Attitudes Towards Mathematics: Confirmatory Factor Analysis for an Arabic Version of the Short Measurement Instrument

Essa A. Alibraheim,

Imam Abdulrahman Bin Faisal University, Saudi Arabia, 22-26/1/2021,
ealibraheim@iau.edu.sa

Abstract

The purpose of this study was to adapt and assess the psychometric properties of an Arabic translation of the shortened version of the Fennema-Sherman Mathematics Attitudes Scales (aFSMAS) in terms of evidence of reliability and validity of scores. The aFSMAS was administered to 157 university students in Saudi Arabia. The results of a confirmatory factor analysis supported the four-factor correlated structure, which was chosen from the original instrument, based on several fit indices. Thus, the findings of this study provided evidence that confirmed the good psychometric properties of the aFSMAS. The present study provides a scale that is valid and reliable to measure the attitudes toward mathematics suitably for Saudis and Saudi culture. The scale may be a helpful tool for teachers and school counselors interested in determining individuals who may have low mathematics performance and achievement because of their attitudes.

Keywords: Fennema-Sherman Mathematics Attitudes Scales, Attitudes toward mathematics, Confirmatory factor analysis, Saudi Arabia

Introduction

There is growing recognition in educational research about the impact of affective factors on mathematics education (Abdul Majeed et al., 2013; Di Martino & Zan, 2011; Liau et al., 2007). MacLeod (1992) divides the affective domain in mathematics education into three parts: emotion, beliefs, and attitudes. Clarkson et al. (2010) agree with the view of Leder and Grootenboer (2005) that attitudes are less stable than beliefs but more stable than emotions, which means that attitudes are in the middle area between beliefs and emotions. Majeed et al. (2013) believe that studying attitudes is important because these make the focal point for research on the factors that affect students' mathematics education. Way and Relich (1993) claim that attitudes can be measured as being either negative or positive. Most studies confirm that the attitudes of students affect their academic performance and achievement in mathematics (Huang, 2011; Mohamed & Waheed, 2011; Nahari, 2014). Students with positive attitudes toward mathematics earn higher scores in the tests than their peers with negative attitudes (Else-Quest et al., 2010; Hemmings & Kay, 2010). As a result, studying the influence of students' attitudes toward mathematics has become a popular topic in educational studies and research in the past five decades. Many researchers have developed instruments that help measure attitudes and identify the factors that cause them (Chapman, 2003; Malik, 2018; Tapia & Marsh, 2004).

However, the term *attitude* is still vague, as there is no precise or clear definition of this term in educational research. Abdul Majeed et al. (2013) mention that in 1969 Neil defined the mathematical attitude as a belief of the individual that mathematics is good or bad, the tendency of the individual to participate or not to participate in mathematical activities, and the awareness of the individual of the usefulness or uselessness of mathematics. Haladyna et al. (1983) describe the attitude toward mathematics as the positive and negative emotions of the individual towards mathematics. In contrast, Palacios et al. (2014) distinguish between attitudes toward mathematics and mathematical attitudes. Attitudes toward mathematics tend to the emotional side, whereby individuals assess mathematics and the extent of enjoyment of the subject. The mathematical attitudes, however, tend to the cognitive side, as individuals use mental mathematical abilities such as reflective thinking and mental openness. The difference between the definitions used in previous studies illustrates the discrepancy in the theoretical backgrounds of the studies. Also, most of the definitions are based on the different instruments that were used to measure attitudes. Researchers assert that previous studies were focused on developing instruments to measure the attitudes, and so, did not focus on the theoretical framework of the concept (Aljodeh, 2016; Malik, 2018; Palacios et al., 2014). Furthermore, most of the widely used instruments, which measure the attitudes of students toward mathematics, originally proceeded from the Western countries that use English language as the medium of instruction. Therefore, those instruments need to be adapted in order to apply them to other cultural contexts. Accordingly, the current study seeks to develop a theoretical base by verifying the validity and reliability of an Arabic translation of the shortened version of Fennema-Sherman Mathematics Attitude Scales (aFSMAS).

Theoretical Framework

This study is based on the Fennema's theory. The term Fennema's Theory began to appear in the educational research when the researches used the Fennema-Sherman scales (Tapia & Marsh, 2004). Fennema and Sherman (1976) identify nine variables that form students' attitudes toward mathematics. Those variables related to students' learning of mathematics and also the impact of their election of mathematics courses. The nine variables pivoted on attitude towards success in mathematics, mathematics as a male domain, the mother and father variables, the teacher variable, confidence in learning mathematics, mathematics anxiety, effectance motivation, and usefulness of mathematics.

As mentioned above, this study is focused only on the four variables of the Fennema-Sherman scales that are related to the students learning, namely confidence in learning mathematics, mathematics anxiety, effectance motivation in mathematics, and usefulness of mathematics. Fennema and Sherman (1976) define the scales that measure those four variables as follows:

- Confidence in Learning Mathematics Scale is used to measure students' self-confidence to learn and solve mathematical tasks during the class or in the exam.
- Mathematics Anxiety Scale is used to measure students' feelings of fear, confusion, and nervousness during learning mathematics, as well as during tests.
- Effectance Motivation Scale in Mathematics is used to measure the level of students' willingness to participate in mathematics problems and the extent of their joy during the process of solving those problems.
- Mathematics Usefulness Scale is used to measure how students perceive the benefits of mathematics in their daily lives and in their future careers.

The Fennema-Sherman Mathematics Attitudes Scales (FSMAS

The FSMAS (1976) can be regarded as the most common instrument to measure students' attitudes toward mathematics in the educational research (Alibraheim, 2020; Huang & Lin, 2015; Palacios et al., 2014). The instrument was originally developed to study the differences between male and female high school students in their attitudes toward mathematics (Fennema & Sherman, 1976). Then, it was modified for application in various stages from primary through university levels and has even been translated to different languages (Afari, 2013; Palacios et al, 2014). The instrument is made up of 108 items that attempt to assess nine aspects of the attitudes: attitude toward success in mathematics, mathematics as a male field, mother's mathematics attitude, father's mathematics attitude, teacher's mathematics attitude, confidence in learning mathematics, mathematics anxiety, effectance motivation in mathematics, and mathematics usefulness. The instrument can be used individually, as a whole instrument, or in groups using two or more scales, to measure the attitude toward mathematics (Afari, 2013; Fennema & Sherman, 1976).

Although the FSMAS has been widely used in educational research, many researchers have criticized it. First, the instrument is very long and takes about 45 minutes to complete the survey (Huang & Lin, 2015; Malik, 2018). Naturally, then, four out of nine scales of the FSMAS were used in this paper to investigate the psychometric properties of the aFSMAS. These four scales are most relevant to student learning, as they focus on confidence in learning mathematics, mathematics anxiety, effectance motivation in mathematics, and usefulness of mathematics (Abdul Majeed et al., 2013; Adediwura, 2011). Second, some names of the scales in the FSMAS may need to be renamed because they do not reflect the basic concept of the scale (Adediwura, 2011; Huang & Lin, 2015). Hence, two of the four scales were renamed in this paper depending on the suggestions of Adediwura (2011). These are "Interest and Commitment to Mathematics" instead of "Effectance Motivation in Mathematics" and "Perceived Value of Mathematics" instead of "Usefulness of Mathematics". Finally, a number of researchers claim that the FSMAS is questionable and might not be valid to measure attitudes of students toward mathematics (Lim & Chapman, 2013; Malik, 2018). Nevertheless, in 1976, Fennema and Sherman published split-half reliabilities of the whole scale ranging from .86 to .93. By the same token, in 1998, Mulhern and Rae published the reliability score of the scale ranging from .83 to .96. In this course, it is worth noting too that Vazeau et al. (1998) found strong support for the validity and reliability of a French version of the FSMAS by reporting the score of an internal consistency reliability ranging from .83 to .96. In 2019, Alibraheim and Fowler published the reliability score of the shortened version of the FSMAS ranging from .72 to .96. Furthermore, the present study may add evidence to support the validity and reliability of the FSMAS by investigating the psychometric properties of an Arabic translation of the shortened version of the Fennema-Sherman Mathematics Attitudes Scales (aFSMAS).

Purpose and Research Objectives

It is especially important to adapt and develop scales to measure attitudes toward mathematics for educational purposes. According to Ma and Kishor (1997), there is an necessary argument that has to be raised up in order to improve the measurement instruments. Therefore, the purpose of the present paper is to study the psychometric properties of the aFSMAS for a university population in Saudi Arabia context.

According to Hogan et al. (2000), reliability is a prerequisite for validating instrumentations. Thus, testing the reliability of the four scales is one goal of this study. In this context, it is important to note that Cronbach's alpha (α) coefficients are often calculated to check internal consistency of the instruments (Majeed et al., 2013).

There are many researchers who suspect that the elements of the FSMAS measure 9 different factors. Some of them suggested reducing the FSMAS to 6 scales, and some recommended combining some scales (Mulhern & Rae, 1998). Furthermore, several studies that attempted to validate the validity of the FSMAS used Exploratory Factor Analysis (EFA) (Liau et al., 2007). Thompson and Daniel (1996) criticized the EFA approach because it focuses on statistics and neglects the theory that determines the structure of an instrument. As such, one aim of this study is to test the factor structure of the aFSMAS and ensure whether the aFSMAS measures four different factors, still keeping on mind that factor structure of the FSMAS is still not an assessment (Bai et al., 2009). According to Gorusch (1983), Confirmatory Factor Analysis (CFA) is often used to investigate a specific hypothesized factor structure based on theoretical evidence.

Based on the conflicting results in the study of gender differences among students' attitudes toward mathematics (Middleton et al., 2013; Huang, 2011; Alibraheim & Fowler, 2019), one of the goals of this study is also to test the differentiation between gender groups.

In summary, the research objectives that guided the current study are (1) testing internal consistency reliability, (2) examining factor structure, (3) calculating item-total correlations, and (4) testing discriminant validity.

Method

Participants

The participants in the study were 157 undergraduate students from Imam Abdulrahman Bin Faisal University (IAU) in the East of Saudi Arabia. Participants completed the survey as part of a voluntary activity (male, n = 101, 64.3%; female, n = 56, 35.7%). All participants were above 18 years of age and enrolled as freshmen students in the engineering program during the Fall Term of the Academic Year 2018.

The reason this study was conducted with undergraduate students of the engineering program is that most studies that measured students' attitudes toward mathematics were focused on elementary, middle and high school levels (Tahir & Abu Bakar, 2009). Therefore, this study aimed to test and adapt a scale that measures students' attitudes at the university level. Moreover, IAU engineering students usually face challenges in mathematics courses, with most of them getting low grades in mathematics exams (Alibraheim, 2019). As mentioned above, several studies confirm the influence of students' attitudes on their academic achievement in mathematics (Goodykoontz, 2008; Huang, 2011; Nahari, 2014).

Thus, IAU engineering students were chosen to be the subjects of this study.

Instrumentation

The aFSMAS is a 48-item Arabic translation version of the Fennema-Sherman Mathematics Attitudes Scales (Fennema & Sherman, 1976). This instrument measures attitudes toward mathematics by presenting 48 situations grouped into four scales: confidence in learning mathematics, mathematics anxiety, interest and commitment to mathematics, and perceived value of mathematics. Items are answered on a five-point Likert format with a mix of positive and negative statements. Each scale in the aFSMAS includes twelve statements, six positive and six negative. The possible total score of each scale in the aFSMAS ranges between 12 and 60.

In the current study, three modifications were applied to the original instrument. Two changes occurred on the scale titles; the scale “Effectance Motivation” was renamed as “Interest and Commitment to Mathematics” and “Usefulness of Mathematics” as “Perceived Value of Mathematics”. The final modification was applied to the Usefulness of Mathematics Scale, which changed the word “school” to “university” in item 12. Such modifications have better accommodated the instrument to university students. Sample items of the aFSMAS are provided in Table 1.

Table 1: *Sample Items of the aFSMAS*

Scale	Sample Item
1. Confidence in Learning Mathematics (Confidence)	I feel confident trying math.
2. Mathematics Anxiety (Anxiety)	Math does not scare me at all.
3. Interest and Commitment to Mathematics (Interest)	Math is enjoyable to me.
4. Perceived Value of Mathematics (Value)	I’ll need math for my career.

Source: Fennema and Sherman (1976)

Translation

The original instrument was developed in English. Because all the participants in the present study spoke Arabic, the instrument was translated into Arabic to make sure that all participants were able to understand the statements. First, a professional translator from Saudi Arabia translated each statement in the instrument into Arabic. Then, another expert translated a back-translation of the Arabic form into English. Finally, the two versions, the original English instrument and the back-translated instrument, were sent to a third professional translator, who was expert in both languages and not involved in the two translations. The expert recommended minor changes regarding the clarity and language level. All recommendations and suggestions were taken into consideration after evaluating all the statements in order to ensure the appropriateness of the objectives of the study.

Results

Descriptive Statistics

Table 2 provides the descriptive statistics for data and total scores. The minimum possible mean score of each scale in the aFEMAS is 12, and the maximum possible mean score is 60. Participants with higher mean scores are considered to have more positive attitudes, and participants with lower scores are considered to have more negative attitudes toward mathematics. In the current study, the *value* (*M* = 51.15, *SD* = 7.604) gained the highest score, followed by the *confidence* (*M* = 45.32, *SD* = 8.49), the *interest* (*M* = 43.08, *SD* = 7.586), and *anxiety* (*M* = 39.92, *SD* = 10.223), the latter having received the lowest scores. The results of the aFSMAS showed that the university students who participated in this study had more positive attitudes toward mathematics.

Table 2: *The Descriptive Statistics of Scales*

Scale	n	Mean	SD	Min	Max
Confidence	157	45.32	8.49	22	60
Anxiety	157	39.92	10.223	14	60
Interest	157	51.15	7.586	28	60
Value	157	43.08	7.604	21	60

Internal Consistency Reliability

As provided in Table 3, Cronbach's α coefficients for the four scales of the aFSMAS were estimated to assess the reliability using SPSS version 25.0. The aFSMAS obtained a very high Cronbach's α score (0.96). The Cronbach's α of each scale was 0.93 for *confidence*, 0.93 for *anxiety*, 0.92 for *value*, and 0.86 for *interest*. Thus, the instrument was reliable because all the scores of Cronbach's α were larger than the criterion value of > 0.80 (Gall, Gall, & Borg, 2007).

Table 3: *Internal Consistency of the Scales of the aFSMAS*

Scale	Cronbach's α
1. Confidence in Learning Mathematics (Confidence)	0.93
2. Mathematics Anxiety (Anxiety)	0.93
3. Interest and Commitment to Mathematics (Interest)	0.86
4. Perceived Value of Mathematics (Value)	0.92
Total	0.96

Confirmatory Factor Analysis

Because the four scales of the aFSMAS were highly correlated as seen in Table 4, a confirmatory factor analysis was used to test the theoretical model of this study, which consisted of four related factors: *Confidence*, *Anxiety*, *Interest*, and *Value*.

Table 4: *Correlations among aFSMAS Scales*

	Anxiety	Interest	Value
Confidence	.768**	.698**	.376**
Anxiety		.668**	.371**
Interest			.414**

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

To conduct a confirmatory factor analysis, the AMOS version 26.0 was used to analyze the students' responses. Table 5 provided the ten indices that are commonly used to examine the model fit, which are Chi-square (χ^2), chi-square with degrees of freedom (χ^2/df), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), incremental fit index (IFI), normed fit index (NFI), Tucker-Lewis index (TLI), root mean squared residual (RMR), and root mean square error of approximation (RMSEA). The value of indices GFI, AGFI, CFI, IFI, NFI and TLI range from 0 (zero) to 1 (one). The model fit indicates a very good fit when the values of these indices are closer to 1 (Arbuckle, 2009; Hair, Black, Babin, & Anderson, 2010). When the value of the RMR is equal or less than 0.08, the model fit indicates a good fit (Hu & Bentler, 1998). Also, the model fit indicates a good fit when the value of RMSEA is less than 0.08 (Hu & Bentler, 1998). Because the chi-squared statistic (χ^2) is greatly affected by the sample size (Byrne, 2010), the χ^2/df ratio is usually used, and the value of the ration should be less than 5 for an acceptable model fit, less than 3 for a good fit, and less than 2 for an excellent fit (Bentler, 2006).

Table 5: *Initial Goodness of fit indices for the model of aFSMAS*

Fit indices	Fit indices' name	Value
χ^2	Chi-squared statistic	2051.698
df	Degrees of freedom	1072
χ^2/df	Chi-square with degrees of freedom	1.914
GFI	Goodness of fit index	.656
AGFI	Adjusted goodness of fit index	.623
CFI	Comparative fit index	.816
IFI	Incremental fit index	.818
NFI	Normed fit index	.682
TLI	Tucker-Lewis index	.806
RMR	Root mean squared residual	.078
RMSEA	Root mean square error of approximation	.077

Table 5 emphasizes that the initial fit indices obtained for the model of aFSMAS are appropriate according to literature (Arbuckle, 2009; Hair et al., 2010; Hu & Bentler, 1998; Bentler, 2006).

Figure 1 presents the relations between observed variables and latent variables of the measurement model of aFSMAS. Boxes in Figure 1 symbolize the observed variables, and the ellipses symbolize the latent variables. The four factors for the aFSMAS were in good correlation, ranging from 0.35 to 0.84. The correlations were similar to the value of correlations in Table 3. Also, the software in Figure 1 indicated that there were four items with two correlated errors, which may have appeared because of similar phrasings (Byrne, 2010). In this study, items C2 and C4 had similar content; both items were formulated positively to describe the confidence in one's ability to learn mathematics. Thus, the answers of item C2 may have affected the answers of item C4 and vice versa. As in the case of A4 and A5, both items formulated positively to describe the feelings of anxiety during mathematics tests. These four items with correlated errors may be reviewed with item content retained.

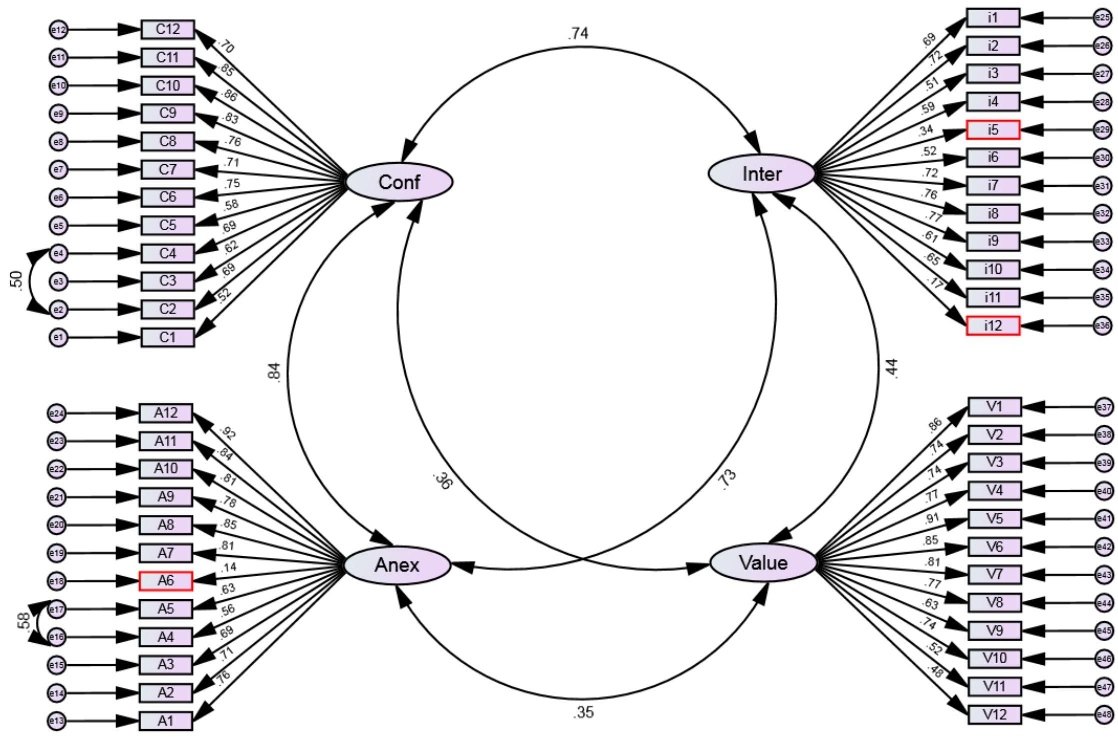

Figure 1. Factor Correlated Model for aFSMAS.

The job of factor loadings is to give evidence of the extent to which items of the model relate to the underlying latent factors. According to Hair et al. (2010), 0.40 is the minimally acceptable value of the factor loadings for the items. As shown in Figure 1, the factor loadings of the current study ranged from 0.48 to 0.92, except items A6 (0.14), i5 (0.34), and i12 (0.17).

According to Lim and Chapman (2013), the model could be improved by removing the items with low values of factor loadings. Before deleting the low value items, the researcher rechecked the item wording for both languages, English and Arabic; however, there were no comments about the changes during the translation process. Therefore, The low value items, A6, i5, and i12, were removed to improve the model aFSMAS. The goodness of fit indices for aFSMAS was recalculated, and the results showed the improvements in the fit indices as provided in Table 6. Also, the relations between observed variables and latent variables of the final measurement model of aFSMAS ranged from 0.48 to 0.92 for factor loadings and from 0.35 to 0.84 for the four factor correlations. Therefore, the results confirm the discriminant validity of the model aFSMAS among the four underlying latent factors.

Table 6: *Goodness of fit indices for the revised model of aFSMAS*

Fit indices	Fit indices' name	Value
χ^2	Chi-squared statistic	1787.873
df	Degrees of freedom	937
χ^2/df	Chi-square with degrees of freedom	1.908
GFI	Goodness of fit index	.672
AGFI	Adjusted goodness of fit index	.638
CFI	Comparative fit index	.835
IFI	Incremental fit index	.837
NFI	Normed fit index	.710
TLI	Tucker-Lewis index	.826
RMR	Root mean squared residual	.077
RMSEA	Root mean square error of approximation	.076

Additionally, internal consistency of the final aFSMAS, which includes 45 items, was assessed through recalculating the Cronbach's coefficient (α) of each dimension. The reliability analysis showed clear improvement of internal consistency of the aFSMAS after eliminating the items with low values of factor loadings. The Cronbach's α of each scale is as follows: *confidence* (0.93), *anxiety* (0.94), *value* (0.93), and *interest* (0.88). The reliability scores of the aFSMAS were very good based on Gall et al.'s criterion (Gall et al., 2007). Hence, the results referenced that the items of the aFSMAS were internally consistent in representing the corresponding factors.

Differentiation Between Groups

After preparation of the final model of the aFSMAS, a gender group was defined to assess the ability of the aFSMAS to differentiate between groups. Independent sample t-test was used to compare the gender scores on the four scales of the aFSMAS. All the assumptions underlying the usual independent sample t-test were satisfied. Table 7 provides the mean scores and standard deviations of the aFSMAS scores by gender. Female students showed higher levels of attitudes toward mathematics than males, a result that aligns with previous studies (Eng et al., 2010; Huang, 2011). The statistically significant differences were found in *confidence* (t (155) = – 3.595, p = .000), *anxiety* (t (155) = – 2.313, p = .023) and *interest* (t (155) = – 3.833, p = .000). In other words, compared to male students, females showed higher levels of self-confidence, and interest and commitment in mathematics; also, females showed lower levels of anxiety. Furthermore, the mean scores of the *value* did not show any statistically significant differences between genders (t (155) = – 1.851, p = .067). However, female students (M = 52.61) still had higher mean scores than males (M = 50.35).

Table 7: *Results of 2- tailed t-test between university students' attitudes toward mathematics*

Variables	n		Mean		Std. Deviation		t	df	p
	Male	Female	Male	Female	Male	Female			
Confidence	101	56	43.53	48.54	7.939	8.570	-3.595	155	.000**
Anxiety	101	56	34.44	38.32	9.721	10.278	-2.313	155	.023*
Interest	101	56	34.71	39.13	6.282	7.234	-3.833	155	.000**
Value	101	56	50.35	52.61	7.772	7.075	-1.851	155	.067

Note. * $p < .05$, ** $p < .001$.

Discussion

The main goal of this study was to examine the psychometric properties of an Arabic translation of the shortened version of the Fennema-Sherman Mathematics Attitudes Scales (aFSMAS) in a Saudi Arabia context. The subject of attitudes toward mathematics has become increasingly significant in educational settings because of its ramification on academic performance and achievement in mathematics. Thus, the researcher found it necessary to develop Arabic test for measuring this construct and decided to adapt the aFSMAS (Fennema & Sherman, 1976) into Arabic because this scale has been commonly used in educational research, as its internal consistency reliability have been demonstrated. Furthermore, the aFSMAS includes four subscales that can be used individually to measure each variable separately or as a whole instrument, options that are not present in other attitude tests.

Four latent factors of the aFSMAS were chosen as a first-order factor model: these are confidence in learning mathematics, mathematics anxiety, interest and commitment to mathematics, and perceived value of mathematics. Goodness of fit indices for the model aFSMAS was calculated, and further improvements were made after testing standardized factor loadings. The last version of aFSMAS yielded a better model fit after three original items were removed, and other four items showed two correlated errors. The measures of the Arabic version of the aFSMAS showed excellent internal consistency reliability for the four scales. The Cronbach's alpha ranged from 0.88 to 0.94, and for the total instrument, the Cronbach's alpha was 0.96, which is considered an excellent value (Nunnally, 1978). The values of the Cronbach's alpha for aFSMAS are close to the values reported by Fennema and Sherman (1976) in the original test. Moreover, the four latent factors for the aFSMAS were not statistically isomorphic because the inter-factor correlation scores were positive and ranged from 0.35 to 0.84. Thus, the four domains in the aFSMAS (confidence in learning mathematics, mathematics anxiety, interest and commitment to mathematics, and perceived value of mathematics) were also evident in the Arabic version. Confirmatory factor analysis provided evidence of the stability of the measures of the Arabic translation of the aFSMAS.

Also, discriminant validity evidence was tested, and the findings were not consistent with most prior researches in which female students had fewer positive attitudes toward mathematics than males (Asante, 2012; Gunderson et al., 2012; Hoang, 2008; Middleton et al., 2013). The current study found that female students scored higher on attitudes toward mathematics than male students.

Therefore, based on the previous reliability and validity evidence, the 45-item aFSMAS proves to be a suitable instrument for assessing university students' attitudes toward mathematics. The results of this study largely supported the validity and the reliability of the Arabic translation of the shortened version of the Fennema-Sherman Mathematics Attitudes Scales (aFSMAS). Also, the developed scale (aFSMAS) is easy to administer and takes a short time to complete compared to the original instrument (FSMAS).

Conclusion

The results discussed here illustrate that attitudes toward mathematics can be validly and reliably measured by the proposed Arabic version of the aFSMAS. Also, internal consistency and discriminant validity were clear for the four scales and the overall aFSMAS instruments. Therefore, this study provides an Arabic translated instrument for measuring attitudes toward mathematics for university students in Saudi Arabia. That can be a helpful tool for parents, teachers, and school counselors who are interested in scrutinizing students who may have low mathematics performance and achievement because of their attitudes. In addition, this study can be helpful to other researchers who are interested in investigating the cognitive consequences of attitudes toward mathematics. Even though the results of the study are promising, the researcher suggests conducting more research, such as weekly test-retest reliability on the Arabic version to provide extra evidence of the stability of the measures of the aFSMAS.

Limitations

Although the results of the validity and reliability scores of the aFSMAS indicate that it is valid for use in Saudi Arabia context, the findings of this study should be used with caution and not be generalized because the sample was applied to one out of 43 universities in Saudi Arabia. This study encourages conducting more research on the Arabic translation of the shortened version of the Fennema-Sherman Mathematics Attitudes Scales (aFSMAS) and its application in other parts of Saudi Arabia and in different Arab countries to provide extra evidence of the stability of the measures of this scale and to be able to generalize its results.

The second limitation is that this study compared only the students' mean scores with general mean scores of the aFSMAS, which is 24, to determine students' attitudes toward mathematics. Naturally, this way is not a sufficient method to sustain the claim that the participants of this study had more positive attitudes towards mathematics. More evidence is needed to support this finding, then.

References

Abdul Majeed, A., Darmawan, G., & Lynch, P. (2013). A confirmatory factor analysis of attitudes toward mathematics inventory (ATMI). *The Mathematics Educator, 15*(1), 121-135. http://math.nie.edu.sg/ame/matheduc/journal/v15_1/v15_7.aspx

Adediwura, A. (2011). The development and confirmatory factor analysis of a scale for the measurement of gifted students attitude towards mathematics. *World Journal of Education, 1*(1), 52-62. https://doi.org/10.5430/wje.v1n1p52

Afari, E. (2013). Examining the factorial validity of the attitudes towards mathematics inventory (ATMI) in the united arab emirates: confirmatory factor analysis. *International Review of Contemporary Learning Research, 2*(1), 15-29. http://dx.doi.org/10.12785/IRCLR/020102

Alibraheim, E. (2019). *Demographic factors affecting freshman engineering students' attitudes toward mathematics at a university in saudi arabia*. [Unpublished Doctoral dissertation]. Florida Institute of Technology.

Alibraheim, E. (2020). Investigating the attitudes toward mathematics for the saudi scholarship students in the united states. *The International Journal of Science, Mathematics and Technology Learning*, *27*(2), 57-65. https://doi.org/10.18848/2327-7971/CGP/v27i02/35-50

Alibraheim, E., & Fowler, S. (2019). Examining the gender differences among saudi scholarship students' attitudes toward mathematics in the united states. *The International Journal of Humanities Education, 17*(2), 57-65. https://doi.org/10.18848/2327-0063/CGP/v17i02/57-65

Aljodeh, M. (2016). Confirmatory factor analysis for mathematics attitude scale. *Humanities Journal*, *30*(7), 1433-1452. https://hdl.handle.net/20.500.11888/3030

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

Asante, K. (2012). Secondary students' attitudes towards mathematics. *Ife Psychologia*, *20*(1), 121-133. https://www.ajol.info/index.php/ifep/article/view/74705

Bai, H., Wang, L. S., Pan, W., & Frey, M. (2009). Measuring mathematics anxiety: Psychometric analysis of a bidimensional affective scale. *Journal of Instructional Psychology, 36*, 185-193.

Bentler, P. (2006). *EQS 6 structural equations program manual*. Encino, CA: Multivariate Software, Inc.

Byrne, B. (2010). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (2nd ed.). New York: Routledge.

Clarkson, P., Bishop, A., & Seah, W. (2010). Mathematics education and student values: The cultivation of mathematical wellbeing. In T. Lovat, R. Toomey & N. Clement (Eds.). *International research handbook* *on values education and student wellbeing* (pp. 111-135). Dordrecht: Springer. https://doi.org/10.1007/978-90-481-8675-4_7

Chapman, E. (2003). Development and validation of a brief mathematics attitude scale for primary-aged students. *Journal of Educational Enquiry, 4*(2), 63-73. https://ojs.unisa.edu.au/index.php/EDEQ/article/view/524

Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: a bridge between beliefs and emotions. *ZDM: The International Journal on Mathematics Education, 43(4)*, 471-482. https://doi.org/10.1007/s11858-011-0309-6

Else-Quest, N., Hyde, J., & Linn, M. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103-127. https://doi.org/10.1037/a0018053

Eng, T. H., Li, V. L., & Julaihi, N. H. (2010). The relationships between students' underachievement in mathematics courses and influencing factors. *Procedia-Social and Behavioral Sciences, 8*, 134-141. https://doi.org/10.1016/j.sbspro.2010.12.019

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

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: An introduction*. Boston: Pearson Education.

Goodykoontz, E. N. (2008). *Factors that affect college students' attitude toward mathematics.* [Doctoral dissertation, West Virginia University]. The Research Repository @ WVU. https://researchrepository.wvu.edu/etd/2837

Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum.

Gunderson, E., Ramirez, G., Levine, S., & Beilock, S. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles, 66*(3), 153-166. https://doi.org/10.1007/s11199-011-9996-2

Hair, J., Black, W., Babin, B. & Anderson, R. (2010). *Multivariate data analysis* (7th ed.). Pearson.

Haladyna, T., Shaughnessy, J., & Shaughnessy, M. (1983). A causal analysis of attitude toward mathematics. *Journal for Research in Mathematics Education, 14*(1), 19-29. https://doi.org/10.2307/748794

Hemmings, B., & Kay, R. (2010). Prior achievement, effort, and mathematics attitude as predictors of current achievement. *Australian Educational Researcher, 37*(2), 41-58. https://doi.org/10.1007/BF03216921

Hoang, T. (2008). The effects of grade level, gender, and ethnicity on attitude and learning environment in mathematics in high school. *International Electronic Journal of Mathematics Education, 3*(1), 47-59.

https://www.iejme.com/download/the-effects-of-grade-level-gender-and-ethnicity-on-attitude-and-learning-environment-in-mathematics.pdf

Hogan, T. P., Benjamin, A., & Brezinski, K. L. (2000). Reliability methods: A note on the frequency of use of various types. *Educational and Psychological Measurement, 60*(4), 523-531. http://dx.doi.org/10.1177/00131640021970691

Hu, L., & Bentler, P. (1998). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Huang, C. (2011). Investigating the attitudes toward calculus of engineering students in taiwan. *World Transactions on Engineering and Technology Education, 9*(2), 80-85. http://www.wiete.com.au/journals/WTE%26TE/Pages/Vol.9,%20No.2%20(2011)/03-Huang-CH.pdf

Huang, Y., & Lin, S. (2015). Development and validation of an inventory for measuring student attitudes toward calculus. *Measurement and Evaluation in Counseling and Development, 48*(2) 109-123. https://doi.org/10.1177/0748175614563314

Leder, G., & Grootenboer, P. (2005). Affect and mathematics education. *Mathematics Education Research Journal, 17*(2), 1-8. https://doi.org/10.1007/BF03217413

Liau, A., Kassim, M., & Loke, M. (2007). Reliability and validity of a malay translation of the fennema-sherman mathematics attitudes scales. *The Mathematics Educator, 10*(2), 71-84. http://math.nie.edu.sg/ame/matheduc/journal/v10_2/v102_71.aspx

Lim, S., & Chapman, E. (2013). Development of a short form of the attitudes toward mathematics inventory. *Educational Studies in Mathematics, 82*(1), 145-164. https://doi.org/10.1007/s10649-012-9414-x

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: a meta-analysis. *Journal for Research in Mathematics Education, 28*(1), 26-47. https://doi.org/10.2307/749662

Majeed, A., Darmawan, G., & Lynch, P. (2013). A confirmatory factor analysis of attitudes toward mathematics inventory (ATMI). *The Mathematics Educator, 15*(1), 121-135. http://math.nie.edu.sg/ame/matheduc/journal/v15_1/v15_7.aspx

Malik, S. (2018). Subscales of undergraduates' attitudes toward mathematics: a quantitative investigation. *Journal of Mathematics Education, 11*(3), 1-32. http://educationforatoz.net/images/2018_3-1_JME_Dec--Soofia_Malik.pdf

Middleton, K., Ricks, E., Wright, P., & Grant, S. (2013). Examining the relationship between learning style preferences and attitudes toward mathematics among students in higher education. *Institute for Learning*

Styles Journal, 1, 15. https://www.semanticscholar.org/paper/Examining-the-Relationship-Between-Learning-Style-Middleton-Ricks/9fc2621173aacd5d38356860c392d3e56087eba6

Mohamed, L. & Waleed, H. (2011). Secondary students' attitude towards mathematics in a selected school of maldives. *International Journal of Humanities and Social Science, 1*(15), 277-281. http://www.ijhssnet.com/journals/Vol_1_No_15_Special_Issue_October_2011/34.pdf

Mulhern, F. & Rae, G. (1998). Development of a shortened form of the fennema-sherman mathematics attitudes scales. *Educational and Psychological Measurement, 58*(2), 295-306. https://doi.org/10.1177/0013164498058002012

Nahari, N. (2014). *Mathematical skills and attitudes of first year engineering students.* [Unpublished Master Thesis]. Dublin City University.

Nunnally, J. (1978). *Psychometric theory* (2nd ed.). New York, NY: McGraw-Hill.

Palacios, A., Arias, V., & Arias, B. (2014). Attitudes towards mathematics: construction and validation of a measurement instrument. *Revista de Psicodidáctica, 19*(1), 67-91. https://doi.org/10.1387/RevPsicodidact.8961

Stipek, D. J., & Gralinski, J. H. (1991). Gender differences in children's achievement-related beliefs and emotional responses to success and failure in mathematics. *Journal of Educational Psychology, 83*(3), 361-371. https://doi.org/10.1037/0022-0663.83.3.361

Tahir, I., & Abu Bakar, N. (2009). Influence of demographic factors on students' beliefs in learning mathematics. *International Education Studies, 2*(3), 120-126. https://doi.org/10.5539/ies.v2n3p120

Tapia, M., & Marsh, G. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*(2), 16. https://www.semanticscholar.org/paper/An-Instrument-to-Measure-Mathematics-Attitudes-Tapia-Marsh/32ed2b764953aec7bc656267a41a28c923fc5fbf

Thompson, B., & Daniel, L. G. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement, 56*, 197-208. https://doi.org/10.1177/0013164496056002001

Vezeau, C., Chouinard, R., Bouffard, T., & Couture, N. (1998). Adaptability and validity of Fennema and Sherman's scales for measuring secondary school students' attitudes to mathematics.. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement, 30*(2), 137-140. https://doi.org/10.1037/h0085804

Way, J., & Relich, 1. (1993). Development of positive attitudes to mathematics: the perspective of pre-service teachers. Proceedings of the Sixteenth Annual Conference of the Mathematics Education Research Group of Australasia. Brisbane.