have the potential to be high-performing, that student achievement changes over time with a potential linear trend (Yasin et al., 2020), and that students achieve well on student-perceived mathematics instructional characteristics (Lazarides & Rubach, 2017). A student is expected to take responsibility for his/her learning through a curriculum that inspires confidence and has an impact on the student, thereby increasing the student's ability to engage in active learning (Darling-Hammond, 2017).

According to international assessments conducted by the Program for International Student Assessment (PISA), Indonesian students performed poorly in mathematics compared with students in other countries. PISA comprises basic tests in reading, mathematics, and science that are not based on any national curriculum. The PISA process is widely regarded as having strong legitimacy in describing a country's educational quality. Indonesia has taken part in PISA since 2000. In the most recent PISA iteration, conducted in 2018, Indonesian students ranked 72 out of 78 countries studied in mathematics. Indonesian students have a lower average score than most Organisation for Economic Co-operation and Development countries, particularly in mathematics (Schleicher, 2019). Regarding the data of Trends International Mathematics and Science Study (TIMSS), Indonesia participated between 1999 and 2015. Luschei (2017) examined and interpreted Indonesia's TIMSS results and ATM results. For eighth-grade students, in 1999, Indonesia scored 403. In short, Indonesia achieved a standard deviation of 97% less than the international mathematical average. In 1999, Indonesia ranked 34th out of 38 participating countries in mathematics. The score for mathematical performance increased to 411 in 2003, then decreased to 397 in 2007, and further decreased to 386 in 2011. In 2015, the mathematical performance score increased to 397, whereas the scientific performance score decreased to 397; however, these data come from fourth – instead of eighth-graders and hence difficult to compare with earlier TIMSS rounds.

Luschei (2017) also studied students' ATM and indicated the IEA asked students how much they enjoy or value mathematics in every TIMSS round. These questions usually show that Indonesian students have a high level of mathematical value. About 92% of the students reported "looking a lot" or "loving" mathematics in 1999, and 71% of students in 2003 gave high priority to mathematics. In 2007, the percentage increased to 95%. The IEA changed the matter in 2011 to directly evaluate the value of the students in mathematics, and the percentages declined to 31%, meaning the students valued mathematics. Although TIMSS included fourth-graders in 2015, the IEA did not ask how valuable mathematics was to the fourth-grade students.

Method

Participants

A total of 502 secondary school students, ranging in age from 11 to 15 (mean: M = 13.57, standard deviation: SD = 0.990), participated in the study. The students were randomly selected from 14 different secondary schools in Indonesia and were asked to fill out a questionnaire online (because of the impact of the COVID-19 pandemic period), which took an average of 20 min. to complete. The demographic profile of the participants is presented in Table 2. The data collection was performed from July to August 2021.

Table 2
Demographic Characteristics of the Sample in this Study

Demographic		**Frequency**	**Percentage (%)**
Gender	Girls	193	38.4
	Boys	309	61.6
School Category	Private	185	36.9
	Public	317	63.1
Living Place	City	237	47.2
	District	265	52.8
Ethnicity	Batak	23	4.6
	Betawi	1	0.2
	Bugis	1	0.2
	Java	344	68.5
	Lampung	84	16.7
	Padang	1	0.2
	Sunda	12	2.4
	Others	36	7.2

Note. N = 502; M = 13.57 years of age; SD = 0.99; S.E = 0.04.

Instrument

The ATMSE developed by (Mutohir et al., 2018; Palacios et al., 2014; Yaşar, 2014) was examined through a 34-item questionnaire. In this questionnaire, students were asked to indicate their agreement with each statement by selecting from the following choices for positive items: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. For negative items, the opposite is the case. All items were composed and adapted based on the four core dimensions of ATM and categorized into four factors: the self-perception of mathematics (8 items), value of mathematics (10 items), enjoyment of mathematics (9 items), and perceived mathematics achievement (7 items). All items constructed were measured independently.

Procedures

The original questionnaire was created in English. Everyone in my study spoke Indonesian as their native language; English was their second language. Thus, the questionnaire was translated into Indonesian to ensure that everyone who speaks Indonesian as a first language could comprehend its contents, and the questionnaire's validity could be improved as a result of the translation. Three Ph.D. candidates in the UK, US, and Australia helped translate the Indonesian version to English again. They all had extensive knowledge in the field of mathematics education and linguistics. Everything about the new English versions was comprehensively examined, contrasted, and criticized. To clarify any ambiguous points, a few minor word choice modifications were requested. Finally, a trial version of the questionnaire was developed in Indonesia and sent via email to some experts in the field, who were asked to comment on the validity of the questions and document content. They offered suggestions on the words and phrases that should be used to describe the items to ensure that they were meaningful and easy to understand.

Data analysis

Analytical procedures followed three steps. First, the data analysis was performed using Mplus 8, and SPSS Version 25.0. CFA was performed to assess the fit of the measurement model (Jomnonkwao & Ratanavaraha, 2016). After the CFA, we used the following goodness of fit indexes to evaluate the model's fit: the chi-square test, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and Kaiser–Meyer–Olkin (KMO) index (Kline, 2015). The chi-square statistic, including its degrees of freedom and p-value, is represented mathematically. According to Kline (2015), the chi-square test statistic is highly sensitive to sample size, with statistically significant chi-square values being discovered more frequently when large samples are involved. Therefore, we considered CFI values, which are insensitive to sample size. Its values range from 0 to 1, and a value consistently greater than 0.90 indicates that the model is fit satisfactorily and is acceptable. RMSEA is an absolute fit index scaled as a statistic of poor fit, with zero representing the best result. A good model fit is typically defined as 0.08 or less. SRMR is a measure of absolute fit that can also be used to quantify fit inadequacy. It is a standardized version of the root mean square residual (RMSR), a statistical term that refers to the mean absolute covariance residual in a regression model. RMSR = 0 indicates that the model is perfectly fitted, and increasing values indicate that the model is becoming increasingly unfit. Hence, RMSEA ranging from 0.03 to 0.08 needs to be reported (Hair et al., 2010). The KMO test determines whether the data is appropriate for factor analysis. When factor loadings exceed

0.60, they are considered to be statistically significant. Our findings revealed that factor loadings of 0.80 or greater were considered statistically significant.

Second, after completing the CFA, we looked at Cronbach's alpha and composite reliability to determine the overall reliability of the research. To assess reliability, the internal consistency reliabilities (Crbα; Cronbach's alpha) and composite reliabilities (ω; McDonald's coefficient omega; Raykov (1997)) were calculated. As previously stated by Habók and Magyar (2018), values greater than 0.70 indicate favorable outcomes for empirical research (Habók & Magyar, 2018; Hair et al., 2010). Finally, the construction validity and discriminant validity tests were used to assess the validity of a measurement model's constructs. When evaluating the convergence of a theoretical model, it is important to consider the degree to which the elements of the model are related. When the sum of all factors in a single construct is greater than 0.70, it is considered to be confirmed. In addition, the construct reliability (CR) for each construct should be greater than 0.70, and the average variance extracted (AVE) for each construct should be greater than 0.50, according to the guidelines. Lower values are acceptable only when the CR value is greater than 0.60 (Fornell & Larcker, 1981). Further, we used HTMT as a discriminant validity criterion, which we calculated by comparing with a predefined threshold, to determine discriminant validity. As an eligibility criterion for discriminant validity, a threshold value of 0.90 is considered acceptable in terms of discriminant validity (Kline, 2015). This threshold is reached when the HTMT value is less than a certain threshold, indicating that the test has demonstrated discriminant validity. The last was multidimensional analysis. We performed multigroup analysis on measurement models based on gender differences to ensure that the measurement model used in this study measures the same thing across gender.

Results

CFA

CFA is used to confirm latent factors in the measurement model, which demonstrated that all latent factors were operating properly and achieving GoF indexes. According to Chuah et al., (2016) recommendation, we performed analyses for CR, convergent validity, and discriminant validity. To assess model fit, we created a CFA diagram in the measurement model using Gaskin & Lim (2016)'s pattern matrix builder plugin. In this structure model, single-headed arrows represent hypothesized one-way directions in the structured model, whereas double-headed arrows represent the correlation between two variables in the structured model. A latent variable (e.g., a questionnaire factor) is represented by an oval, whereas an observed variable (e.g., a questionnaire item) is represented by a rectangle. The small circles on the graph represent the measurement errors attributed to each of the observed indicators.

Moreover, KMO was 0.936. Then, the factor loading was less than 0.4. In conformance with Tabachnick et al. (2007), it is common to use a lower limit on item factor loadings to help determine whether to delete items from a database or keep them. A principal component analysis was performed, and values less than 0.4 were suppressed from further consideration. Some items with a value less than 0.4 were removed from the database. This was consistent with the 0.4 threshold value proposed by scholars in social science research (Straub et al., 2004). We analyzed the report using modification indices and covariance with items in the same factor that had values greater than 5 to obtain an exceptional result and improve the model fit in CFA. The modification to the most appropriate measurement model is to covary error terms that are part of the same factor (Hermida, 2015). A more accurate model fit was obtained (= 853.768; = 291; p =< 0.000; CFI = 0.918; TLI = 0.908; RMESA = 0.062, and SRMR = 0.056). The CFA diagram after modification indices is in Figure 2, along with information about the GoF values.

Reliability

Calculating internal consistency and reliability for each subscale was a necessary part of the process (Table 3). Reliability values for the four subscales ranged between 0.79 and 0.89 both consistency reliability using Crb and composite reliability using, indicating that they had satisfactory reliabilities on each of them.

Table 3

Internal Consistency Reliability and Composite Reliability

Factors		
Self-Perception of Mathematics	0.79	0.79
Value of Mathematics	0.79	0.79
Enjoyment of Mathematics	0.89	0.89
Perceived Mathematics Achievement	0.87	0.87

Note. Cronbach's alpha; , McDonald's coefficient omega

The reliability of the self-perception of mathematics subscale was the highest (Crb = 0.87; = 0.88); the reliability of the value of mathematics subscale was also high (Crb = 0.83; = 0.83). Cronbach's alpha and omega coefficients for enjoyment of mathematics (Crb = 0.72; = 0.78) and perceived mathematics achievement (Crb = 0.78; = 0.78) were also acceptable. The overall reliability values of ATMSE show that the instrument used is highly reliable.

Construct validity

Convergent validity

Convergent validity was used to assess the factor of correlation between multiple variables within a single construct in an instrument. In other words, convergent validity has been achieved when the variables within a factor are highly correlated. To ensure convergent validity in this study (Table 4), the CR and AVE should be calculated (Ab Hamid et al., 2017).

Table 4

Validity Measurement-Based on the Fornell–Lacker Criterion

	CR	AVE	SPM	VoM	EoM	PMA
SPM	0.79	0.39	.62			
VoM	0.83	0.45	.361**	.67		
EoM	0.89	0.52	.767**	.524**	.72	
PMA	0.87	0.54	.602**	.369**	642**	.73

Note: ** Correlation is significant at the 0.01 level. SPM, Self-Perception of Mathematics; VOM, Value of Mathematics; EOM, Enjoyment of Mathematics; PMA, Perceived Mathematics Achievement.

According to the results of AVE, all factors had values that were slightly less than the mean, with values ranging from 0.39 to 0.54 points lower than the mean, whereas the CR values were greater than 0.60 in all factors. The convergent validity of the construct is also accepting the minimum thresholds, as demonstrated by the fact that the CR values were higher than 0.60 in all factors (Fornell & Larcker, 1981; Malhotra & Dash, 2011), In addition, the convergent validity of the study was established.

Discriminant validity

Adiscriminant validity test was performed to assess whether latent factors differ from one another on an empirical level (Hair Jr et al., 2021). The HTMT ratio was used to determine discriminant validity (Henseler et al., 2015). The results are summarized in Table 5.

Table 5

$HTMT_{0.90}$ Ratio of the Correlations Four Factors

	PMA	EOM	VOM	SPM
PMA	-			
EOM	0.74	-		
VOM	0.43	0.61	-	
SPM	0.74	0.90	0.47	-

Note: SPM, Self-Perception of Mathematics; VOM, Value of Mathematics; EOM, Enjoyment of Mathematics; PMA, Perceived Mathematics Achievement. All correlations are significant at p < 0.01.

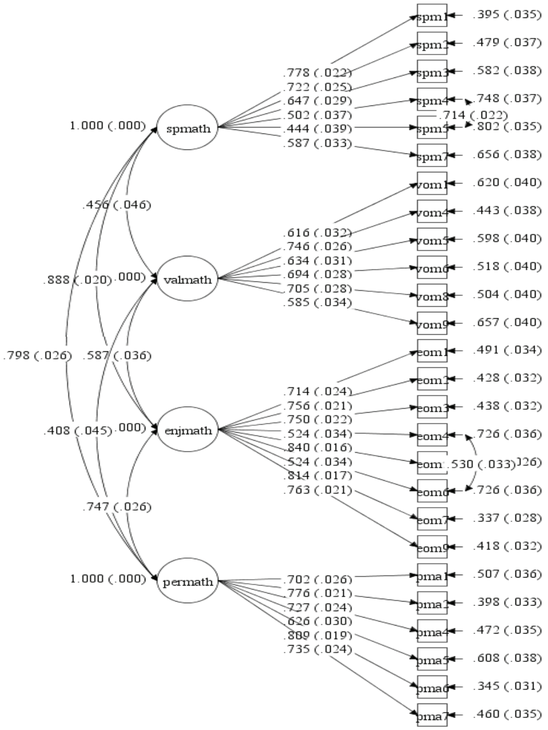
The values varied between 0.47 and 0.90. Consequently, discriminant validity has been established for all of the values less than 0.90 (Hair et al., 2010; Henseler et al., 2015).

Multidimensional analysis

We performed a multidimensional analysis of the measurement models and divided them into two groups based on gender, women and men, to ensure that the measurement model used in this study measures the same for all genders. In other words, the instrument remains unchanged when men and women are measured separately (Soeharto & Csapó, 2021). To analyze the scale scores for all ATMSE components, we compared the mean scores of the four latent factors in the ATMSE using the independent samples t-test. In addition, the effect size was determined according to Cohen's d. The effect size criterion includes the following categories: negligible (0-0.19), small (0.2-0.49), medium (0.5-0.79), and large (0.8 and above) (Cohen, 1992). We found the following: self-perception of mathematics ($t(502) = -2.668$, $p < 0.05$, Cohen's $d = 0.24$), value of mathematics ($t(502) = -2.932$, $p < 0.05$, Cohen's $d = 0.27$), value of mathematics ($t(502) = -2.662$, $p < 0.05$, Cohen's $d = 1.04$), and perceived mathematics achievement ($t(502) = -0.884$, $p > 0.05$, Cohen's $d = 0.08$). It is further evident from this analysis that self-perceptions of mathematics and the value of mathematics differ between males and females. In addition, the small effect sizes are both self-perception of mathematics and value of mathematics, while value of mathematics were large effect sizes.

Figure 2

CFA After Modification Indexes for ATMSE



Discussion

Students' ATMs are increasingly being studied because of the important role that they play in their engagement with and mastery of mathematics. Consequently, there has been an increase in interest in studying students' ATMs in recent years (e.g., Goldin, 2002; Grootenboer & Hemmings, 2007; McLeod, 1992). Despite this, the psychometric properties of the instruments used to assess ATMs have posed limitations to the study of attitude variables in mathematics. The results of a thorough review of the existing literature on instruments allow for the formulation of three general conclusions. Starting with FSMAS (Fennema & Sherman, 1976) and ATMI (Tapia & Marsh, 2004), two of the most frequently cited instruments, both of which have been translated into several languages and can be used in various sociocultural contexts, serve as good starting points for further research. Subsequent replication studies of these instruments (Mulhern & Rae, 1998; O'neal, 1988) have shown that, among other things, reconstructing some of their latent factors and reducing the scales to fewer subdomains results in a better fit to the data. The second point is that, while some scales (e.g., MAI, Sandman, 1980; Short Form of Mathematics Attitude Scale, Yaşar, 2014) have been ostensibly designed to assess ATMs, they incorporate both attitudinal and anxiety factors into their design. Despite this, Yáñez-Marquina & Villardón-Gallego (2016) argue that ATMs and mathematics anxiety are distinct subdomains of the broader domain of mathematical effect, as opposed to the other way around. This implies that ATMs have a distinct factor structure and should be evaluated separately from mathematics anxiety. The third point is that other measures do not consider students' self-esteem (e.g., the Math Attitude Scale, Aiken Jr & Dreger, 1961; the DAS, Dutton & Blum, 1968; the E and V Scales, Michaels & Forsyth, 1977).

In this study, we developed and validated an ATMSE questionnaire among an Indonesian sample of secondary school students using CFA techniques to address the gap between theoretical conceptualization and construct ATMs. Following the CFA performed in this study, it was determined that a modified four-factor model should be used, in which two items of self-perception of mathematics were removed (i.e., Math comes easily to me and I can spend hours studying and doing math problems, time goes by so fast!), then four items from the value of mathematics (i.e., Mathematics is less important to people than art or literature, Mathematics is not important in everyday life, Mathematics is not important for the advance of civilization and society, and There is nothing creative about mathematics; it's just memorizing formulas and things). In addition, one item for each of enjoyment of mathematics and perceived mathematics achievement (It's time for math, how awful! and I am not a model student in Math, respectively) were removed. The removals are because the loading factors are less than 0.5. The following was the final factor structure for the 26-item questionnaire (see Appendix). After this process, there are several items of ATMSE: eight items from the enjoyment of mathematics and six items from each of the self-perception of mathematics, value of mathematics, and perceived mathematics achievement. As a result of these findings, the ATMSE demonstrated good reliability and validity evidence of the instrument (i.e., construct validity and discriminant validity), as well as Cronbach's alpha and omega values comparable to those obtained with the original ATMSE. Although these results indicated that the eight removed items were essentially redundant, the decision was made to keep them. This was determined to be a significant contribution to the research on ATMs. The brief form is completed in only 10 min by secondary school students, whereas the developed scale is simple to administer and does not require a significant amount of time. It could be used to assess students' ATMs and provide early intervention in cases of low mathematical self-perception and enjoyment; as a result, school counselors and educators could make use of it.

Considering the funding, the validity of a scale that represents ATMSE in Indonesian was established through our research. Although his scale could be applied to a wide range of groups, it would be necessary to perform a completely new investigation into the measurement properties of the instrument. These investigations may yield a structure and strategy classification that is somewhat diverse, which will be characteristic of the sample in question, depending on the results of the investigation; however, this will be dependent on the results of the investigation. Different samples have varying degrees of variation in the factor that determines the structural characteristics.

Conclusion

Overall, we discovered that our questionnaire contains critical constructs for assessing the observed samples' ATMs. Our research is significant in that it provides empirical evidence for the viability of transferring Bloom's taxonomy theory from educational psychology to an attitude in mathematics teaching and for the possibility of developing a self-reported scale to assess secondary students' ATM in Indonesia. In conclusion, the Mplus enabled a new perspective on ATMSE. It was performed in-depth analyses of ATMSE data and confirmed the instrument's reliability and validity for assessing constructs related to "ATM."

Limitations and Future Research

Based on this study, we learned how to validate an instrument and measure ATMs, but there are some limitations to our findings. First, we could only identify four factors and were unable to include the remaining factors. The ATMSE was discovered to be composed of four factors based on previous research (Alken, 1974; Palacios et al., 2014; Yaşar, 2014). Consequently, the measurement model is only evaluated in this study, and no further investigation into the relationship between latent factors is performed. Second, we only included Indonesian secondary school students in our study. As a result, our findings can only be extrapolated to other countries with the help of additional research. The questionnaire's reliability for other populations may also be confirmed if it is made available for use by other age groups in addition to those who have completed the questionnaire. Third, although we followed appropriate procedures for data collection and took all necessary precautions, there is a possibility that the research will be somewhat skewed.

To assess students' enjoyment, value, self-confidence, and motivation toward a subject, the ATMSE can be used to determine their attitudes toward a particular subject matter. Using self-report questionnaires to determine students' psychometric levels in this study, existing literature on attitude measurements and self-report questionnaires has been further developed and expanded. In future studies, larger samples should be tested; also, the relationship between motivation, self-efficacy, and overall enjoyment, among other variables should be explored.

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Declaration of Competing Interest

No conflict of interest exists.

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Appendix: Attitudes Toward Mathematics Scale Items (after purification)

Self-Perceptions

1. I am really good at math.
2. I understand math.
3. I can solve difficult math problems.
4. Math is very hard for me.
5. Math is confusing to me.
6. I can tell if my answers in math make sense.

Value of Mathematics

1. I feel confident in my abilities to solve mathematics problems.
2. I am good at math.
3. I can understand my teacher's explanation easily.
4. Mathematics is interesting.
5. I would like to use math in my real job after I leave school.
6. I spend lots of time to practice mathematics or work on assignments.

Enjoyment of Mathematics

1. When I have to do math homework, I do it with some joy.
2. If given the opportunity, I would choose elective courses related to mathematics.
3. The subject taught in mathematics classes is very interesting.
4. Mathematics is one of the most boring subjects.
5. I like mathematics.
6. Studying mathematics is dead boring.
7. I feel comfortable doing math problems
8. Doing math is easy for me.

Perceived Mathematics Achievement

1. My friends think that I am successful at Math.
2. I see myself as a successful student in Math.
3. I think I am a good student in Math.
4. I am sure I will be successful in math class.
5. According to my friends, I am a successful student in mathematic.
6. I am sure that my teachers found me successful in math class.

Mokinių matematinės nuostatos: pritaikymas ir validumas Indonezijoje

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Santrauka

Esamos matematikos nuostatų vertinimo priemonės yra per ilgos, pasenusios arba pagrįstos tik vakarietiškomis imtimis. Tuo tikslu buvo parengtas ir patvirtintas specialiai Indonezijai skirtas vidurinio ugdymo matematikos nuostatų vertinimo klausimyno variantas (angl. *ATMSE*). Klausimynas matuoja keturias subskales: matematinę savivoką, matematikos vertę, pasitenkinimą matematika ir įgytus matematikos pasiekimus. Tyrime dalyvavo 502 dalyviai iš Indonezijos vidurinių mokyklų.

Keturių faktorių struktūros modelio validumas buvo įvertintas taikant patvirtinamąją faktorinę analizę. Kronbacho alfa ir omega koeficientai patvirtino veiksnių nuoseklumą, o konvergentinis ir diskriminantinis validumas nustatė reikšmingus ryšius tarp jų. Klausimynas yra tinkamas instrumentas mokinių matematinėms nuostatoms (angl. *ATM*) Indonezijoje vertinti. Nustatyta, kad klausimyne yra svarbiausių konstruktų, leidžiančių įvertinti mokinių vidurinio ugdymo matematines nuostatas. Tyrimas reikšmingas tuo, kad pateikta empirinių įrodymų, patvirtinančių Bloom taksonomijos teorijos pritaikymą mokinių mokymo perspektyvumui realizuoti ir galimybę savianalizės skalei sukurti, norint vertinti vidurinių mokyklų mokinių matematines nuostatas Indonezijoje. Be to, buvo naudota Rasch analizė ir Mplus, o tai leido naujai pažvelgti į vidurinio ugdymo mokinių matematines nuostatas.

Esminiai žodžiai: *matematinės nuostatos, patvirtinamoji faktorinė analizė, vidurinės mokyklos mokiniai.*

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