Development of Attitudes towards Mathematics Scale (ATMS) using Nigerian Data – Factor Analysis as a Determinant of Attitude Subcategories

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Abstract

This study was aimed at the development of an instrument for measuring students' attitudes towards mathematics. A survey research design was adopted involving 510 students randomly selected. Exploratory factor analysis (EFA) was carried out to determine the number of factors to be retained in the ATMS. The adequacy of the sample was confirmed by means of Bartlett's Sphericity Test (BST), the Kaiser- Meyer-Olkin (KMO) index, and the matrix determinant. The BST was significant at $p < 0.01$ with KMO index of .93 and correlation matrix determinant of 0.00006207. The factors were extracted using principal component analysis and the components were rotated using Varimax with Kaiser Normalization and converged after 10 iterations. The final 30-item ATMS contains four attitude subcategories: perception of difficulty, feelings of anxiety towards mathematics, usefulness of mathematics, mathematics phobia and has a reliability coefficient of .91 with sufficient evidence of content and face validity.

Keywords: Attitudes, Mathematics, Scale, ATMS

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Introduction

The affective domain is essentially critical in the educational development of individuals as it is enshrined in the Bloom's taxonomy of educational goals (Eryaman & Genc, 2010). The emotions and feelings of students before, during and after studying mathematics are of great concern to mathematics educators and have been investigated over the years (Dowker, Bennett, & Smith, 2012; Dursun, 2015; Haladyna, Shaughnessy, & Shaughnessy, 1983; Jenkins & Gering, 2006). The importance of students' attitudes towards mathematics cannot be overemphasized with due consideration for the number of researches related to its measurement or its correlation with students' academic achievements and performance. Despite these, concise instruments with high psychometry properties are still lacking in the literature for measuring students' attitudes towards mathematics. The available instruments are either too old, too lengthy (containing numerous items), un-directional or lacking psychometry properties which posed concerns for researchers. In addition, putting the diverse cultural heritage of Nigerian society with over 400 ethnic groups into consideration coupled with the fact that attitudes towards mathematics are influenced by societal norms (Mata, Monteiro, & Peixoto, 2012) it became paramount to develop an instrument using indigenous data for measuring students' attitudes. This study therefore, stemmed from the measurement of students' attitudes towards mathematics through the development of a concise and directional instrument with high psychometric properties, specifically item total correlation, internal consistency, reliability and validity.

Attitude can be described as "a tendency attributed to the individual and regularly constitutes his/her thoughts, feelings and behaviours related to the psychological incident" (Dursun, 2015). Researchers have made some distinctions between mathematical attitudes and attitudes towards mathematics. According to Palacios, Arias and Arias (2014), mathematical attitudes as to do with the way one utilizes general capacities that are relevant for mathematics (such as mental openness, flexibility when seeking solutions to a problem, reflective thinking), aspects which are all more closely related to cognition than to affect. Attitudes towards mathematics on the other hand, refer to the valuation, the appraisal, and the enjoyment of mathematics which underline the affective domain more than the cognitive one. There have been diverse views among researchers in relation to attitudes of students towards mathematics. Some studies had been reported on the relationship between attitudes, achievements and performance (Chagwiza, Mutambara, Tatira, & Nyaumwe, 2013; Michelli, 2013) while others have been reported on its measurement (AbdulMajeed, Darmawan, & Lynch, 2013; Afari, 2013). This article was directed at contributing to the discussion on the development of instruments for measuring students' attitudes towards mathematics.

Students' attitudes towards mathematics have been correlated with mathematics achievements and performance and found to be an important predictive factor of achievement in mathematics (Chagwiza et al., 2013). Attitudes of students towards mathematics could be positive or negative which are constant unchangeable beliefs acquired due to the experiences of the students (Sirmaci, 2010). Sirmaci (2010) investigated the correlation between attitudes and learning styles of 190 ninth year high school students in Erzurum, Turkey and found that there was a significant positive relationship between students' attitudes towards mathematics and their learning styles. Some other researchers have investigated teachers' and students' attitudes and their combined effects on academic performance of students. Their findings revealed that teachers' positive attitudes radiated confidence in students which made them develop positive attitudes towards the learning of Mathematics (Kalder & Lesik, 2011; Mensah, Okyere, & Kuranchie, 2013; Standslause, Maito, & Ochiel, 2013). Attitudes towards mathematics have also been investigated from gender perspectives. Adebule and Aborisade (2014) reported an empirical study on the gender comparison of 600 secondary school students' attitudes towards mathematics and found that attitudes did not depend on gender. This was in support of the findings of Mohamed and Waheed (2011) that had earlier reported no significant gender difference in the attitudes towards mathematics of secondary school students. Evidences abound in the literature on the impacts of attitudes on students' academic performance in mathematics. Therefore, development of a well-structured instrument for measuring these attitudes will go a long way in understanding the underlying constructs of students' attitudes.

Several attempts have been made by mathematics educators and educational psychologists alike to develop measuring instruments of students' attitudes towards mathematics at all levels. The historical mathematics attitude instrument of Alken in 1974 and Fennema-Sherman mathematics attitudes scales developed by Fennema and Sherman in 1976 have been described as the pioneers and most popular instruments for measuring students' attitudes towards mathematics in the literature (Palacios et al., 2014). The 40-item opinionnaire of Alken was made of 12 items on enjoyment of mathematics, 11 items on value of mathematics and 17 items on interests, achievement, and other biographical information. The instrument was administered on 190 subjects including 100 women and 90 men, the collected data was analysed and a correlation coefficient of r = 0.95 was computed on the final 11-item enjoyment of mathematics subscale after deleting one item. The final 10-item value of mathematics subscale also had a correlation coefficient of r = 0.85 after deleting one item (Alken, 1974). The Fennema-Sherman mathematics attitudes scales on the other, was developed initially to include nine domain-specific subscales which are; attitude towards success in mathematics, mathematics as a male domain, mother/father scales, teacher scale, confidence in learning mathematics, mathematics anxiety, motivation in mathematics and usefulness of mathematics. The final scale consisted of four subscales: a confidence scale, a usefulness scale, a scale that measures mathematics as a male domain and a teacher perception scale. Each of these scales consists of 12 items. Six of them measure a positive attitude and six measure a negative attitude (Fennema & Sherman, 1976). These two historic instruments have received wide acceptance among researchers but have also been criticised for being too old, lengthy and overdue for modifications especially with regards to their psychometry properties (Chamberlin, 2010).

More recently, mathematics educators have reported developed instruments for measuring students' attitudes towards mathematics. Tapia and Marsh (2004) reported a 40 – item attitudes towards mathematics inventory (ATMI) using a total sample of 545 high school students that cut across all levels. Their initial attitudes scale was made up six factors upon application of a maximum likelihood factor analysis with a Varimax rotation the final retained factors were self-confidence, value of mathematics, enjoyment of mathematics and motivation. The instrument had a reliability coefficient alpha of 0.97 and was recommended for investigating attitudes of students towards mathematics. Several adaptations of this instrument have been reported over the years contrary to the view of Chamberlin (2010) who submitted that the instrument had not been given much attention by educators despite its high psychometry properties. For example, a validation and confirmatory factor analysis (CFA) of the ATMI was reported by AbdulMajeed, Darmawan, and Lynch (2013) involving 699 year 7 and 8 students in South Australia. Their CFA of the ATMI also gave four-factor solution of the 40-item inventory with high internal consistency and validity. In the same year, ATMI was also translated to Arabic by Afari and validated. His study involved 269 middle school students in United Arab Emirate and his CFA also yielded four-factor solution with high psychometry properties which corroborated his later study (Khine & Afari, 2014) on the same instrument. All these and many other unpublished studies are indications of wide utilizations of the ATMI among researchers.

The contribution of Tahar, Ismail, Zamani and Adnan (2010) cannot be overlooked in the development of attitudes towards mathematics scales. Their study involved 746 respondents in their first year diploma course. Exploratory factor analysis yielded five-factor solution on the final 21-item questionnaire: interest in mathematics, anxiety towards mathematics, self-efficacy, extrinsic motivation and students' self-concept. A Cronbach's alpha coefficient of .888 was also reported. Two years later, a more robust psychometric procedure validated instrument using a sample of 4,807 students of non-university students was developed by Palacios et al. The 39 – item instrument was centered around five factors: liking-enjoyment of mathematics, anxiety towards mathematics, perception of difficulty, perceived utility, and mathematical self-concept. The instrument is available in two languages Spanish and English and a contrasted evidence of validity and reliability were presented in the article. Evidence abound in the literature on the development of instrument for measuring students' attitudes towards mathematics.

However, an extensive search of the literature revealed that most of the developed instruments are either too old, lengthy or lack some psychometry properties. Besides, no of these instruments had been developed using indigenous data from this part of the world. Perhaps, some have been developed but are nowhere to be found on the internet. Researchers in this country have been dependent on adoption and adaption of foreign instruments to measure students' attitudes in their educational researches, for example see (Adebule & Aborisade, 2014). It is therefore pertinent to develop an instrument using indigenous data generated from our students and sophisticated statistics to determine the subcategories that constitute students attitudes towards mathematics. This study was aimed at filling this gap and thereby contributing to knowledge in the affective domain of mathematics as a step towards educational development of the country.

Method

Item Development

The development of items for the attitudes towards mathematics scale (ATMS) required drawing from the reviewed literature in Section 1. The initial ATMS contains 52 items including two biodata items (I) gender, (II) age in years, and 50 items on attitudes of students towards mathematics. The ATMS items on attitudes have seven subcategories: usefulness of mathematics, feelings of anxiety and mathematics phobia, liking-enjoyment of mathematics, motivation and confidence, teacher's attitude as perceived by the students, perception of difficulty and subject perceived as a male domain. The distribution of the items into these subcategories are shown in Table 1. Five point Likert – scale format was used in which respondents have to choose by ticking from SA – Strongly Agree (5), A – Agree (4), N – Neither agree nor disagree (3), D – Disagree (2) and SD – Strongly Disagree (1) and 23 items were reversed coded. The respondents were urged to complete the inventory with utmost sincerity. The content and face validity of ATMS was done by three senior lecturers in the department of science education, Ahmadu Bello university and they gave satisfactory comments and recommendations for modifications of some items.

Table 1. *Attitude Subcategory Item Distribution*

SN	Attitude subscale	Item number	Total
1	Usefulness of Mathematics	1, 8, 15, 22, 29, 36 and 43	7
2	Feelings of Anxiety and mathematics Phobia	2, 9, 16, 23, 30, 37, 44, 47, 49 and 50	10
3	Liking-Enjoyment of Mathematics	3, 10, 17, 24, 31, 38, 45 and 48	8
4	Motivation and Confidence	4, 11, 18, 25, 32 and 39	6
5	Teacher's Attitude as perceived by the students	5, 12, 19, 26, 33 and 40	6
6	Perception of difficulty	6, 13, 20, 27, 34, 41 and 46	7
7	Subject perceived as a male domain	7, 14, 21, 28, 35 and 42	6
			50

Research Design

Keeping in mind, the adaptability of the proposed design with respect to the type of study, variables under consideration, size of respondents and phenomenon to be studied, one-shot survey design was selected as an appropriate research design. According to Jansen (2010) one-shot survey involves only one empirical cycle (research question—data collection—analysis—report) in parallel to the typical case of a statistical survey. The factors (students' attitudes towards mathematics) were studied in their natural form without the researcher manipulating any of the variables. The researcher simply collected the data using the ATMS and analyzed it to provide an objective description of the phenomenon.

Participant

The sample for this study involved 510 senior secondary school II students of Sabon – Gari local government area of Kaduna state Nigeria drawn from the target population of senior secondary schools students. Five government public secondary schools in the local government were randomly selected out of eleven public schools in the area. One of the sampled schools was only girls while the remaining four schools were co-educational. These students consisted of 228 (45%) males and 279 (55%) females with an average of 17 years ranging from 12 to 25 years. Three students did not indicate their gender and so were excluded in calculating the percentage by gender.

Procedure

The ATMS was administered initially to 530 secondary school II students with the help of five research assistants. The exercise took 2 days as permissions were sought from the school principals the first day before distribution of the questionnaires the second day. The subjects completed the questionnaires before the first period in the morning and took 15 minutes to complete. Twenty questionnaires were not included in the analysis as a result of improper filling – out. The remaining 510 were analysis using statistic package for social sciences (SPSS) version 20.0 though with some missing values. The missing values of course could not affect the results as SPSS software was designed to exclude missing values in the analysis.

Results and Discussion

Evidence of reliability

In other to estimate internal consistency of the scores, Cronbach's alpha coefficient was computed. Cronbach's alpha coefficient for scores on the 50-item ATMS was .84, indicating a moderate degree of internal consistency for group analyses. Besides, only 14 out of the 50 items had item-to-total correlations above .50, the highest being .547 while the inter-item total correlations ranging from -.319 to .547. This suggested that quite a number of the items contributed less to the total scale. Hence, a necessity for item deletion. The mean and standard deviation of the total score were 159.32 and 22.36 respectively. Table 2 summarizes the 50 – item scale descriptive statistics and reliability.

Table 2. *50 – Item Scale Statistics and Reliability*

	N of Items	Mean	Variance	Std. Deviation	Cronbach's Alpha
Item	50	3.186	.300	.55	
Scale	50	159.32	499.79	22.36	0.84

An iterative item deletion process was carried out in order to increase the value of the Cronbach's alpha. Items were deleted based on their item-to-total correlation and effect on the alpha value if deleted. We were left with no option but to delete twenty items one at a time starting with the one with the lowest item-to-total correlation. After deleting these twenty items, Cronbach's alpha reached a value of .91.

The revised inventory had a mean of 86.09, a standard deviation of 22.29. Most of the 30 items had item-to-total correlation above .50, with the highest being .63. This suggested that all items contributed significantly to total scale. The test items were homogeneous, which is interpreted to mean that they tend to measure a common trait. Table 3 summarizes the 30 – item and scale descriptive statistics and reliability.

Table 3. *30 - Item and Scale Statistics*

	N of Items	Mean	Variance	Std. Deviation	Cronbach's Alpha
Item	30	2.87	.122	.35	
Scale	30	86.09	496.32	22.28	0.91

Exploratory Factor Analysis

Exploratory factor analysis (EFA) was carried out to determine the number of factors to be retained in the ATMS subcategories. Prior to the conduct of the EFA the adequacy of the input data was confirmed by means of Bartlett's sphericity test, the Kaiser- Meyer-Olkin (KMO) index, and the matrix determinant. The test was significant at $p < 0.01$ with KMO index of .93 and correlation matrix determinant of 0.00006207 which is greater than the necessary value of 0.00001 (Table 4). Hence, the data were adequate for the EFA and multicollinearity is not a problem for this data.

Table 4. *KMO and Bartlett's Test*

	Approx. Chi-Square	df	Sig.		
Bartlett's Test of Sphericity	3498.728	435	.000		
KMO index				.93	
Matrix determinant					0.00006207

Further, principal component analysis (PCA) method was used in extracting the factors to be retained. A total of six factors were identified with factor 1 explaining 29.89% of the total variance and factor 6 explaining only 3. 53% of the total variance. Table 5 described the eigenvalues associated with linear component before extraction, after extraction and after rotation of the six extracted factors.

Table 5. *Total Variance Explained*

Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cumulative %	Total	% of Var.	Cum. %
1	8.968	29.892	29.892	8.968	29.892	29.892	3.836	12.785	12.785
2	1.566	5.220	35.112	1.566	5.220	35.112	3.391	11.304	24.090
3	1.333	4.443	39.555	1.333	4.443	39.555	2.645	8.815	32.905
4	1.191	3.969	43.524	1.191	3.969	43.524	2.387	7.956	40.861
5	1.084	3.615	47.139	1.084	3.615	47.139	1.767	5.890	46.751
6	1.059	3.531	50.670	1.059	3.531	50.670	1.176	3.919	50.670
7	.991	3.303	53.973						
8	.944	3.147	57.121						
9	.914	3.048	60.168						
10	.892	2.973	63.141						
11	.859	2.863	66.003						
12	.795	2.650	68.654						
13	.786	2.619	71.273						
14	.728	2.426	73.699						
15	.690	2.301	76.000						
16	.670	2.232	78.232						
17	.627	2.092	80.324						
18	.602	2.007	82.331						
19	.583	1.945	84.276						
20	.537	1.790	86.066						
21	.511	1.702	87.768						
22	.474	1.580	89.347						
23	.469	1.562	90.909						
24	.444	1.480	92.389						
25	.433	1.444	93.834						
26	.417	1.391	95.225						
27	.390	1.300	96.525						
28	.365	1.218	97.743						
29	.343	1.142	98.885						
30	.334	1.115	100.000						

Extraction Method: Principal Component Analysis.

In order to improve the interpretability of the extracted factors both Varimax and Promax rotations were performed. The results were compared and found to have no significant difference. Therefore, Varimax rotation which converged after 10 iterations with Kaiser Normalization was reported in Table 6. The communalities of each item were also included and small coefficients less than 0.3 were surprised for convenience reading.

Table 6. *Rotated Component Matrix and Communality*

Item	Component						Communality	
	1	2	3	4	5	6	Initial	Extraction
Item_43	.689						1.000	.484
Item_45	.578						1.000	.508
Item_47	.578						1.000	.516
Item_34	.491	.425					1.000	.499
Item_36	.485		.475				1.000	.467
Item_26	.473		.452				1.000	.518
Item_44	.461	.396					1.000	.454
Item_46	.453	.316					1.000	.487
Item_30	.431	.368					1.000	.420
Item_37	.429		.379	.365			1.000	.525
Item_31	.424	.322					1.000	.460
Item_6		.690					1.000	.530
Item_9		.667					1.000	.518
Item_27		.631					1.000	.494
Item_16		.576				.308	1.000	.512
Item_23		.494					1.000	.491
Item_20	.379	.465					1.000	.466
Item_25		.366	.304	.321			1.000	.427
Item_8			.699				1.000	.588
Item_15			.644				1.000	.599
Item_22	.385		.538				1.000	.479
Item_33				.651			1.000	.573
Item_32		.311		.553			1.000	.422
Item_49	.380			.533			1.000	474
Item_40			.361	.487			1.000	.485
Item_13					.745		1.000	.620
Item_12				.363	.706		1.000	.693
Item_14	.355		.310		.458		1.000	.585
Item_29						.751	1.000	.336
Item_21						.401	1.000	.497

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 10 iterations.

An investigation into the item communality revealed that the average communality which is got by adding up all the communalities and dividing by 30 gave 0.435. Since our sample is more than 300 and the average communality is less than 0.6 the Kaiser criterion for correctly retaining the extracted factors has been violated. Hence, all the six factors with eigenvalues greater 1.0 cannot be retained. A bail out of this problem is to look at the Scree plot (Figure 1) as suggested in the literature (e.g Field, 2009).

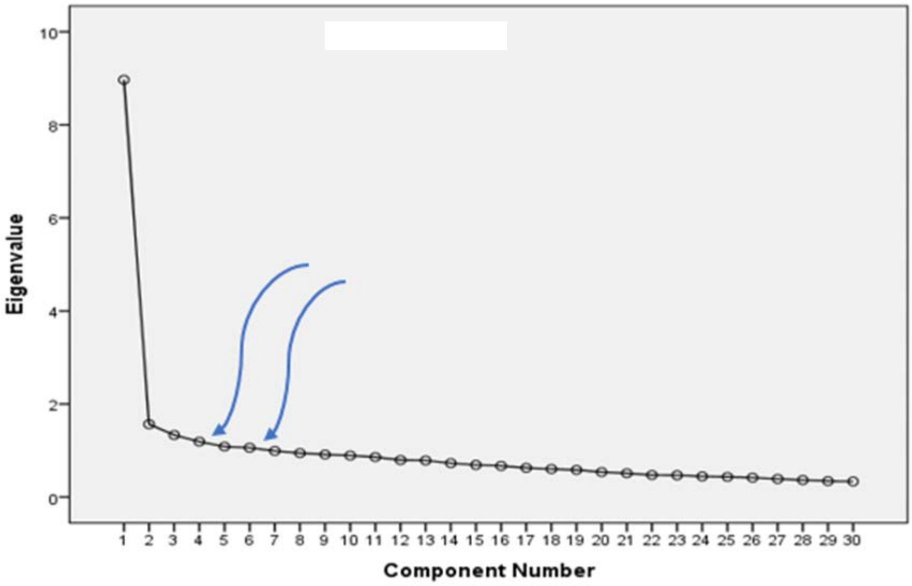

Figure 1. *Scree Plot Indicating Number of Retained Factors*

It can be read from the Figure 1 that we have two options of either retaining 4 factors or 6 factors. Due to the aforementioned low average communality and the large sample coupled with the fact that 3 items each are extracted in factors 4 and 5 and only 2 items in factor 6 the default recommendation of EFA was therefore disregarded. In sum, we have only retained factors 1, 2, 3 and factors 4, 5 and 6 were merged to be one factor which gave us four factors. These also have some implications on the nomenclatures of the ATMS subcategories. Factor 1 is now student's perception of difficulty, factor 2 – feelings of anxiety towards mathematics, factor 3 – usefulness of mathematics and factor 4 – Mathematics phobia. The distribution of these items by factors is presented in Table 7 as well as Cronbach's Alpha of the items in each factor.

Table 7. *Distribution of ATMS Items and correlations*

Factor	Attitude subcategory	Item number	Cronbach's Alpha
1	Students' perception of difficulty	6, 9, 16, 20, 23, 25, 27 and 34	.81
2	Feelings of anxiety towards mathematics	30, 31, 37, 43, 44, 45, 46 and 47	.80
3	Usefulness of Mathematics	8, 15, 22, 26, 36 and 40	.75
4	Mathematics phobia	12, 13, 14, 21, 29, 32, 33 and 49	.62

Evidence of Internal Consistency

Having retained four factors, Cronbach alpha was computed to estimate internal consistency and reliability of the scores on the subcategories of the ATMS. Factor I contains 8 items with a mean of 23.50 (SD = 7.26). Factor I is characterized by students' perception of difficulty items. The scores for these items had a Cronbach's alpha value of .81. Factor II contains 8 items with a mean of 22.87 (SD = 7.98). Factor II is characterized by feelings of anxiety towards mathematics items. These items produced a Cronbach's alpha value of .80. Factor III contains 6 items with a mean of 15.47 (SD = 5.72). Factor III is characterized by usefulness of mathematics items. The scores on these items produced a Cronbach's alpha value of .75. Factor IV contains 8 items with a mean of 24.82 (SD = 5.66). Factor IV is characterized by mathematics phobia items. The scores for these items produced a Cronbach's alpha value of .62. These data indicated high level of reliability of the scores on the subcategories. Table 8 presents sample items based on the attitude subcategories the full mathematics attitude inventory is available upon request from the corresponding author.

Table 8. *Sample Items on Final ATMS*

Factor	Sample Item
I – Students' Perception of Difficulty	1. Math is hard for me 5. Usually I have difficulty with mathematics 9. Math confuse me
II – Feelings of Anxiety towards Mathematics	6. I hate studying maths, even the easiest parts 18. I do not know how to study math 29. I'm one of those people who were not born to learn math
III – Usefulness of Mathematics	3. Taking math is a waste of time 7. Math will not be important to me in my life's work 11. Doing well in math is not important for my future
IV – Mathematics Phobia	4. I am afraid to ask questions in math class 24. When a woman has to solve a math problem, she should ask a man for help 30. It's hard to believe a female could be a genius in math

Conclusion

The importance of attitudes of students towards mathematics cannot be overemphasized with due consideration for number of researches related to its measurement or its correlation with students' academic achievement and performance. Despite the diverse disparity in the attempts to measure these attitudes, some important common points have also emerged, especially concerning the factor structure of the construct underlying attitudes towards mathematics. Palacios et al. (2014) posited that liking/enjoyment of mathematics, the value/utility of mathematics, perception of self-efficacy, and mathematical anxiety have been present in an important part of the research on this topic. This study stemmed from the measurement of students' attitudes towards mathematics through the development of an instrument with the caption "Attitudes towards Mathematics Scale". We have not only used the Nigerian data for the development of ATMS but also used some sophisticated statistics in the analysis.

A sample of 510 respondents were used which is higher than some previous researches reported on attitude (Jenkins & Gering, 2006). The adequacy of this sample was also confirmed for the EFA using KMO index and Bartlett's sphericity test that proved significant at $p < 0.01$ with .923 index. The reliability of the instrument after series of item deletions to optimize the coefficient was 0.91which can be considered superb. Even though the Cronbach's alpha is less than that reported by Tapia (2004) and Palacios et al. (2014), the discrepancy can be ascribed to the larger samples involved in both studies which are 545 and 4807 respectively.

Four factors were finally retained which constitute the four mathematics attitudes subcategories. The factors are (1) students' perception of difficulty, (2) feelings of anxiety towards mathematics, (3) usefulness of mathematics and (4) mathematics phobia. The items in factor 1 addressed perceptions of students in relation to confusion, math difficulty, low self-assessment of performance, encountered trouble in mathematics, etc. Items in factor 2 addressed students' feelings of inability to study mathematics, boredom, terrible strains in class, hatred for mathematics, etc. Items in factor 3 addressed the relevance of mathematics in students' future careers, mathematics as a waste of time, limitations of mathematics to science careers and the teachers' thoughts on the utility of mathematics. Lastly, items in factor 4 described students' lack of confidence in mathematics, fear of asking questions in mathematics class, lack of supportive teachers to instil confidence in students and mathematics as male domain discipline. These factors have been supported by what are available in the literature (Alken, 1974; Fennema & Sherman, 1976; Palacios et al., 2014; Tapia & Marsh, 2004).

Finally, a very important discovery in this study is the deletion of items that addressed positive attitudes towards mathematics due to their poor item-item total correlations. Items such as “I like Math”, “I enjoy studying Math”, “The topics taught in mathematics classes are very interesting”, etc, that addressed liking – enjoyment of mathematics were deleted. Further, items such as “I can become a good student of mathematics”, “I am good at mathematics”, “I am sure of myself when I do math”, “I know I can do well in math”, etc., that addressed motivation and self-confidence in mathematics were also deleted. A possible explanation for this phenomenon is that students over the years have developed negative attitudes towards mathematics which manifested when completing the questionnaires. Perhaps, students’ poor performance, poor methodologies of their teachers or ill treatment from their teachers could be responsible for this attitudinal change.

Recommendations

Based on the findings of this study the following were recommended:

a. The instrument ATMS is recommended for use to measure secondary school students’ attitudes towards mathematics (it is available on request from the corresponding author).
b. Mathematics educators and researchers should intensify more efforts to improve negative attitudes of students towards mathematics.
c. Mathematics educators in every other part of this country can replicate this study or improve upon it.

References

AbdulMajeed, A., Darmawan, G. N., & Lynch, P. (2013). A Confirmatory Factor Analysis of Attitudes Toward Mathematics Inventory (ATMI). *The Mathematics Educator*, *15*(1), 121–135.

Adebule, O. S., & Aborisade, J. O. (2014). Gender Comparison of Attitude of Senior Secondary School Students Towards Mathematics in Ekiti State , Nigeria. *European Scientific Journal*, *10*(19), 153–160.

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*, *29*(1), 15–29.

Alken, L. R. . (1974). Two Scales of Attitude toward Mathematics. *Journal for Research in Mathematics Education*, *5*(2), 67–71.

Chagwiza, C. J., Mutambara, L., Tatira, B., & Nyaumwe, L. J. (2013). An Analysis of Attitudes and Mathematics Achievement o f “ O ” Level Pupils : Insight from Some Bindura Urban Secondary Schools. *International Journal of Academic Research in Progressive Education and Development*, *2*(2), 223–235.

Chamberlin, S. A. (2010). A review of Instruments Created to Assess Affect in Mathematics. *Journal of Mathematics Education*, *3*(1), 167–182.

Dowker, A., Bennett, K., & Smith, L. (2012). Attitudes to Mathematics in Primary School Children. *Child Development Researach*, *2012*(1), 1–8. http://doi.org/10.1155/2012/124939

Dursun, Ş. (2015). Investigation of high school students ’ attitude and anxiety levels towards Mathematics in terms of some variables. *Educational Research and Reviews*, *10*(13), 1773–1780. http://doi.org/10.5897/ERR2015.2206

Eryaman, M. Y. & Genc, S. Z. (2010). Learning theories. In C. Kridel (Ed.). *Encyclopedia of Curriculum Studies.* Sage Publications.

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.

Field, A. P. (2009). *Discovering Statistics Using SPSS* (3rd ed., Vol. 8057). 55 City Road London EC1Y 1SP: SAGE Publication Ltd.

Haladyna, T., Shaughnessy, J., & Shaughnessy, M. J. (1983). A Causal Analysis of Attitude toward Mathematics. *Journal for Research in Mathematics Education*, *14*(1), 19–29.

Jansen, H. (2010). The Logic of Qualitative Survey Research and its Position in the Field of Social Research Methods. *Qualitative Social Research*, *11*(2), 1–43.

Jenkins, N., & Gering, N. (2006). *Factors that Influence Mathematics Attitudes Factors that Influence Mathematics Attitudes*. University of Nebraska-Lincoln.

Kalder, R. S., & Lesik, S. A. (2011). A classification of attitudes and beliefs towards mathematics for secondary mathematics pre-service teachers and elementary pre-service teachers: An exploratory study using latent class analysis. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *5*(1), 1–21.

Khine, M. S., & Afari, E. (2014). Psychometric properties of an inventory to determine the factors that affect students ' attitudes toward mathematics. *Psychology, Society, & Education*, *6*(1), 1–15.

Mata, M. D. L., Monteiro, V., & Peixoto, F. (2012). Attitudes towards Mathematics : Effects of Individual , Motivational , and Social Support Factors. *Child Development Research*, *1*(1), 1–10. http://doi.org/10.1155/2012/876028

Mensah, J. K., Okyere, M., & Kuranchie, A. (2013). Student attitude towards Mathematics and performance : Does the teacher attitude matter ? *Journal of Education and Practice*, *4*(3), 132–139.

Michelli, M. P. (2013). *The Relationship between Attitudes and Achievement in Mathematics among Fifth Grade Students*. The University of Southern Mississippi.

Mohamed, L., & Waheed, H. (2011). Secondary Students ' Att itude towards Mathematics in a Selected School of Maldives Institute of Education. *International Journal of Humanities and Social Science*, *1*(15), 277–281.

Palacios, A., Arias, V., & Arias, B. (2014). Attitudes Towards Mathematics : Construction and Validation of a Measurement Instrument. *Revista de Psicodidáctica*, *19*(1), 67–91. http://doi.org/10.1387/RevPsicodidact.8961

Sirmaci, N. (2010). The relationship between the attitudes towards mathematics and learning styles. *Procedia Social and Behavioral Sciences*, *9*(1), 644–648. http://doi.org/10.1016/j.sbspro.2010.12.211

Standslause, O. E. O., Maito, T. L., & Ochiel, J. K. O. (2013). Teachers and Students Attitude Towards Mathematics in Secondary School in Siaya County, Kenya. *Asina Journal of Management Sciences and Education*, *2*(3), 116–123.

Tahar, F. N., Ismail, Z., Zamani, D. N., & Adnan, N. (2010). Students ' Attitude Toward Mathematics : The Use of Factor Analysis in Determining the Criteria. *Procedia Social and Behavioral Sciences*, *8*(5), 476–481. http://doi.org/10.1016/j.sbspro.2010.12.065

Tapia, M., & Marsh, G. E. (2004). An Instrument to Measure Mathematics Attitudes. *Academic Exchange Quarterly*, *8*(2). Retrieved from http://www.rapidintellect.com/AEQweb/cho25344l.htm