DOI: https://doi.org/10.67203/jossme.2026.t4h6t2yb

Journal of Studies in Science and Mathematics Education

ISSN: 2630-662x

Published: 06.10.2026

Volume (issue): *6*(2)

Page: 91–102

Psychometric Properties of Instruments for Assessing Teachers' Knowledge, Beliefs, Interest and Self-Efficacy in Mathematics among Pre-service Teachers in North-West Nigeria

Emmanuel Yohanna[1]*, Yusuf Feyisara Zakariya[1,2], Umar Aminu Ginga[1], Mohammed Kabir Falalu[1]

[1]Department of Science Education, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

[2]TETFUND Centre of Excellence in Pedagogy, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

*Corresponding author: emmybage2@gmail.com

Abstract

This paper reports the development and psychometric validation of four instruments designed to assess pre-service mathematics teachers' content knowledge, beliefs, interest, and teaching self-efficacy in North-West Nigeria. The instruments include the Mathematics Teachers' Content Knowledge Test (MTCKT), Teachers' Mathematics Beliefs Inventory (TMBI), Interest in Mathematics Teaching (IMT) Questionnaire, and Mathematics Teaching Self-Efficacy (MTSE) Scale. The study employed a correlational survey design with a sample of 212 pre-service teachers (87 university students and 125 college of education students). Content and face validity were established through expert reviews by mathematics education specialists and educational psychologists. Construct validity was examined through confirmatory factor analysis (CFA) for the TMBI, IMT, and MTSE instruments. Item analysis for the MTCKT included difficulty and discrimination indices, resulting in the removal of two items. Reliability was assessed using split-half reliability with Spearman-Brown coefficient for the MTCKT (r = 0.671) and McDonald's Omega coefficient for the Likert-scale instruments (TMBI ω = 0.945; IMT ω = 0.943; MTSE ω = 0.969). CFA results demonstrated acceptable model fit for two-factors of TMBI and three-factor structures of the IMT, and MTSE instruments. The findings suggest that the adapted instruments have a good psychometric properties for use in the Nigerian context, though further refinement is recommended for the knowledge test.

Keywords: instrument validation, pre-service teachers, mathematics education, psychometric properties, content knowledge, beliefs, interest, self-efficacy.

1 Introduction

The quality of mathematics instruction in Nigerian classrooms is fundamentally dependent on teachers' knowledge, beliefs, interest, and self-efficacy (Ball et al., 2008; Ekmekci et al., 2019). Empirical evidence from Nigeria reveals concerning deficiencies in teachers' mathematical content knowledge, with studies in Kwara, Kaduna, and Bauchi states showing that over 70% of primary school teachers failed assessments on the mathematics content they are expected to teach (Abdulhamid et al., 2020; Adamolekun, 2013; Nasir, 2017). These findings highlight the urgent need for comprehensive assessment tools to evaluate pre-service teachers' mathematical competencies and related psychological constructs. The measurement of teachers' knowledge, beliefs, interest, and self-efficacy presents significant methodological challenges, particularly in developing country contexts where instruments developed in Western settings may not be culturally appropriate or psychometrically sound (Mosvold & Fauskanger, 2014; Delaney et al., 2008). While several instruments exist for measuring these constructs internationally—such as the Learning Mathematics for Teaching (LMT) instruments (Hill et al., 2004), the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Enochs et al., 2000), and the TEDS-M beliefs scales (Tatto et al., 2008)—few have been systematically validated for use with pre-service teachers in Nigeria.

This paper addresses this gap by reporting the development, adaptation, and psychometric validation of four instruments for assessing pre-service mathematics teachers' content knowledge, beliefs about mathematics, interest in teaching mathematics, and mathematics teaching self-efficacy in the North-West geopolitical zone of Nigeria. The study is guided by the theoretical frameworks of Social Cognitive Theory (Bandura, 1986), Constructivist Learning Theory (Piaget,

1970), and Expectancy-Value Theory (Eccles & Wigfield, 2002), which collectively inform the conceptualization and measurement of these constructs.

The following research questions are designed to guide the study. They are:

1. What is the level of mathematical knowledge of pre-service teachers across higher institutions in North-West, Nigeria?
2. What beliefs do pre-service teachers hold regarding nature and teaching of mathematics across higher institutions in North-West, Nigeria?
3. What is the relationship between the mathematical knowledge of pre-service teachers and their interest in mathematics?
4. What is the relationship between the mathematical knowledge of pre-service teachers and their teaching self-efficacy?
5. What is the relationship between the beliefs of pre-service mathematics teachers and their interest in mathematics?
6. What is the relationship between the beliefs of pre-service mathematics teachers' interest and their teaching self-efficacy?
7. What is the relationship between the mathematical knowledge of pre-service teachers' interest and their teaching self-efficacy?

2 Literature Review/Theoretical Framework

The development and validation of the instruments in this study are anchored in three complementary theoretical frameworks that explain the interrelationships among teachers' knowledge, beliefs, interest, and self-efficacy.

2.1 Social Cognitive Theory

Bandura's (1986) Social Cognitive Theory posits that learning occurs within a dynamic interplay of personal factors, behavioral patterns, and environmental influences. Central to this theory is the concept of self-efficacy, defined as an individual's belief in their capability to organize and execute the courses of action required to manage prospective situations (Bandura, 1997). This theory provides the foundational framework for understanding how pre-service teachers' beliefs about their capabilities are developed and how these beliefs drive their motivation and professional behavior. The Mathematics Teaching Self-Efficacy (MTSE) Scale was developed based on this theoretical foundation, incorporating the four primary sources of efficacy beliefs identified by Bandura (1997): enactive mastery experiences, vicarious experiences, social persuasion, and physiological and affective states.

2.2 Constructivist Learning Theory

Piaget's (1970) Constructivist Learning Theory emphasizes that knowledge is actively constructed by the learner through experiences and interactions with the world. This epistemological perspective views learning as an organic process of assimilation and accommodation, where individuals build new understandings upon their existing cognitive frameworks (Piaget, 1970). From this viewpoint, mathematical knowledge is not a static set of rules to be memorized but a dynamic and interconnected web of concepts that individuals must mentally structure (Philipp, 2007). This theory underpins the conceptualization of teachers' knowledge in the Mathematics Teachers' Content Knowledge Test (MTCKT) and informs the Teachers' Mathematics Beliefs Inventory (TMBI) by linking epistemological stances on the nature of mathematics to pedagogical approaches.

2.3 Expectancy-Value Theory

Eccles and Wigfield's (2002) Expectancy-Value Theory provides a motivational framework for understanding why individuals choose to engage, persist, and perform in given tasks. The theory posits that motivation is jointly determined by expectations for success and the subjective value attached to the task, which includes attainment value, intrinsic value, utility value, and cost (Eccles & Wigfield, 2002). This theory directly informs the Interest in Mathematics Teaching (IMT) Questionnaire, conceptualizing interest as a product of high intrinsic value and expectancy beliefs. The instrument

measures three dimensions of interest: enjoyment and intrinsic motivation, personal value and importance, and engagement and curiosity, consistent with the multidimensional nature of value proposed by the theory.

3 Materials and Methods

3.1 Research Design

This study adopted a correlational design with a quantitative approach to establish the psychometric properties of the instruments. The predictive correlational design was employed as the primary objective was to validate instruments for subsequent investigation of predictive relationships among variables (Creswell & Guetterman, 2018). A positivist philosophical stance underpinned this design, emphasizing measurable, objective data through surveys and validated scales.

3.2 Participants

The pilot study involved 212 pre-service mathematics teachers comprising 87 final-year university students and 125 third-year Colleges of education students from North-West Nigeria. This sample was drawn from the study population of 376 university students and 695 college of education students. Participants were selected because they had completed substantial coursework in mathematics content and pedagogy, making them appropriate representatives of the target population. The sample size of 212 exceeds the recommended minimum of 200 for factor analysis (Kline, 2016) and satisfies guidelines for item-to-participant ratios (recommended 5:1 to 10:1) for the instruments with the largest number of items (30 items on TMBI, requiring at least 150 participants).

3.3 Instruments

3.3.1 Mathematics Teachers' Content Knowledge Test (MTCKT)

This instrument originally comprised 20 multiple-choice items. The instrument assessed pre-service teachers' content knowledge across five mathematics content areas: numbers and numerations, plane and circle geometry, trigonometry, statistics, and probability. A sample of the items is: The distance, d, through which a stone falls from rest varies directly as the square of the time, t, taken. If the stone falls 27cm in 3 seconds, how far will it fall in 5 seconds? Items were adapted in line with existing measures as those in the LMT MKT Measures (Hill et al., 2004), Measures of Effective Teaching (Phelps et al., 2014), and MKT measures by Howell et al. (2016). Items were contextualized based on Nigerian secondary and basic education curriculum contents.

3.3.2 Teachers' Mathematics Beliefs Inventory (TMBI)

This 30-item instrument measured beliefs about the nature of mathematics (15 items) and beliefs about the teaching of mathematics (15 items). For instance, items on Teachers' Beliefs about Nature of Mathematic: "There's usually only one correct way to solve a math problem" and "Effort and persistence can overcome natural math ability limits (R)," "Drill and practice is the most effective way to learn math ". While items on Beliefs about Teaching of Mathematics: "Students should discover math concepts through exploration (R)". Please indicate with a tick (√) on your agreement with each statement using: 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Slightly Agree (SlA), 4 = Agree (A), and 5 = Strongly Agree (SA). Items were adapted from scales by Tatto et al. (2008) and Angel-Cuervo et al. (2024), using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The dimension of Beliefs about the Nature of Mathematics (BNM) consisted of 10 negatively worded as can be seen in the first instance with no (R) and five positively worded items. The reverse-scored items were included to mitigate response bias.

3.3.3 Interest in Mathematics Teaching (IMT) Questionnaire

This 15-item instrument measured pre-service teachers' interest in teaching mathematics across three dimensions: Enjoyment and Intrinsic Motivation (5 items), sample of item on this dimension: "I find teaching mathematics enjoyable and fulfilling." Personal Value and Importance (5 items), sample of item on this dimension is "I feel that my skills are well-suited for teaching mathematics." and Engagement and Curiosity (5 items), a sample of item on this dimension is "I like exploring new ways to teach math concepts creatively." All the 15 items were positively worded. Respondents were

asked to indicate with a tick (√) on your agreement with each statement using: 1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Slightly Agree (SlA), 4 = Agree (A), and 5 = Strongly Agree (SA). Items were adapted from Oliveira et al. (2023) using a 5-point Likert scale.

3.3.4 Mathematics Teaching Self-Efficacy (MTSE) Scale

The MTSE was a 25-item instrument adapted Enochs et al. (2000). For the purpose of this, only 15 items from the original was adapted spread across three dimensions and containing five items as in the original. These dimensions are Instructional Strategies Self-Efficacy (ISSE) (e.g., I can use a variety of teaching methods to explain mathematical concepts effectively), Classroom Management Self-Efficacy (CMSE) (e.g., I can maintain discipline in the classroom while teaching mathematics), and Student Engagement and Motivation Self-Efficacy (EMSE) (e.g., I can motivate students who show little interest in mathematics). All the items were positively worded in all the three dimensions and caption on a 5-point Likert scale ranging from not at all confident through moderately confident to extremely confident.

3.4 Expert Validation

Content and face validity were established through expert reviews. Two experts in Mathematics Education (a PhD holder from the Department of Science Education, ABU Zaria, and a PhD holder from the Department of Mathematics, FUE Zaria) reviewed the MTCKT items for content coverage, clarity, difficulty level, and alignment with the curriculum. They assessed whether items adequately covered the mathematics content domains and identified items that were too difficult or ambiguous. Based on their recommendations, items with word-problem complexity that might disadvantage students due to time constraints were replaced with more direct questions. Typographic errors, grammatical issues, and ambiguous phrasing were corrected. For the TMBI, IMT, and MTSE instruments, two experts from the Department of Educational Psychology (a Professor and a PhD holder) assessed the degree to which items measured the theoretical constructs of teachers' beliefs, interest, and teaching self-efficacy. The expert panel evaluated item relevance, clarity, and representativeness, ensuring cultural and contextual appropriateness for the Nigerian setting. These experts were familiar with the theoretical frameworks underpinning each instrument and provided recommendations for item modifications.

3.5 Procedures for Data Collection and Analysis

Administration of the instruments was carried out by research assistants (lecturers and some pre-service teachers) following approved timing from each institution's department. The instruments were administered simultaneously using paper-and-pencil format at different intervals based on various academic calendars. No personal identifying information was collected; participants only indicated their gender. Item analysis for the MTCKT involved calculating difficulty and discrimination indices for each item. Difficulty index (p) was computed as the proportion of respondents who answered the item correctly. A difficulty index of less than 0.3 indicates a difficult item, between 0.5 and 0.7 is ideal, and greater than 0.7 indicates an easy item (Bhavsar et al., 2022). Discrimination index (d) was calculated using the point-biserial correlation or the difference between proportions in upper and lower scoring groups. A discrimination index of greater than or equal to 0.36 indicates an excellent item, between 0.25 and 0.35 is good, between 0.21 and 0.25 is acceptable, and 0.20 or below indicates a poor item (Bhavsar et al., 2022). Items falling outside acceptable ranges were considered for removal.

Data were analyzed using SPSS version 26.0 and Mplus version 8.3 for confirmatory factor analysis. Descriptive statistics were computed for all items. For the MTCKT, split-half reliability was calculated using the Spearman-Brown coefficient, which correlates scores from two halves of the test. This method was chosen because it is appropriate for a single administration of a performance test with varying item difficulty and provides a conservative estimate of reliability (Nunnally & Bernstein, 1994). For the Likert-scale instruments (TMBI, IMT, and MTSE), McDonald's Omega coefficient (ω) was calculated to estimate reliability. Omega was preferred over Cronbach's alpha because it allows items to have different factor loadings and provides a more accurate estimate of Reliability Coefficients, particularly for multidimensional scales (Zakariya, 2022; McNeish, 2018). Omega is derived from factor analysis and focuses on how well items measure the underlying construct rather than just item quantity.

Confirmatory Factor Analysis (CFA) was conducted to test the hypothesized factor structures of the TMBI, IMT, and MTSE instruments. Model fit was evaluated using multiple fit indices: Chi-square (χ^2), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). Acceptable model fit was indicated by CFI and TLI values ≥ 0.90, and SRMR values ≤ 0.08 (Hu & Bentler, 1999).

4 Results

4.1 Validity Evidence

4.1.1 Content and Face Validity

Expert reviews confirmed that the MTCKT items adequately covered the specified content domains of numbers and numerations, geometry, trigonometry, statistics, and probability. The panel recommended modifications to item 8 and item 19, which were subsequently removed based on item analysis results. For the TMBI, experts confirmed that items effectively measured the theoretical constructs of beliefs about the nature of mathematics and beliefs about mathematics teaching, with items reflecting both instrumentalist and constructivist perspectives. The IMT questionnaire items were deemed clear and representative of the three interest dimensions (enjoyment and intrinsic motivation, personal value and importance, engagement and curiosity). The MTSE items were confirmed to represent the five efficacy dimensions: instructional strategies, classroom management, student engagement, content knowledge and pedagogy, and personal teaching efficacy.

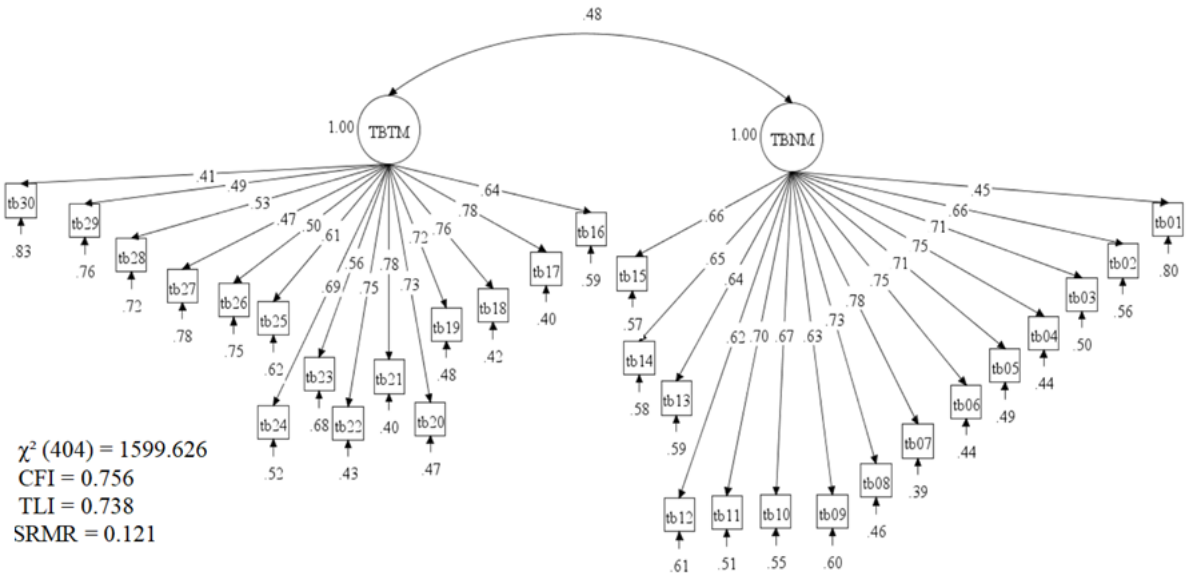
4.1.2 Construct Validity: Confirmatory Factor Analysis

Teachers' Mathematics Beliefs Inventory (TMBI)

The CFA was conducted to examine a two-factor structure of the Teachers' Mathematics Beliefs Inventory (TMBI) was supported by the data. The results are presented in Figure 1.

Figure 1

Evaluated two-factor TMBI model



As shown in Figure 1, the two-factor TMBI model produced $\chi^2(404) = 1599.626$, CFI = 0.756, TLI = 0.738, SRMR = 0.121 and a $\chi^2 / df_{ratio} \cong 3.9$, which lied within the lenient criteria. The CFI and TLI values fall below the commonly recommended threshold of 0.90, and the SRMR is somewhat elevated, indicating that the model fit is not optimal. These results suggest potential issues with the factor structure or with specific items. As noted in the analysis, this may reflect the complexity of measuring beliefs, which often exhibit multidimensional and context-dependent structures (Fives & Buehl, 2016), or it may indicate a need for further item refinement.

Interest in Mathematics Teaching (IMT) Questionnaire

The CFA for the Interest in Mathematics Teaching (IMT) Questionnaire examined a **three-factor structure** consisting of enjoyment and intrinsic motivation, personal value and importance, and engagement and curiosity. The results are presented in Figure 2.

Figure 2

Evaluated three-factor IMT model

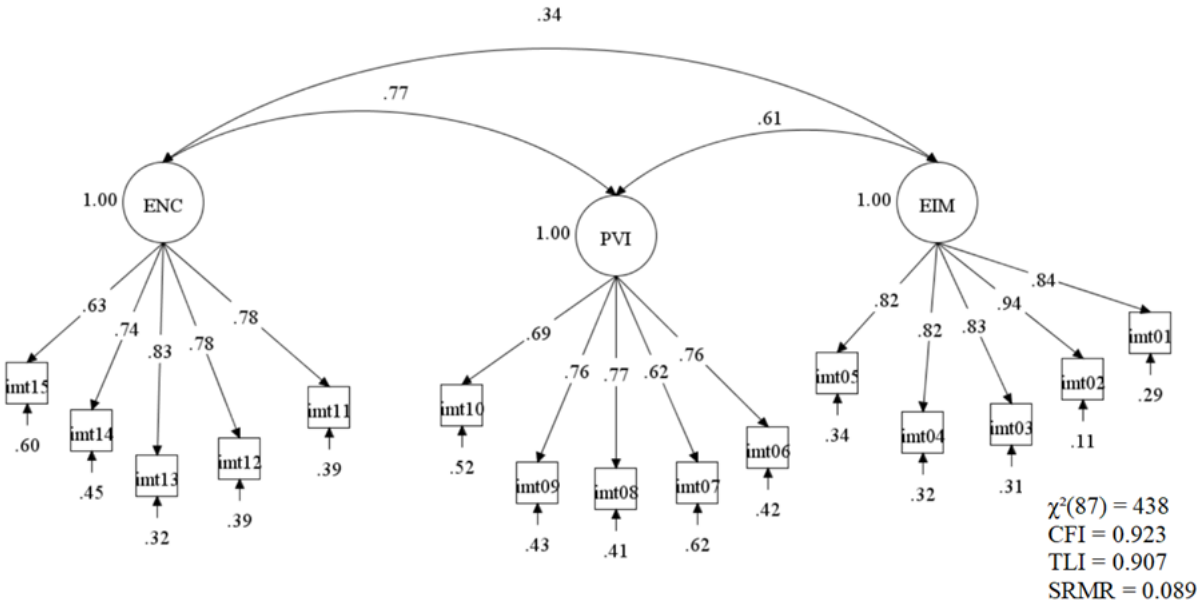


Figure 2 presents the CFA results for the three-factor IMT model: $\chi^2(87) = 438$, CFI = 0.923, TLI = 0.907, SRMR = 0.089 and a $\chi^2 / df_{ratio} \cong 5.03$, which is little above the lenient criteria of <**5.0**. These indices indicate acceptable to good model fit, with both CFI and TLI exceeding the 0.90 threshold. The three-factor structure—representing enjoyment and intrinsic motivation, personal value and importance, and engagement and curiosity—is therefore supported by the data. This confirms that the IMT questionnaire effectively measures the hypothesized dimensions of interest in mathematics teaching.

Mathematics Teaching Self-Efficacy (MTSE) Scale

The CFA of the Mathematics Teaching Self-Efficacy (MTSE) Scale examined a **three-factor model** comprising instructional strategies self-efficacy, classroom management self-efficacy, and student engagement and motivation self-efficacy. The results are presented in Figure 3.

Figure 3 *Confirmatory Factor Analysis of the Three-Factor Structure of the Mathematics Teaching Self-Efficacy (MTSE) Scale*

Mathematics Teaching Self-Efficacy (MTSE)

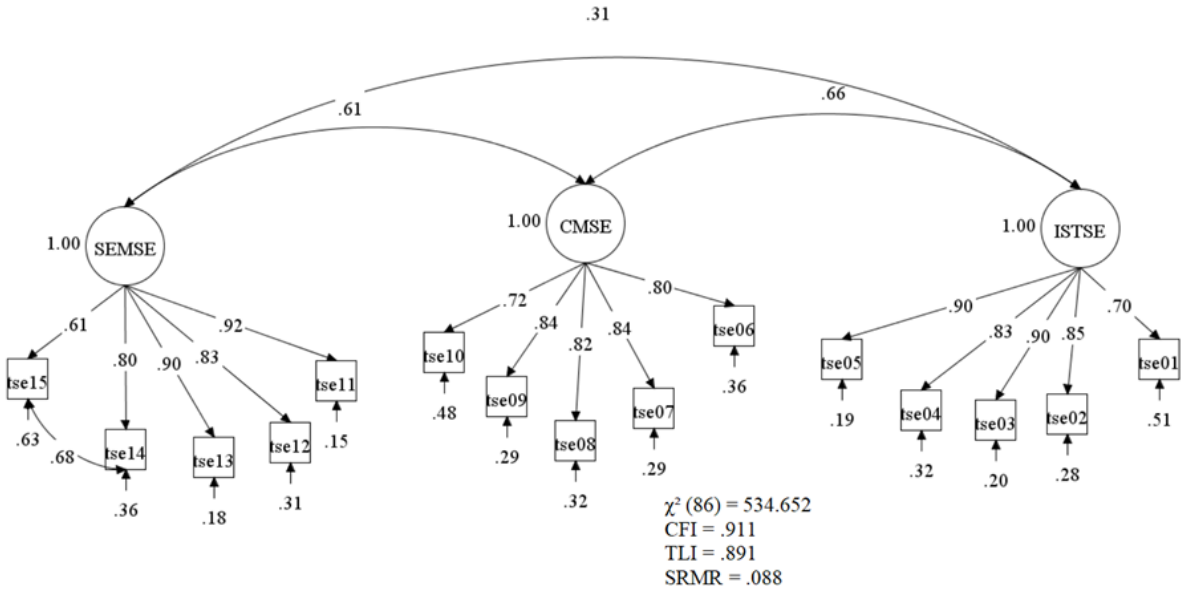


Figure 3 displays the CFA results for the three-factor MTSE model, comprising ISSE, CMSE, and SEMSE. The fit statistics were $\chi^2(86) = 534.652$, CFI = .911, TLI = .891, SRMR = .088 and a $\chi^2 / df_{ratio} \cong 6.2$, which is above the lenient criteria of **<5.0**. These values suggest that the hypothesized three-factor structure does not provide an adequate fit to the data, indicating the need for further refinement of the factor structure or item content. This may be due to the complexity of measuring self-efficacy as a multidimensional construct, which often exhibits intercorrelations among subscales (Tschannen-Moran & Hoy, 2001), or it may reflect cultural differences in how Nigerian pre-service teachers conceptualize teaching self-efficacy.

4.1.3 Item Difficulty and Discrimination (MTCKT)

Item analysis for the initial 20 MTCKT items revealed the following difficulty indices ranging from 0.22 to 0.70, and discrimination indices ranging from 0.180 to 0.527. Based on the established criteria, two items were removed: Item 8 had a difficulty index of 0.26 (below the minimum acceptable threshold of 0.30) and a discrimination index of 0.180 (below the minimum acceptable threshold of 0.21). This indicated that the item was too difficult for most respondents and did not effectively discriminate between higher and lower performing participants. Item 19 had a difficulty index of 0.22 (below the minimum acceptable threshold of 0.30) and a discrimination index of 0.220. While the discrimination index was technically acceptable, the very low difficulty index indicated the item was too difficult for the target population, confirming the expert reviewers' concerns about the item's complexity.

Table **1**

Summary of Item Analysis for MTCKT

Items	Description	Difficulty Index	Discrimination Index	Remarks
Q1	Difference of two square expression	0.56	0.338	Accepted
Q2	Indicial expression	0.65	0.306	Accepted
Q3	Invertible of a matrix	0.61	0.478	Accepted
Q4	Reading out scores on a graph	0.50	0.225	Accepted
Q5	Finding percentages from a graph	0.33	0.284	Accepted

Items	Description	Difficulty Index	Discrimination Index	Remarks
Q6	Conditions for solving triangles	0.50	0.307	Accepted
Q7	Determining zero's of a fraction	0.63	0.393	Accepted
Q8	Angles in the same segment of a circle	0.26*	0.180*	Rejected
Q9	Simplification of Surdic expression	0.63	0.464	Accepted
Q10	Solving indicial equation	0.63	0.487	Accepted
Q11	Indicial expression	0.54	0.393	Accepted
Q12	Proportions in word problem	0.48	0.337	Accepted
Q13	Factoring expression	0.63	0.341	Accepted
Q14	Determining unknown base in equation	0.68	0.495	Accepted
Q15	Determining of constant quadratic eqtn.	0.70	0.452	Accepted
Q16	Finding equation of line, given two pts.	0.36	0.271	Accepted
Q17	Probability of experimental events	0.69	0.404	Accepted
Q18	Compliment and intersection of sets	0.48	0.280	Accepted
Q19	Mean deviation of ungroup data	0.22*	0.220	Rejected
Q20	Product of decimal in standard form	0.61	0.527	Accepted

*Note: *Indicates values outside acceptable range

4.2 Reliability Coefficients

4.2.1 MTCKT

Split-half reliability using the Spearman-Brown coefficient for the remaining 18 items of the MTCKT yielded a coefficient of 0.671. This value is considered moderate but acceptable for a knowledge test, particularly given the heterogeneity of content areas assessed and the relatively small number of items (Salvia et al., 2017). The value falls within the acceptable range for research purposes, though it suggests that further item development could improve reliability.

4.2.2 TMBI

McDonald's Omega reliability coefficients for the TMBI were: 0.927 for the Teachers' Beliefs about the Nature of Mathematics (TBNM) dimension, 0.912 for the Teachers' Beliefs about the Teaching of Mathematics (TBTM) dimension, and 0.945 for the whole 30-item instrument. These high omega values indicate excellent reliability estimate, confirming that items within each dimension and the overall scale reliably measure the intended belief constructs.

4.2.3 IMT Questionnaire

McDonald's Omega reliability coefficients for the IMT were: 0.931 for the Enjoyment and Intrinsic Motivation (EIM) dimension, 0.845 for the Personal Value and Importance (PVI) dimension, 0.869 for the Engagement and Curiosity (EnC) dimension, and 0.943 for the whole 15-item scale. These values indicate good to excellent internal consistency across all dimensions and the total scale.

4.2.4 MTSE Scale

McDonald's Omega reliability coefficients for the MTSE dimensions were: .919 for ISSE, .903 for CMSE, .908 for SEMSE, and 0.969 for the 15-item scale. These values indicate excellent internal consistency across all dimensions and the total scale.

5 Discussion

5.1 Interpretation of Validity and Reliability Findings

The validation of instruments for assessing pre-service teachers' knowledge, beliefs, interest, and self-efficacy represents a critical contribution to mathematics education research in Nigeria. The current study provides evidence that these adapted instruments have good psychometric properties for use in this context, though with some caveats.

The content validity of all instruments was well-established through expert review, a process that ensured alignment with theoretical frameworks. This is consistent with best practices in educational measurement, which emphasize the importance of expert judgment in establishing content validity (Johnson & Onwuegbuzie, 2004; Messick, 1995). The experts' recommendations led to the removal of ambiguous or overly difficult items from the MTCKT, improving its content coverage and appropriateness for the target population.

The reliability coefficients obtained for the Likert-scale instruments (TMBI, IMT, and MTSE) are excellent, with McDonald's Omega values ranging from 0.845 to 0.969. These values exceed the commonly recommended threshold of 0.70 for research purposes (Nunnally & Bernstein, 1994) and compare favorably with similar instruments in the literature. For instance, the MTEBI has reported Cronbach's alpha values typically above 0.70 (Enochs et al., 2000; Segarra & Julià, 2022), and the TEDS-M beliefs scales have demonstrated acceptable reliability across 17 countries (Tatto et al., 2008). The consistently high omega values suggest that items within each dimension are highly internally consistent and that these instruments can be used with confidence for research purposes.

The split-half reliability coefficient of 0.671 for the MTCKT is moderate, reflecting the challenges inherent in measuring content knowledge with a limited number of items across diverse mathematics content areas. This value is consistent with other knowledge tests in mathematics education research; for example, Bowie et al. (2019) reported varying reliability coefficients for their MCK assessment, and Alshehri and Youssef (2022) reported a KR20 of 0.73. The moderate reliability suggests that the MTCKT is adequate for group-level comparisons but may not be sufficiently precise for individual-level assessment. Future research should focus on expanding the item pool to enhance reliability.

5.2 Implications of CFA Results

The construct validity findings present a mixed picture. The IMT questionnaire demonstrated acceptable to good model fit (CFI = 0.923, TLI = 0.907), confirming the three-dimensional structure of interest as conceptualized by Expectancy-Value Theory (Eccles & Wigfield, 2002). This finding is theoretically meaningful, distinguishing between the affective dimension of interest (enjoyment and intrinsic motivation), the cognitive dimension (personal value and importance), and the behavioral dimension (engagement and curiosity). These dimensions align with the multidimensional nature of value proposed by Eccles and Wigfield (2002) and support the utility of the IMT for research on teacher motivation.

The TMBI and MTSE instruments, however, showed less optimal fit indices, with CFI and TLI values below the recommended threshold of 0.90. Several factors may explain these results. For the TMBI, beliefs are inherently complex, multidimensional, and context-dependent constructs that may not conform to simple factor structures (Fives & Buehl, 2016; Skott, 2019). The conceptual distinctions between beliefs about the nature of mathematics and beliefs about teaching mathematics may be less clear-cut in practice, with these beliefs operating as an integrated belief system (Ernest, 1989; Thompson, 1992). Additionally, the expert reviewers noted that some items may have been ambiguous to participants, which could have contributed to suboptimal model fit. For the MTSE, the high intercorrelations among self-efficacy dimensions (Tschannen-Moran & Hoy, 2001) may produce a unidimensional or hierarchical structure rather than distinct factors. The content of the items, spanning five dimensions of efficacy, may also have led to response patterns that do not align with the hypothesized factor structure. These findings suggest the need for further validation studies, including cross-validation with independent samples, to refine the factor structures of these instruments for the Nigerian context.

5.3 Comparison with Previous Studies

The psychometric properties obtained in this study are broadly consistent with previous validation research. The omega values for the TMBI (0.945) and MTSE (0.969) are comparable to or exceed those reported in similar studies. For example, Purnomo (2017) reported Cronbach's alpha values of 0.715–0.787 for a mathematics beliefs scale, while Sainuddin et al. (2022) reported omega values of 0.88–0.92 for a holistic assessment instrument. The reliability coefficients for the IMT (0.943) align with the findings of Oliveira et al. (2023), who reported total scale reliability of 0.71 for their Teacher Motivation for Teaching (TMT) questionnaire. The item analysis for the MTCKT revealed that most items fell within acceptable ranges for difficulty and discrimination, consistent with item analysis standards for

multiple-choice assessments (Bhavsar et al., 2022). However, the presence of items with low difficulty indices (Q8 and Q19) suggests that some content areas may be more challenging for pre-service teachers than anticipated, which is consistent with previous findings of content knowledge deficiencies among Nigerian mathematics teachers (Abdulhamid et al., 2020; Adamolekun, 2013; Nasir, 2017).

5.4 Limitations of the Validation Study

Several limitations should be acknowledged. First, the pilot sample, while adequate for initial validation, was relatively small and drawn from a specific geographic region. Generalizability to other regions of Nigeria or to different populations of pre-service teachers may be limited. Second, the study relied on self-report data for the belief, interest, and self-efficacy instruments, which may be subject to social desirability bias despite efforts to ensure anonymity (Safrudiannur & Rott, 2019). Finally, criterion-related validity (e.g., correlations with actual teaching performance or student outcomes) was not established, which would strengthen the case for the instruments' validity.

6 Conclusion

This paper has reported on the development and psychometric validation of four instruments for assessing pre-service mathematics teachers' content knowledge, beliefs, interest, and teaching self-efficacy in North-West Nigeria. The instruments—MTCKT, TMBI, IMT, and MTSE—demonstrate acceptable to excellent psychometric properties, with strong evidence for content validity, face validity, and internal consistency. The IMT questionnaire shows good construct validity, while the TMBI and MTSE instruments require further refinement of their factor structures. The MTCKT, while useful, would benefit from the addition of more items to improve reliability. These instruments fill an important gap in the assessment of pre-service mathematics teachers in Nigeria and provide researchers and practitioners with tools to investigate the complex relationships among knowledge, beliefs, interest, and self-efficacy in mathematics education. The validation process underscores the importance of adapting and validating instruments for local contexts rather than relying solely on measures developed in Western settings. Future research should continue to refine these instruments and extend their validation to other populations and regions, contributing to the broader goal of improving mathematics teacher education and ultimately student learning outcomes in Nigeria.

7 Recommendations

The study recommends that the TMBI, IMT, and MTSE instruments can be confidently used for research in Nigeria due to their strong reliability, though researchers should explore alternative factor structures for the TMBI and MTSE, while the MTCKT should be used cautiously and only for group comparisons, not individual assessment. For practitioners, the validated instruments can support teacher education program evaluation, identify pre-service teachers needing efficacy-building experiences, help shift beliefs toward constructivist orientations, and enhance interest in mathematics teaching. Future research should involve cross-validation with larger and more diverse samples, investigate alternative factor structures using EFA and CFA, expand the MTCKT item pool, examine measurement invariance across groups, and explore relationships between these constructs and variables such as teaching practices, student outcomes, and teacher retention.

8 References

Abdulhamid, L., Yushau, B., & Sambo, A. A. (2020). Analysis of Universal Basic Education teachers' mathematical content knowledge in Nigerian public schools. *The Journal of Mathematical Association Nigeria, 45*(1).

Adamolekun, A. (2013). Primary school teachers' competency test in Kwara State. *Journal of Education and Practice, 4*(2), 45–56.

Alshehri, K. A., & Youssef, H. N. (2022). The influence of mathematical knowledge for teaching towards elementary teachers' mathematical self-efficacy. *EURASIA Journal of Mathematics, Science and Technology Education, 18*(6), em2118.

Angel-Cuervo, Z., Briceño-Martínez, J., & Bernal-Ballén, A. (2024). Validation of a questionnaire to evaluate mathematics teachers' beliefs about mathematics, teaching, and learning. *Eurasia Journal of Mathematics, Science and Technology Education*. https://doi.org/10.29333/ejmste/14447

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall.

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman.

Ball, D., Thames, M., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*, 389–407.

Bhavsar, S. D., Jadhav, S. S., & Abhange, R. S. (2022). Analysis of multiple-choice questions based medical undergraduate assessment tool. *Research and Clinical Medicine Journal, 6*(1), 12–16.

Bowie, L., Venkat, H., & Askew, M. (2019). Pre-service primary teachers' mathematical content knowledge: An exploratory study. *African Journal of Research in Mathematics, Science and Technology Education, 23*(3), 286–297.

Creswell, J. W., & Guetterman, T. (2018). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (6th ed.). *Pearson*.

Delaney, S. F., Ball, D. L., Hill, H. C., Schiling, S. G., & Zopf, D. A. (2008). Adapting U.S. measures of "Mathematical knowledge for teaching" for use in Ireland. *Journal of Mathematics Teachers Education, 11*, 171–197.

Dunn, T. J., Baguley, T., & Brunsden, V. (2014). From alpha to omega: A practical solution to the pervasive problem of internal consistency estimation. *British Journal of Psychology, 105*(3), 399–412.

Eccles, J., & Wigfield, A. (2002). Motivational beliefs, values, and goals. Annual Review of Psychology, *53*, 109–132.

Ekmekci, A., Corkin, D. M., & Fan, W. (2019). A multilevel analysis of the impact of teachers' beliefs and mathematical knowledge for teaching on students' mathematics achievement. *Australian Journal of Teacher Education, 44*(12).

Enochs, L. G., Smith, P. L., & Huinker, D. A. (2000). Mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194–202.

Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of Education for Teaching, 15*(1), 13–33.

Fives, H., & Buehl, M. M. (2016). Teachers' beliefs, in the context of policy reform. *Policy Insights from the Behavioral and Brain Sciences, 3*(1), 114–121.

Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal, 105*, 11–30.

Howell, H. K., Phelps, G., Croft, A., & Gitomer, D. (2016). Using think-aloud interviews to characterize the knowledge for teaching of secondary mathematics. *Journal of Mathematics Teacher Education, 19*(2-3), 207–235.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–-55.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14–26.

Kline, R. B. (2016). Principles and practice of structural equation modeling (4th ed.). Guilford Press.

McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological Methods, 23*(3), 412–433.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning. *American Psychologist, 50*(9), 741–749.

Mosvold, R., & Fauskanger, J. (2014). Teachers' beliefs about mathematical horizon content knowledge. *Journal of Mathematics Teacher Education, 17*(5), 415–432.

Nasir, A. (2017, November 6). Poor quality of education in public primary school: Chairman Kaduna State SUBEB. Punch Newspaper.

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (3rd ed.). McGraw-Hill.

Oliveira, P. D., Rufini, S. É., & Bzuneck, J. A. (2023). Teacher's motivation for teaching: questionnaire validity evidence. *Estudos de Psicologia (Campinas)*, 40, e210084.

Phelps, G., Weren, B., Croft, A., & Gitomer, D. (2014). Developing content knowledge for teaching assessments for the measures of effective teaching study. *ETS Research Report Series*.

Philipp, R.A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), Second Handbook of Research on Mathematics Teaching and Learning (pp. 257-315). Charlotte, NC: Information Age Publishing.

Piaget, J. (1970). Science of education and the psychology of the child. Orion Press.

Purnomo, Y. W. (2017). A scale for measuring teachers' mathematics-related beliefs: *A validity and reliability study*.

Safrudiannur, & Rott, B. (2019). Measuring Teachers' Beliefs: A Comparison of Three Different Approaches. *eurasia Journal of Mathematics, Science and Technology Education*, *16*(1), em1796 ISSN:1305-8223 https://doi.org/10.29333/ejmste/110058

Sainuddin, S., Subali, B., Jailani, Elvira, M. (2022). The development and validation prospective mathematics teachers holistic assessment tools. Ingénierie des Systèmes d'Informatio, *27*(2), 171–184. https://doi.org/10.18280/isi.270201

Tatto, M. T., J. Schwille, S. Senk, L. Ingvarson, R. Peck, and G. Rowley. 2008. Teacher Education and Development Study in Mathematics (TEDS-M): Policy, *Practice, and Readiness to Teach Primary and Secondary Mathematics. Conceptual Framework*. East Lansing MI: Teacher Education and Development International Study Center, College of Education, Michigan State University

Tschannen-Moran, M., & Hoy, A.W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, *17*(7), 783–805.

Zakariya, Y. F. (2022). Cronbach's alpha in mathematics education research: Its appropriateness, overuse, and alternatives in estimating scale reliability. *Frontiers in Psychology*, *13*, 1074430. https://doi.org/10.3389/fpsyg.2022.1074430

Publisher's Note

The views, interpretations, and conclusions expressed in this article are solely those of the author(s) and do not necessarily reflect the views or policies of the Journal of Studies in Science and Mathematics Education (JOSSME), its publisher, editorial board, editors, reviewers, or the authors' affiliated institutions. The publisher remains neutral with respect to jurisdictional claims in published maps, institutional affiliations, and other representations. Any products, materials, methods, or manufacturers mentioned or evaluated in this article are presented solely for scholarly purposes and do not constitute endorsement, recommendation, or guarantee by the publisher.