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A Structural Equation Model Examining the Relationship among Remembering, Understanding, Applying and Students' Achievement in Mathematics

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Abstract: Bloom's taxonomy of educational objectives has been used by educators as a useful model of learning concepts and ideas. While every Mathematics teacher would dream of his/her students reaching the highest level of Bloom's taxonomy, the reality in Nigeria and other developing countries is far from this. This study investigated the relationship between three dimensions of the cognitive domain namely: remembering, understanding and applying and mathematics achievement among secondary students in Nigeria. A measure of the three levels of the cognitive domain was used for data collection from 250 respondents. Multivariate statistical techniques via Exploratory Factor Analysis (EFA) and Structural Equation Modeling (SEM) revealed that the observed variables' measuring the latent constructs: remembering, understanding and applying measured it. Significant covariance relationships among the latent constructs were established. The three dimensions of the cognitive domain directly and positively influenced academic achievement of mathematics students. Lastly, the overall model fit the data. Suggestions are offered on the effective utilization of the three dimensions of the cognitive domain in mathematics instructional contents delivery.

Keywords: Bloom's taxonomy, Mathematics achievement, secondary school Mathematics, cognitive domain.

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INTRODUCTION

The Taxonomy of Educational Objectives (TEO), popularly and better known as Bloom's Taxonomy, is a classification system that deals with how learning objectives are designed, implemented and assessed. In 1956, Benjamin Bloom began analysis into educational objectives by exploring the cognitive domain which involves the development of mental skills and the acquisition of knowledge. This process includes recollection or recognition of specific facts; procedural patterns, and concepts that serve in the development of intellectual abilities and skills of individual or groups of learners. Later, Benjamin Bloom and his colleagues Lorin W. Krathwohl and S. R. Kibler added the affective and psychomotor domains to round-off the body of their study. Under the cognitive domain, Bloom's taxonomy identified six levels of teaching and learning: (i) remembering, (ii) understanding, (iii) applying, (iv) analyzing, (v) evaluating and (vi) creating.

The cognitive domain plays a very crucial role not only in the teaching and learning of mathematics but also in the entire instructional system of education. For example, at the "remembering level" learners usually derived values from their ability to memorize some of the ideas received from learning a particular mathematical task especially at a lower level of secondary education. These values attained are usually manifested through repetitive writing on the board or on paper. At that level, mathematics teachers focus on the "knowing" and "memorizing" abilities of learners (Lancaster, 2006; Liman, Ibrahim & Shittu, 2011a).

With regard to the second phase, the "understanding level", value inculcation via mathematics conceptual understanding significantly facilitates mathematics learners' love of the subject. Mathematics conceptual understanding enables learners to realize the essence of teaching and learning of the subject. At this stage, mathematics teachers try to inculcate values through practically using mathematics concepts and applying them to other domains of human life (Schoenfeld, 1992 & Clark, 2009).

Understanding of mathematics concepts can be built in the learners mind through effective utilization and improvisation of teaching and learning materials/aids that facilitate mathematics understanding.

Organizing a classroom mini shopping corner and introducing money for buying and selling greatly enhances the teaching of the topic "profit and loss" and can enable mathematics teachers to make students value the subject (Lim & Ernest, 1997; Seah, 1999).

Another example of this is the practical application of the Pythagorean principle in sharing of land. According to this theorem, the square of the hypotenuse side of any given right-angle triangle is equal to the sum of the squares of the other two sides, mathematically expressed as $\mathbf{c^2 = a^2 + b^2}$ (Liman, Sahari & Shittu 2011b).

Practical usage of formulas of calculating the area of plane shapes such quadrilaterals and triangles helps to enhance and cultivate value-based mathematics teaching and learning. Mathematics teachers can use places like the school farm and football pitch in teaching these mathematics concepts with the aim of demonstrating the importance of learning mathematics, ultimately leading to the valuing processes of the subject (Bishop, Gunstone, Clarke & Corrigan 2010).

In relation to "applying" category of the cognitive domains, it is important to situate the teaching and learning encounter within the framework of understanding the relationships that exist between and among mathematical concepts. Mutual understandings of mathematical conceptual connections ultimately make it possible to have creative and innovative minds among mathematics learners. The application of mathematical concepts into newly realizable situations simplifies all classroom mathematical abstractions. Furthermore, there is no doubt that the success of any mathematics teaching and learning encounter solely rests within learners' abilities to applying the learned concepts in related situations or occurrences (Bishop, Gunstone, Clarke & Corrigan 2010).

Mathematics teachers should focus more on the applicability of knowledge than on procedural knowledge by way of engaging mathematics learners to apply their mathematical knowledge. This could be by, for instance, using a paper and pencil to manually calculate an employer's vacation time or applying the laws of statistics to evaluate the reliability of a written test. Such applications will enable mathematics teachers to pass value judgments on applicative tendencies of mathematics learners. In writing their objectives, Mathematics teachers should use behavioral verbs like apply change, compute, construct, demonstrate, discover, manipulate modify, operate, prepare, produce, relate, show, solve, use etc, while testing applicability of mathematical knowledge among mathematics learners (Clark, 2009).

The cognitive domain of educational objectives has played a great role in the area of teaching and learning generally and mathematics teaching in particular. The term cognitive usually referred to psychological processes involved in the acquisition and understanding of knowledge, formation of beliefs, attitudes, decision making and problem solving (Bloom, 1956; Krathwohl et al., 1973). It is distinct from emotional and volitional processes involved in wanting and intending (Krathwohl, Bloom, and Masia, 1964). The cognitive domain encompasses a hierarchical series of intellectual skills involving the acquisition and use of knowledge that ranges from simple recall (remembering) to the ability to judge and evaluate learned materials. Bloom categorized six levels within the cognitive domain as follows below (Figure 1):

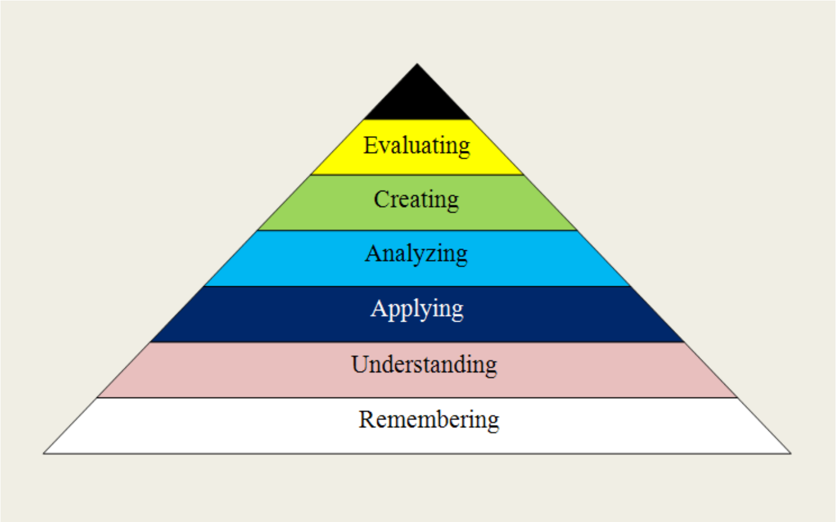

Figure 1: Hierarchy of Sub-components of cognitive Domain

The term taxonomy is used in classifying learning outcomes which usually helps in gaining a perspective of a certain behavior by a particular set of educational plans. Taxonomy can help curriculum developers/planners to organize learning experiences and prepare evaluation devices (Lindlof & Taylor, 2002; Naomee & Tithi, 2013; Simpson, 1972; Tyler, 1949; Ornstein & Hunkins, 1978).

A number of criticisms have been directed to the categorization of the cognitive domain. Some educators like Furst (1994, p.34); Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths and Wittrock (2001, p.309) regarded the cognitive domain classification processes to be ordered on a single dimension of simple to complex behavior. They were of the view that "Cumulative Hierarchy" which means, "Mastery of a more complex category required prior mastery of all the less complex categories below it" which to them is a "stringent condition and standard." The sub-components must not overlap in order to keep the trend of "Cumulative Hierarchy." But some of the verbs of each sub-domain clearly pre-empt the occurrences of this overlap.

Contradictions were noted in the use of the original taxonomy in the sense that some knowledge based objectives are more difficult than some analysis or evaluation based objectives (Ormall, 1974; Naomee & Tithi, 2013). Krietzer and Madaus (1994); Naomee and Tithi (2013) argued that unlike evaluation synthesis is multipart and actually requires evaluation. Some educators regarded the original taxonomy as being based on behaviorist learning theories than being a constructivist approach (Naomee & Tithi, 2013).

However, this notion has gradually been erased through the introduction of several new theories such as constructivism, meta-cognition, etc, which consider students more knowledgeable and responsible for their own learning and thinking. This adjustment into the original taxonomy and the emergence of a newly adopted taxonomy can be credited to a group of cognitive psychologists, curriculum and instructional researchers and testing and assessment specialists (e.g. Anderson et al., 2001; Raths, Harmin & Simon, 1987).

Anderson et al., (2001) made tremendous contributions toward some major changes that emerged on the original taxonomy of educational objectives in order to keep it updated and check its flaws. The new version of the taxonomy is known as the revised taxonomy of educational objectives. The noticeable change in the revised taxonomy is the shift from one dimension to two dimensions. The revised taxonomy separates the noun and verb components of the original taxonomy into two separate dimensions: The knowledge dimension and the cognitive process dimension.

Pohl (2000); and Naomee and Tithi (2013) asserted that the names of six major categories have been changed and others reorganized. As the taxonomy reflects different forms of thinking which is an active process, verbs were used rather than nouns. The knowledge category was renamed, considering knowledge to be an outcome or product of thinking not a form of thinking. It was replaced by remembering. Comprehension and synthesis were re-titled to understanding and creating respectively. This was done to better reflect the nature of the thinking defined in each category.

Numerous studies have been conducted on Bloom's Taxonomy. Fain & Bader (1983) found that few educational innovations have had equal impact upon the profession. Rahman (2006) employed qualitative methodology and found that the contents of the secondary social science textbooks were mainly cognitive domain based; the objectives and learning outcomes of secondary social science were not able to develop attitude, values and skills in the learners; and that learners were not completely able to achieve desired learning outcomes through the textbook contents.

Shahzad, Qadoos, Badsha, Muhammad and Ramzan (2011) conducted a study on Analytical Study on "Biology Question Papers and the Bloom's Taxonomy of educational objectives". The analytic procedure was document analysis of all Biology question papers prepared by BISE (Bannu) and the sample was taken last five years (2005-2009) Questions Papers for analysis of Cognitive domain, psychomotor domain and Affective domain categories of Bloom Taxonomy were evaluated simple frequency and percentage for each category were calculated. The findings of the study indicated significant discrepancies between Biology Questions papers and the educational objectives and recommends that (a) Board of Intermediate and Secondary Education (Bannu) should set the papers by those papers setters that they have full command on Bloom's Taxonomy. (b) Such types of papers should prepare learners to develop intellectual skill, practical and physical movement of knowledge base and attitude of the leaner towards learning the subject. (c) Question papers should be made according to Bloom Taxonomy to determine the future targets of the learner. (d) Balance should be keeping in mind during the allocation of marks among three categories (Cognitive, Affective and Psychomotor domain).

Conceptual Model of the Study

Using the three categorization of the Bloom taxonomy of educational objectives (namely (i) remembering (ii) understanding and (iii) applying) as the conceptual model, this study sought to find out the relationship between the three categories of the cognitive domain in mathematics teaching and learning and secondary school students' academic achievement in mathematics. Bloom (1956); Krathwohl, Bloom and Masia, (1973); James, (2006); Ngada, (2008); conceptualized the cognitive domain to basically involve six categories namely: (1) remembering (2) understanding (3) applying, (4) analyzing (5) synthesizing, and (6) evaluating. This study only focused on three of the categories in an attempt to find out their relationship with secondary school students' academic achievement in mathematics. Figure:2 shows the proposed model for the study.

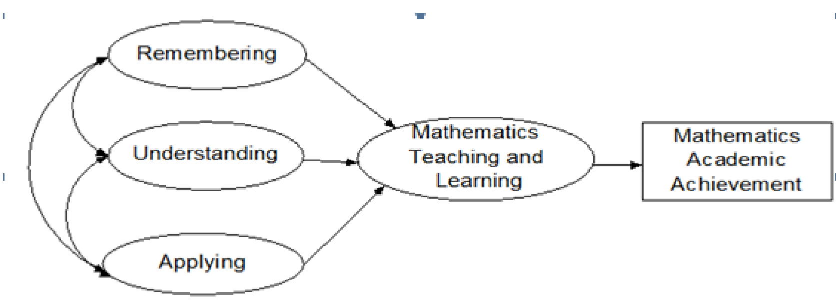

Figure 2: Hypothesized model of the study

Objective of the Study

The main objective of the study is to find out the relationship between three components of the cognitive domain and secondary school students' academic achievement in mathematics subject. The specific objectives of the study were: (1) To find out whether the observed variables measure the latent constructs, remembering, understanding and applying of the cognitive domain in mathematics teaching and learning; (2) To determine the covariance relationships among the latent constructs of the cognitive domain in mathematics teaching and learning; (3) To find out whether the three categorization of the cognitive domain of educational objectives directly and positively influence students' academic achievement in mathematics; and (4) To determine the hypothesized model fitness to the data.

METHODOLOGY

This study employed quantitative methodological approach with descriptive statistics, Exploratory Factor Analysis (EFA) and Structural Equation Modeling (SEM) as the bases for the study's data analysis. The data of this study have been gathered through a seven point likert-type self-administered survey questionnaire cutting across three sub-categories of Bloom's Taxonomy (cognitive domain) of educational objectives and students academic performance in mathematics (end of term mathematics results).

Population and Sample

The population of this study comprised of 200 male and female each of (N= 400) senior secondary school students learning mathematics as a subject drawn from 8 senior secondary schools 4 in Damaturu and the other from Maiduguri, Nigeria. Additionally, two schools were single-sex boys' and the other two schools were girls' schools respectively. The study adopted equal proportionate random sampling technique. Based on population of N= 400 respondents and 95% confidence level, with a 3.5% margin of error, the sample size of the study emerged to be n=265 (Krejcie & Morgan, 1970). Consequently, 304 questionnaires were distributed in order to mitigate respondents' laxity of returning questionnaires and to get more rich data. Out of that number, 270 questionnaires which account for 90.0% were returned, 11 were totally not completed while 9 had one forms of mutilation or the other. As such, out of 270, 20, (7.4%) were null and void, leaving us with 250 which accounted for 92.6% questionnaires were keyed in into the SPSS Version 17.0 as summarized in Tables 1 and 2.

Table1: Sampling Adequacy of Required Sample size

Population Size	Confidence = 95% Margin of Error				Confidence = 99% Margin of Error			
	5.0%	3.5%	2.5%	1.0%	5.0%	3.5%	2.5%	1.0%
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485

Table 2: Sample Size for Senior Secondary schools Mathematics Students

Schools	Total no. Distributed	Total Returned	Percentage Returned	Total Usable	Percentage Usable
G.C.M	38	35	92.1%	31	88.6%
G.S.S.M	38	33	86.8%	30	90.9%
G.G.S.S.Y	38	34	89.5%	29	85.3%
G.G.C.M	38	32	84.2%	30	90.9%
G.S.S.D	38	30	78.9%	30	90.9%
G.D.S.S.D	38	33	86.8%	31	88.6%
G.G.C.D	38	35	92.1%	35	100.0%
G.G.S.S.D	38	38	100.0%	34	89.5%
Total	304	270	88.8%	250	92.6%

Source: The research advisors (2006)

Table Key: G.C.M = Government College Maiduguri; G.S.S.M = Government Secondary School Mafoni; G.G.S.S.Y = Government Girls' Secondary School Yarwa; G.G.C.M = Government Girls' College Maiduguri; G.S.S.D = Government Secondary School Damaturu; G.D.S.S.D = Government Day Secondary School Damaturu; G.G.C.D = Government Girls' College Damaturu and G.G.S.S. D = Government Girls' Secondary School Damaturu

RESULTS AND DISCUSSION

The use of structural equation modeling technique for the data analysis in educational and social science researches cannot be over emphasized in the sense that it is used in validating structural relationships among exogenous and endogenous variables based on certain theoretical frameworks (Hooper, Coughlan, & Mullen, 2008). Therefore, this study used structural equation modelling technique (SEM) for its data analysis. AMOS graphic window version 16 was used to assess the factorial validation of the hypothesized 3-factors dimensions for the three levels of cognitive domain in mathematics teaching and learning measurement model. Based on the recommendations of Hair, Black, Babin & Anderson, (2010) and Sahari, (2011) the minimum range of the sample size for the variance analysis is between 150-above.

Instrument Validity and Reliability

The construct validity and the reliability of the instrument were ascertained through Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) in order to validate the instrument of the study. Principal Component Analysis was used for extraction and Varimax used as the rotation method. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) value of each construct was ascertained, the Barllet's Test of Sphericity value was significant (p=0.000), the Eigen value was greater than one and the percentage of variance explained of each factor was found to be greater than 40%. Three factors were finally generated for the study. To ascertain the reliability of the instrument, Cronbach's Alpha was employed and the result showed values above 0.7, which indicated good internal consistency of the items. Table 3 above presents the 27 items used in the study, their loading and their cronbach alpha.

Table 3: Exploratory Factor Analysis (EFA) Result for Remembering; Understanding and Applying of the Cognitive Domain

FACTORS	ITEM	RMB 1	ATT 2	SOC 3	MSA	M	SD
Remembering	RMB1	.562			.912	5.37	1.68
	RMB2	.638			.867	5.60	1.65
$\alpha\alpha$-value (.862)	RMB3	.739			.928	5.27	1.71
	RMB4	.668			.883	5.42	1.60
	RMB5	.695			.934	5.53	1.67
	RMB6	.668			.930	5.34	1.67
	RMB7	.727			.898	5.45	1.69
	RMB9	.625			.923	5.21	1.74
	RMB10	.611			.922	5.56	1.69
	RMB11	.652			.870	5.52	1.68
	RMB12	.519			.876	5.40	1.73
Understanding	UDT13		.637		.877	5.71	1.49
	UDT14		.660		.876	5.67	1.56
$\alpha\alpha$-value (.834)	UDT15		.637		.834	5.52	1.65
	UDT16		.648		.869	5.64	1.67
	UDT18		.531		.865	5.42	1.77
	UDT19		.602		.889	5.58	1.74
	UDT21		.540		.867	5.45	1.68
	UDT22		.600		.782	5.37	1.67
	UDT23		.697		.905	5.41	1.71
	UDT24		.721		.896	5.93	1.61
Applying	APL26			.683	.839	5.68	1.52
	APL27			.657	.814	5.44	1.65
$\alpha\alpha$-value (.765)	APL28			.644	.821	5.04	1.75
	APL29			.658	.841	5.27	1.65
	APL30			.665	.840	5.20	1.78
	APL31			.748	.808	5.42	1.59

Source: Author

Confirmatory Factor Analysis (CFA)

After the Exploratory Factor Analysis (EFA) the researcher forge ahead in validating the efficacy of the three factor solutions of the cognitive domain of educational objectives in senior secondary schools mathematics teaching and learning among Borno and Yobe states mathematics students in Nigeria. Furthermore, the study tested the hypothesized model fitness to observed data via structural equation modeling (SEM) technique. The proposed model consisted of three exogenous constructs, namely remembering, understanding and applying of the Bloom's Taxonomy of educational objectives, particularly the cognitive domain in mathematics teaching and learning encounter.

Moreover, the study is trying to find out the effectiveness of the three levels of the Bloom's cognitive domain in predicting mathematical ability both in terms of learners' ability to "remember", "understand" and "apply" mathematical knowledge. The research model Confirmatory Factor Analysis (CFA) validation process, test and analysis were conducted through three general approaches. First, the proposed model analyses were conducted using covariance and the most widely used maximum-likelihood estimation method via AMOS graphic software version 16.0 (Anderson & Gerbing 1992).

Furthermore, the measurement model development strategy for this study was followed using a model re-specification procedure which aims to identify the source of misfit and then generate a model that achieve better fit of data (Byrne, 2010). The study examined multiple statistics of model fit because a model may achieve good fit on a particular fit statistics but inadequate on others, (Bollen's, 1990). The selection of fit statistic for this study was based on the recommendations of Hu and Bentler (1999) and Hair et al. (2010).

According to their recommendations, to achieve goodness-of-fit for the empirical data, both the measurement and structural model should meet the requirements of selected indices. Going by the suggestion of Hair et al., (2010), the first overall test of model fit selected was the chi-square test. A significant chi-square statistics indicates a poor model fit. As the chi-square test is extremely sensitive to sample size (Bentler 1990), the chi-square normalised by degrees of freedom (χ^2/df) was also used. An acceptable ratio for χ^2/df value should be less than 3.0 (Hair et al. 2010). According to Hair et al. (2010), researchers should report at least one incremental index and one absolute index, in addition to the chi-square value; at least one of the indices should be the badness-of-fit index. For the badness-of-fit index, RMSEA was chosen as it often provides consistent results across different estimation approaches (Sugawara and MacCallum 1993). Following this guideline, other than chi-square and normed χ^2/df value, model fit for the present study was examined using multiple indices which include Goodness-of-Fit Index (GFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Standardized Root Mean Square Residual(SRMR) and a badness-of-fit index, Root Mean Square Error of Approximation (RMSEA), (Hu and Bentler, 1999).

Following common practice, acceptable model fit is indicated by a value greater than .90 for GFI, CFI, TLI, IFI and a value of less than 0.08 for RMSEA. However, a cut-off value close to .95 for TLI, CFI; and a cut-off value close to .06 for RMSEA are needed to support that there is a relatively good fit between the hypothesized model and the observed data (Hu and Bentler 1999). Table 4 presents the summary of the recommended benchmark for the model fit indices adopted in the present study and the initial model.

Table 4: Recommended Benchmark for Model Fit Statistics

Fit Index	Recommended Value
Absolute Fit Measures	
$\chi2$	*The lower, the better*
$\chi2/df$	≤ 3.0
GFI	≥ 0.90
$RMSEA$	≤ 0.06 *or* 0.08
Incremental Fit Measure	
TLI	≥ 0.95 *or* 0.90
CFI	≥ 0.95 *or* 0.90
IFI	≥ 0.95 *or* 0.90

Source: Hooper, et al., (2008).

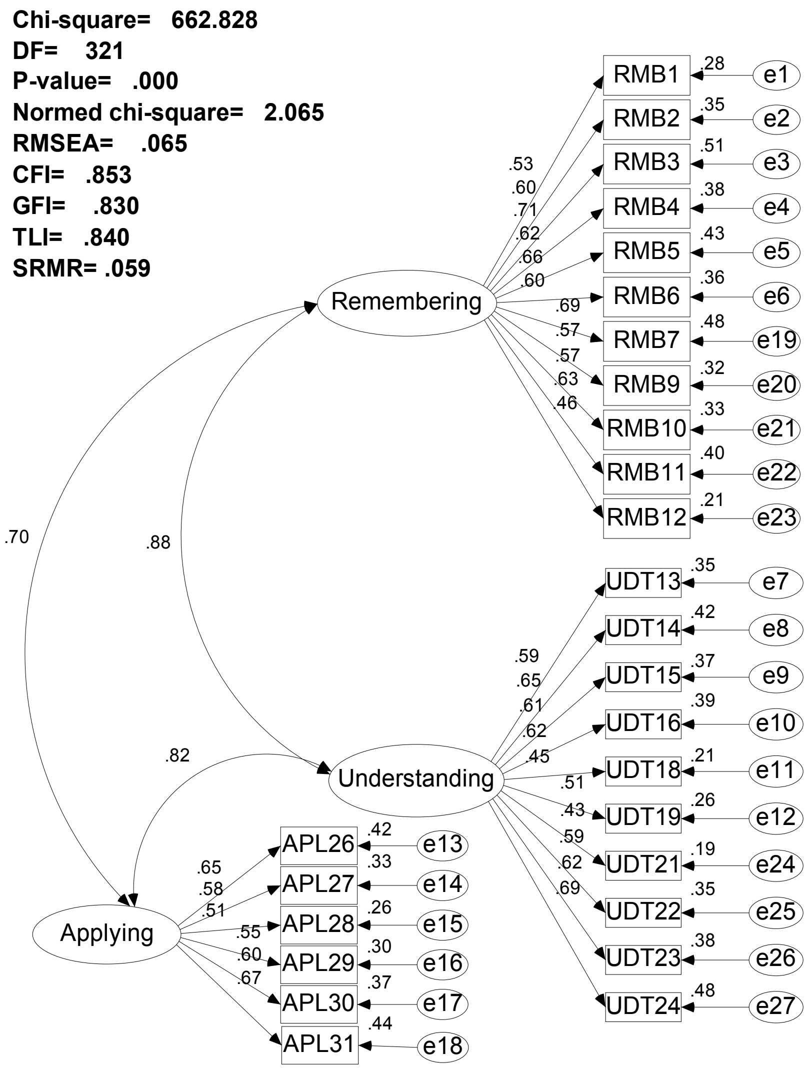

Figure 2: The Initial Structural Equation Measurement Model

Based on the criteria stated above for a model adequacy, the initial model revealed lack of fit as the fit statistics showed that the model did not fit the data Normed Chi-square $\chi/df = 2.065;\ RMSEA = .065; CFI = .853; GFI = .830; TLI = .840\ and\ SRMR = .059$

The results also suggest a revision of the model. This is because among the indicators of goodness of fit statistics only the Normed chi-square, RMSEA and SRMR clinched to the threshold of good fit indices. The CFI, GFI and TLI failed to converge to its cut-off point of .9 and above. This suggested that the model has to be revised since there were a few cases of cross-loaded indicators, some of which showed big error variances (Byrne, 2010; Hu & Bentler, 1999). Figure 2 gives the initial model of the study.

Figure 3: presents the revised 20-item three factor solution measurement model analyzed by performing CFA. This revised model was consistent with the data. This is because the Chi-square (167) = 263.369; P-value =.000; CFI = .936; TLI = .927; IFI =.937; RMSEA = .048; and SRMR = .059 all of which converged to their respective thresholds. The direction and magnitude of the factor loading were substantial and statistically significant (Hair, 2010 & Kline, 2011). Table 5 shows the standardized loadings derived from the Maximum Likelihood (ML), Composite reliability and convergent validity of each item measured using t-values.

Figure 3 shows result of the goodness of fit of the structural equation model which attempted to establish relationship between the three levels of the cognitive domain namely remembering, understanding and applying in mathematics teaching and learning and students' academic achievements in mathematics as a subject. The model adequacy indicated a good model fit between (the three levels of the cognitive domain → students mathematics achievement), with a significant Chi-square statistics; $\chi 2 \chi 2$ (*df=186, N=250*) 273.715, p= .000 (p>.001), Normed Chi-square =1.472, CFI= .942, TLI= .934, IFI= .943, RMSEA= .044 and SRMR = .049. The standardized loadings of the constructs for the three levels of the Bloom's Taxonomy (cognitive domain) of educational objectives in mathematics teaching and learning in both Fig 5 and Table 5 were found to be practically and statistically significant.

Table 5: Summary of Standardized Path Coefficients, Average Variance Explained (AVE) and Composite Reliability

Constructs/Items	Standardized Path Coefficients	Composite Reliability	Convergent Validity (t-value)
Remembering (RMB)		**0.88**	
RMB1	.53		7.24
RMB2	.62		7.75
RMB3	.71		7.41
RMB4	.65		7.41
RMB5	.66		7.09
RMB6	60		7.24
RMB9	.57		6.77
RMB11	.61		7.06
Understanding (UDT)		**.89**	
UDT13	.62		8.97
UDT14	.70		8.97
UDT16	.63		8.09
UDT18	.47		6.46
UDT19	.50		6.83
UDT23	.57		7.47
UDT24	.72		9.15
Applying (APL)		**.87**	
APL27	.58		6.48
APL28	.53		6.48
APL29	.55		6.43
APL30	.61		6.92
APL31	.69		7.18

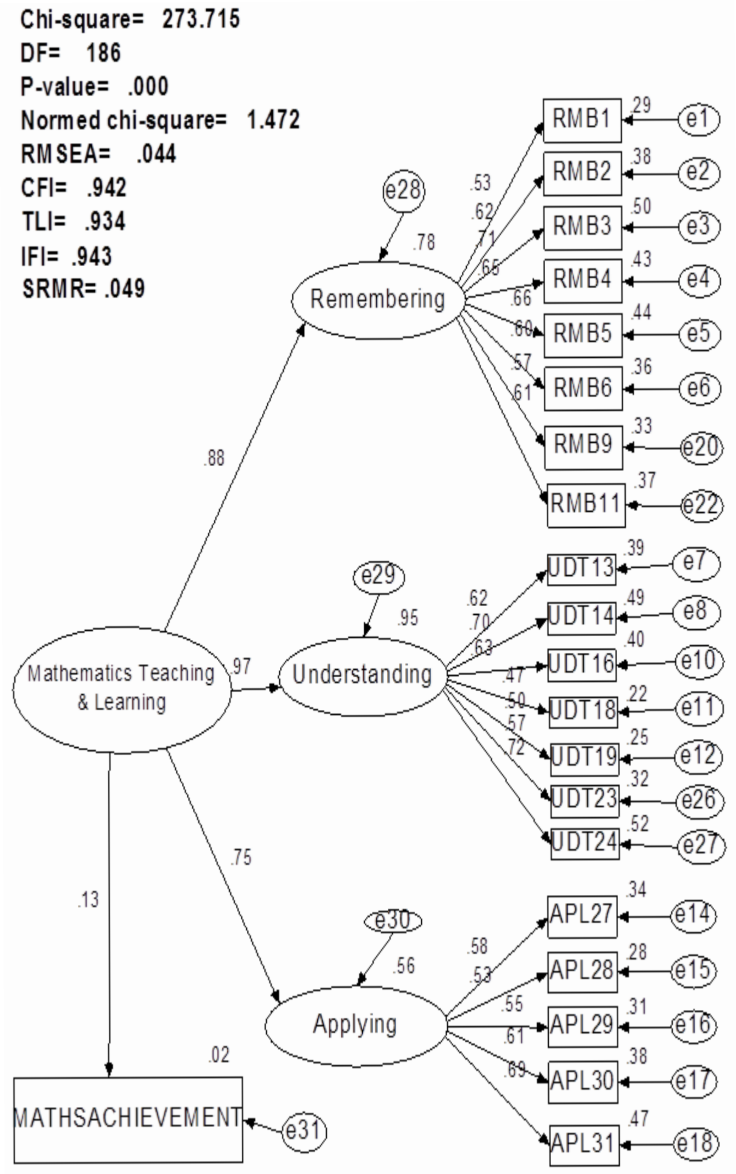

Figure 3: The full structural equation model for the three levels of cognitive domain and Students Mathematics Achievement

The regression weight of the structural equation modeling analysis in (Figure 5) showed that the three levels of the cognitive domain in mathematics teaching and learning directly and positively influenced mathematics achievements of senior secondary schools students in Borno and Yobe states of Nigeria. This was indicated by the direct positive effect between mathematics teaching and learning via the emphasis of remembering, understanding and applying of the cognitive domain and students' mathematics achievements. The influence was statistically significant (CR< 1.96) with the standardized direct positive effect of .13 which implied that the hypothesis model was supported.

The focus of this study was to accomplish the following objectives: first is to find out whether the observed variables measure the latent constructs, remembering, understanding and applying of the cognitive domain in mathematics teaching and learning. This objective has been achieved, considering the exploratory factor analysis in (Table 3) and confirmatory factor analysis in (Fig 3 and Table 5) revealed that the proposed items measuring the three levels of cognitive domain of the Bloom's Taxonomy really measured it. Secondly, the analysis revealed that there exist significant covariance relationships among the latent constructs of the cognitive domain in mathematics teaching and learning. The significant covariance relation of (r =.86) existed between "remembering" and "understanding". There is also significant covariance relationship of (r =.73) between "understanding" and "applying". Lastly, (r = .66) is the significant covariance relationship that existed between "remembering" and "applying".

Furthermore, the findings also revealed that the three categorization of the cognitive domain of educational objectives directly and positively influence students' academic achievement in mathematics with significant direct positive effect of (.13) (Table 5 and Fig. 5). Finally, the overall analysis revealed that the hypothesized model fit to the data.

CONCLUSION

The findings of this study will have important implications for all stakeholders especially mathematics educators, mathematics curriculum designers, educational administrators and policy makers on how to accentuate mathematics teaching and learning via the three levels of cognitive domain of the Bloom's Taxonomy of educational objectives.

Mathematics teachers' should ensure and endeavour to emphasize mathematics teaching via remembering, understanding and applying of the cognitive domain. They should enable learners to see the beauty of learning mathematics through their ability to recall, understand and apply mathematical ideals and principles. Mathematics curriculum designers should be mindful in spelling out strategies of conveying mathematical ideals and principles via the three levels of cognitive domain in mathematics text-books and text-modules. Educational administrators and policy makers should exert greater efforts in ensuring effective conveyance of mathematics teaching and learning through laudable policies such as, train the trainers' workshop, mathematical symposium and further in-service training of mathematics teachers.

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