VALIDITY AND RELIABILITY OF A SCALE FOR EVALUATING ATTITUDE TOWARDS MATHEMATICS TEACHERS IN ONDO STATE STUDENTS' POPULATION

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Abstract
This study developed and validated a scale on attitude towards Mathematics Teachers (ATMT) among secondary school students (male and female) in Ondo State, Nigeria. The attitude towards Mathematics (ATMT) Questionnaire (ATMT-Q) emerged from a review of the literature and expert consensus. The questionnaire was a subset of a larger questionnaire comprising several domains (cognitive, affective, and behavioral dimensions). Convergent and discriminatory validity was assessed in 2,424 students chosen from the population of 360,000 through stratified random sampling. Content and construct validity were determined through Principal Component Analysis (PCA) and correlation coefficients arising from convergent and discriminant validity analysis. The predictive validity of the scale was confirmed through Multiple Regression Analysis (MRA). Tests were carried out at the .05 level of significance. A principal component analysis was loaded one factor structure. Evidence for reliability of the questionnaire was good, and validity appeared

satisfactory. It was concluded that there is evidence to believe that respondents understand the majority of questions in ATMT-Q and interpret them in the intended framework.

Keywords: Attitude, Evaluation, Development, Validation, Mathematics

INTRODUCTION

In this modern world with ever-growing competition in all spheres of activity, the quality of performance has become the key factor for personal growth and progress. With the increasing relevance of Mathematics in our daily life and the need for the students to improve in their performance in this subject; It has been noted that parents of children and students now desire that their wards perform very well and achieve their very best in Mathematics which eventually has added pressure on students, teachers, schools, colleges and in general the education system as a whole. As such, priority attention has been given to the study of Mathematics to enhance students' academic achievements in the subject.

Certainly, quantitative measurement of attitude has evolved into a fairly exact process de Leeuw *et al*. (2019). Of many types of attitude measurement possible, one widely used technique that seem to possess most of the characteristics of a good measure is the agreement, or Likert-type scale. This technique involves the use of statements about the attitudes that are either clearly favourable or unfavourable on the attitude being measured, Matthew et al. (2022). Every adventure requires the right attitude to succeed. At the inception of a school career, every student desire to come out in flying colours; however, several attitudinal factors pose challenges which in most cases truncate this dream. School attitudes are all encompassing: attitude to teachers, school environment, school curriculum, science subjects, school rules and regulations, test and examination, extra-curriculum activities, self, other students, etc. The importance of school attitude cannot be over-emphasized, by measuring students' attitude, different kinds of information can be gathered which can help school management in decision making; it can also help the teachers to adjust their teaching methodologies. The result could be used to predict students' performance in core subjects such as Mathematics and other science subjects.

There exists a challenge of effectively measuring students' attitudes toward Mathematics, a subject that plays a pivotal role in education and career development. Existing tools were found to be limited in scope, often focusing on single dimensions of attitude, such as cognitive, or affective, or behavioral aspects, without offering a comprehensive framework. This lack of integration made it difficult to fully understand the multifaceted nature of students' attitudes toward Mathematics.

In response to this issue, the research aimed to construct and validate a Scale of Attitude to Mathematics (behavioral dimension). The study sought to ensure the scale's reliability and validity while evaluating its ability to capture variations in attitudes among different student populations. Through this effort, the research provided a robust, multidimensional instrument to help educators, researchers, and policymakers gain deeper insights into students' attitudes toward Mathematics

METHODS AND MATERIALS

Research Design: This study adopted a survey research design which involved the collection of data from a large number of participants. No attempt was made to manipulate any of the variables of the study but to describe them as they currently existed among the subjects of the study.

Population: The population of this study comprised 360,000 students of the 242 public senior secondary schools in Ondo State, Nigeria as at June, during the 2016/2017 academic session.

Sample and Sampling Techniques

A sample of 2,424 students was chosen from the population through stratified random sampling. The study made used of existing three senatorial districts in Ondo State, namely: Ondo Central (Akure North, Akure South, Ifedore, Idanre, Ondo West and Ondo East Local government areas); Ondo South (Odigbo, Okitipupa, Igbekebo, Ile-Oluji, Irele and Ilaje Local Government Areas); and Ondo North (Owo, Ose/Ifon, Akoko South, Akoko South West, Akoko North and Akoko North East). Simple random sampling was subsequently used to choose four (4) senior secondary schools from each stratum, which made it 12 schools for this study. In each school, 202 students of both sexes were selected also through simple random sampling. The study also used stratified random sampling to pick two schools each from the urban and rural areas of the state, with equal sample population of 202 senior secondary school students which summed up to 808 students in each district for overall total of 2,424 drawn from the three districts.

Instrumentation: Attitudes towards Mathematics Teacher (ATMT) was developed around the following: Student-teacher rapport/relationship, Communication style, Instructional style, Teachers' emotional states and personality, Teachers' attitudes toward teaching, and Teachers' attitudes toward students. After identifying the indications of the dimensions of the scale, items were subsequently formulated to describe each of the dimensions and indicators. A pool of items was initially generated. These items were formulated as a Likert-type scale with four points (1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree). A five-point scale with a neutral response option (3= Neither agree nor disagree) was not used in this study since the inclusion of a neutral response might make participants take advantage of this option to conceal their opinions.

Procedure for Data Collection: Two research assistants were recruited and trained to facilitate data collection. Together with the assistants, the researcher personally visited each selected school, explained the study's purpose, and secured permission from the school authorities and teachers.

Administration of Questionnaire: The teachers of each school assisted in administering the questionnaires to students. The students were intimated with the purpose of the scale and given verbal instructions on how to respond to each of the items. Emphasis was placed on the confidentiality of information supplied. A total of 2,424 questionnaires were administered in this first phase and same number returned.

At the second phase, the same procedure was followed. The researcher waited for the participants to complete responding to items on the questionnaires. Thereafter, the completed questionnaires were collected. A total of 2,424 questionnaires were administered but 2,163 were returned and captured for data analysis. The researcher appreciated the participants and the school authority for their cooperation.

Data Analysis: The demographic data of participants were analysed by means of descriptive statistics using frequency tables, percentages, mean, standard deviation, and number of cases. Descriptive statistics was used for the ATMT scale. Reliability analysis of the scale was undertaken by means of Cronbach's alpha to determine internal consistency and test-retest method to assess consistency over time. Content validity was carried out by presenting the ATMT to experts for vetting. Construct validity was determined through Principal Component Analysis (PCA) and correlation coefficients arising from convergent and discriminant validity analysis. Finally, the predictive validity of the scale was confirmed through Multiple Regression Analysis (MRA). Tests were carried out at the .05 level of significance. All statistical analyses were executed using the IBM SPSS software.

RESULT AND DISCUSSION

Table 1: Frequency Distribution showing Respondents' Personal Information

Factors	Options	Frequency	%
Gender	Male	1089	50.3
	Female	1074	49.7
Age	Below 13 years	94	4.3
	13 - 15 years	771	35.6
	16 - 18 years	1255	58.0
	19 - 21 years	39	1.8
	Above 21 years	4	.2
Class	SS 1	888	41.1
	SS 2	1102	50.9
	SS 3	173	8.0
	Total	2163	100.0
Subject Area	Art	686	31.7
	Commercial	289	13.4
	Science	1188	54.9
Parent's	No Formal Education	239	11.0
Educational	Secondary School	929	42.9
Attainment	NCE/ OND	251	11.6
	First Degree/ HND	393	18.2
	Higher Degrees	351	16.2
Socio-Economic	Low	295	13.6
Status	Middle	1291	59.7
	High	577	26.7
Religious Belief	Christianity	1723	79.7
	Islam	371	17.2
	Traditional	52	2.4
	Others	17	.8

The findings show that 50.3% of the sampled respondents were males, while 49.7% were females. Their age groupings reveal that 4.3% were below 13 years of age, 35.6% were within the age ranges of 13 and 15 years, 58% were within the age ranges of 16 and 18 years, 1.8% were aged within the range of 19 and 21 years, while just 0.2% were above 21 years of age. Information on the classes of the sampled students were also gotten and it was noted that 41.1% were senior secondary school (SSS) 1 students, 50.9% were SSS2 students, while 8% were SSS3 students. On the subject specification of the respondents, it was observed that 31.7% of the respondents were in arts class, 13.4% were in commercial class, while 54.9% were in science class. This means that the sampled respondents were not restricted to just science related or art related students, but rather, the research outcome could be generalized across senior secondary school students.

Further observations reveal the respondents' parents' education and it was indicated that 11% of the respondents' parents had no formal education, 42.9% had secondary school education, 11.6% attained either NCE or OND, 18.2% had either first degree or HND, while 16.2% of the respondents had parents who had higher degrees. The social-economic status of the respondents was such that

13.6% had low socio-economic status, 59.7% had moderate level, while 26.7% had high level of socio-economic status. Lastly noted was the religious belief of the respondents and it was noted that majority of them (79.7%) were Christians, 17.2% were Muslims, 2.4% were affiliated to the traditional belief system, while 0.8% were affiliated to religious outside the identified ones.

Table 2: Summary of KMO and Bartlett's Test on the Factorability of the 35-Item proposed measure for Attitude towards Mathematics Teacher

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.909
Bartlett's Test of Sphericity	Approx. Chi-Square	16165.594
	Df	595
	Sig.	.000

Table 2 indicated that the KMO measure of sampling adequacy was .909 which was above .05 recommended by Field (2000) and it is within the recommended range of 0 to 1 (Pallant, 2005). The Bartlett's test of sphericity had X^2 value of 16165.594, df of 595 and a p value that was less than 0.05 level of significant. This implied that it was significant (X^2=16165.594, df= 595, P < .001). The results therefore support the factorability of the correlation matrix, thus the principal components analysis (PCA) was conducted.

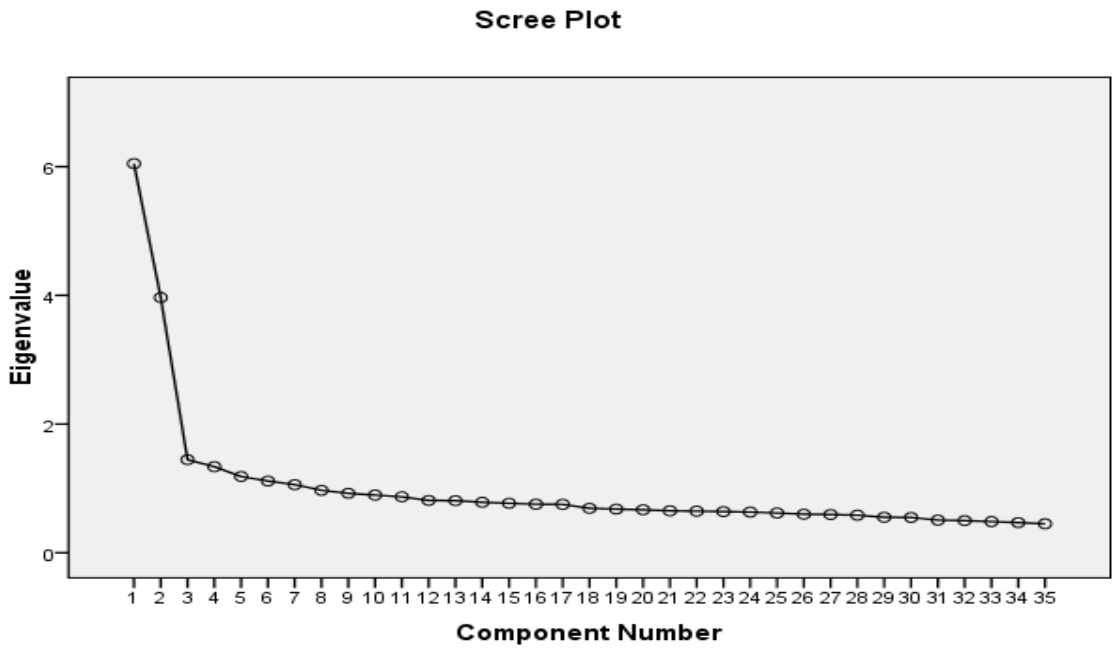

Figure 1: Scree Plot showing Eigen value on the Propose Measure of Attitude towards Mathematics Teacher.

The scree plot in Figure 1 revealed a decline in the slope and an elbow curve after the third component. This proves that there is tendency for irrelevance with the other 4 component making up 7 components observed in the PCA, however, the 7 components were still subjected to the criteria for practical and statistical significance of factor loadings (see Appendix 2). Factor loading will be considered at the level of .40 for variables that will be select for further analysis.

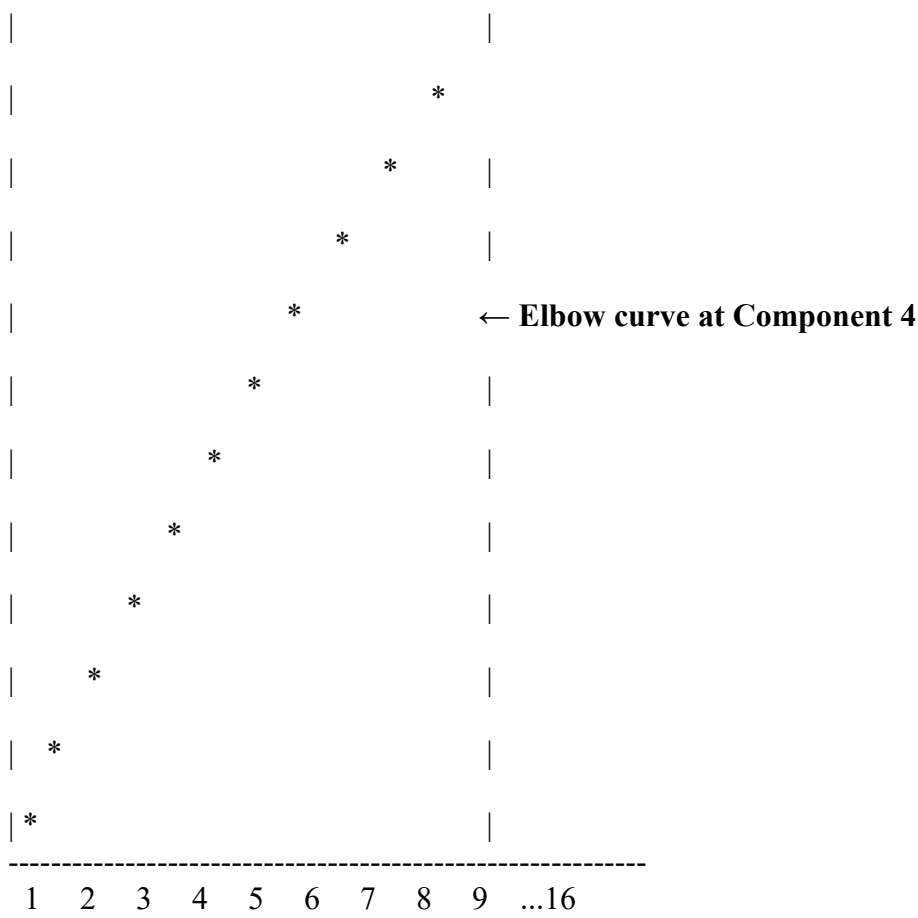

Figure 1a: Principal Components (Factors) →

The line graph shows a steep decline in eigenvalues after the fourth component, forming a clear "elbow" that signals the point where additional components contribute minimal variance. This suggests that retaining four components yields a parsimonious and theoretically sound solution for analysis. The summarised result on the 7 components is presented in Table 3.

Table 3: Principal Components Analysis on the proposed variables of Attitude towards Mathematics Teacher

Factors	ATMT	**1**	**2**	**3**	**4**	**5**	**6**	**7**
The mathematics teacher shows interest in the progress of his/her students	11	.621	-.178	.146	-.041	.063	-.051	-.004
I am very proud of mathematics teachers	30	.607	-.183	-.185	.132	.039	-.064	-.147
Mathematics teachers are good at explaining mathematics concept	28	.598	-.227	-.272	.018	-.041	-.025	-.196
I am impressed by the teaching methods used by mathematics teachers	9	.578	-.203	.141	-.052	-.017	.212	.133
Mathematics teachers are my favourite teachers in school	6	.551	-.087	.289	-.072	.047	-.096	.076

Mathematics teachers take time to prompt the students	29	.544	-.231	-.250	.144	.122	.022	-.205
I like the way mathematics teachers communicate	3	.542	-.145	.223	-.039	.036	-.079	.189
Mathematics teachers are emotionally stable	12	.541	-.167	.202	-.011	.139	-.143	.000
Mathematics teachers are my favourite teachers in school	5	.526	-.105	.090	-.128	-.085	.028	.243
I believe that liking the mathematics teachers will make students have interest and reward in the subject	27	.521	-.261	-.354	-.106	-.196	.133	-.152
Mathematics teachers are very patient with slow learners	10	.512	-.137	.351	-.008	.094	-.012	-.100
Mathematics teachers makes the subject easy to study	21	.496	-.200	-.024	.249	-.166	-.181	.287
It is believed that most mathematics teachers are very competent in teaching the subject	7	.489	-.177	.173	-.286	-.055	.068	.107
Mathematics teachers do not easily lose his temper when dealing with students	13	.446	-.240	.081	.043	-.115	.317	-.231
Mathematics teachers are pleasant to relate with	19	.431	-.216	-.084	.171	-.200	.053	.090
I always approach mathematics teachers with mathematics problems I cannot solve	2	.401	-.171	.282	-.193	-.150	.143	.083
My presence is highly desired by mathematics teachers	35	.378	-.233	-.043	.175	.353	.158	.196
The mathematics teachers like to isolate me so that I can think clearly	31	.368	-.283	-.186	.245	.312	-.151	-.227
If it is possible, I won't have anything to do with mathematics teacher	18	.428	.523	-.061	-.047	.028	-.231	.024
Mathematics is as difficult as those who teach it	20	.274	.513	.057	-.104	.000	.027	.020
Mathematics teachers make me hate the subject	17	.427	.500	-.149	-.074	.000	-.176	.100
I experience a little sadness sometimes about mathematics teachers	34	.236	.477	.169	.119	-.284	-.141	-.277
Mathematics teachers make examination too tough	22	.239	.473	.104	.031	.106	.121	-.385
Mathematics teachers do not care about students	14	.412	.470	-.264	-.059	.083	-.149	.201
Most mathematics teachers are failure as classroom teachers	24	.301	.468	.056	-.101	.187	.335	-.020
Mathematics teachers take teaching unserious	16	.327	.457	-.275	-.187	.059	.158	.200

I don't answer questions in class for fear that the mathematics teacher may shout me down	33	.266	.453	.130	.112	-.441	-.074	-.226
Mathematics teachers do not show interest in the students	23	.395	.435	-.142	-.022	.188	.152	-.204
Sometimes, I experience a feeling of worthlessness about mathematics teachers	32	.205	.429	.076	-.081	-.412	-.049	.028
Mathematics teachers show off their knowledge too much	25	-.042	.395	.289	-.107	.335	.153	-.127
Lack of patience by mathematics teachers discourage students	26	-.080	.385	.434	.251	.278	-.245	.023
Most mathematics teachers do not communicate effectively	4	-.040	.295	.028	.590	-.083	.279	.245
Most mathematics teachers do not care whether the students understand the topic or not	8	.095	.384	-.025	.462	-.056	.415	.167
Mathematics teachers are reluctant to come to class	15	-.029	.396	-.274	-.416	.098	.104	.152
I dislike mathematics teachers	1	.294	.314	-.188	.214	.101	-.379	.119
Percentage of Variance		17.275	11.331	4.132	3.820	3.384	3.183	3.023
Cumulative Percentage of Variance		17.275	28.606	32.738	36.558	39.941	43.124	46.147

Table 3 shows the factor loading and it was noted based on factors loading above 0.40 that 16 factors loaded in the first component (items 11, 30, 28, 9, 6, 29, 3, 12, 5, 27, 10, 21, 7, 13, 19, 2). Factors 35 and 31 loaded best in the first component, but their values were below 0.40 and they were dropped. Factor 18 loaded above 0.40 in the first component (.428), but it was also found to load well and even better in the second component (.523). This was an indication of complex structure such that the factor reflected relevance with two different constructs, therefore, it was dropped. In the second component, 10 factors loaded above 0.40 (items 20, 17, 34, 22, 14, 24, 16, 33, 23, 32), while one factor loaded best in the second component, but it loaded below 0.40 (item 25). One factor also loaded adequately in the third component (item 26), while 3 other factors (items 4, 8, 15) loaded adequately in the fourth component with one having a negative association (item 15). The last factor (item 1) loaded best, but negatively on the sixth component and this factor was also dropped.

The factors loading above 0.40 in components 2, 3 and 4 were re-examined. These factors did not reveal any possible coherent construct. In addition, the theoretical buildup of the construct of students' attitudes toward Mathematics did not indicate any further categorisations (sub-scales), therefore, just items loading above 0.40 in the first component (16 items) was retained for further analysis.

Factor analysis was carried out on the items measuring attitude towards Mathematics teacher. Exploratory factor analysis was preferred because it is a statistical technique that is used to explore the underlying theoretical structure of the phenomena. Principal component factor analysis

(PCA) was utilized. This method allows one to drive the minimum number of factors and explain the maximum portion of variance in original variable.

Sample adequacy is essential in the conduct of factor analysis and in order to avoid shortcomings or limitations to the outcome of the collected and analysed data, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy Kaiser (1974) and Bartlett's test of sphericity Bartlett (1954) were used to assess the factorability of the data. This explains weather the sample is large enough or adequate to conduct factor analysis.

DISCUSSION OF FINDINGS

The findings of this study underscore the importance of students' attitudes toward mathematics teachers as a significant determinant of their performance and interest in mathematics. The Kaiser-Meyer-Olkin (KMO) measure (.909) and Bartlett's Test of Sphericity ($\chi^2 = 16{,}165.594$, $df = 595$, $p < .001$) confirmed the adequacy of the sample and the suitability of the data for factor analysis. According to Kaiser (1974), a KMO value above 0.80 is considered meritorious, while values above 0.90 indicate superb sampling adequacy, thereby validating the appropriateness of conducting Principal Component Analysis (PCA). Similarly, Bartlett's (1954) test of sphericity, which was significant at $p < .001$, further strengthened the factorability of the correlation matrix, consistent with Field (2000) and Pallant (2005).

The PCA extracted seven initial components, accounting for 46.15% of the cumulative variance. However, based on the scree plot and theoretical considerations, the analysis suggested that only the first component provided a meaningful structure for students' attitudes toward mathematics teachers. Sixteen items with loadings above .40 clustered around this first factor, suggesting that the construct of attitude toward mathematics teachers is largely unidimensional rather than multifaceted. This aligns with the argument of de Leeuw et al. (2019), who emphasized that quantitative measurement of attitudes has become increasingly precise, especially when utilizing psychometrically sound instruments.

Furthermore, the retention of items based on the .40 threshold is in line with methodological recommendations by Hair et al. (2010), who argue that factor loadings above .40 are acceptable in social science research, as they indicate practical significance. The decision to drop cross-loading items (e.g., ATMT18) also reflects good psychometric practice, since items that load on multiple factors compromise construct clarity Tabachnick and Fidell (2013).

The use of a Likert-type scale for data collection proved effective in capturing students' nuanced perceptions. As Matthew et al. (2022) highlight, Likert scales remain one of the most robust tools for measuring attitudes, given their ability to capture both favourable and unfavourable dispositions. The current study's findings demonstrated that attitudes toward mathematics teachers encompass relational, communicative, and instructional dimensions, all of which are crucial for shaping students' engagement in mathematics. This confirms prior research indicating that positive teacher-student relationships and effective communication foster a more supportive learning environment Ifedili and Ifedili (2010); Pam et al. (2022).

Interestingly, the results also showed that negative attitudes (e.g., perceptions of teachers' lack of care, impatience, or strictness) clustered alongside positive perceptions within the same

dimension, highlighting the ambivalent nature of students' experiences with mathematics teachers. This resonates with Aremu and Tella (2003), who reported that while some students are inspired by their teachers, others develop anxiety and disengagement due to perceived harshness or lack of empathy.

The findings further justify the need for comprehensive instruments that go beyond isolated affective, behavioural, or cognitive measures. As emphasized by de Leeuw et al. (2019), attitude measurement requires multidimensional and psychometrically validated approaches to provide meaningful insights for both research and practice. By retaining 16 psychometrically strong items, this study has contributed to the development of a valid and reliable scale that can guide educators and policymakers in diagnosing and addressing attitudinal barriers to mathematics learning.

Overall, the validated Attitude toward Mathematics Teacher (ATMT) scale provides a robust foundation for predicting students' academic engagement and performance in mathematics. The scale holds practical relevance for teachers, who can leverage feedback to refine their instructional strategies and foster more positive teacher-student interactions. It also has policy implications, as education authorities can incorporate attitudinal assessments into routine monitoring frameworks to enhance teaching effectiveness and student outcomes.

CONCLUSION AND RECOMMENDATION

In conclusion, there is evidence to believe that respondents understand the majority of questions in ATMT-Q and interpret them in the intended frame. The bother-scores assessing impact of ATMT proved to have significant convergent and discriminatory validity, and the ATMT-Q was reliable over time. The positive disposition to Mathematics subject by the students as revealed from the findings of this research substantiated the fact that the students knew the usefulness of Mathematics as it affects their career choices and its everyday application to life

Based on the findings, this study provides key recommendation that the newly developed scale should be deployed, in each state of the Federation, to measure students' attitude towards the attitudinal variables which determine the students' achievement in Mathematics subject. The results obtained will enable stakeholders determine the course of action(s) to be taken to further improve student's performance in Mathematics subject.

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