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CONSTRUCTION AND STANDARDIZATION OF TEST OF MATHEMATICS ACHIEVEMENT (TMA) FOR CLASS VIII STUDENTS

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ABSTRACT
The present study aimed to construct and standardize a Test of Mathematics Achievement (TMA) for Class VIII students to ensure a valid and reliable measurement of mathematical proficiency. The tool was developed following a systematic process that included content selection from the Mizoram Board of School Education (MBSE) syllabus, item construction based on Bloom's taxonomy, and expert validation. The TMA initially contained 35 multiple-choice items, which were piloted and analysed for item difficulty and discrimination. Following item analysis, 30 items meeting acceptable psychometric standards were retained. Reliability was established using the split-half and Kuder–Richardson (K-R 20) methods, yielding coefficients of 0.78 and 0.79, respectively, indicating high internal consistency. Content and construct validity were verified through expert judgment and theoretical alignment. The standardized TMA thus provides an effective tool for assessing mathematics achievement, facilitating pedagogical improvements, and supporting evidence-based educational practices, particularly in culturally responsive and ethnomathematical contexts.
KEYWORDS: *Mathematics, Mathematics Achievement, Standardization, Construction.*

INTRODUCTION

Mathematics has always been viewed as a fundamental part of human knowledge and an essential component of education at all levels. Often described as the language of science and technology due to its clarity, logical structure, and universal importance (Devlin, 2012), mathematics is more than just an academic subject. It is a vital life skill that supports rational decision-making, analytical thinking, and problem-solving in everyday life (Kilpatrick, Swafford, & Findell, 2001). It helps develop reasoning, abstract thinking, and systematic problem-solving abilities—skills that are crucial in the 21st century (Schoenfeld, 2016). As a result, math literacy has become a key indicator of a nation's educational standards and human capital development (OECD, 2019). At the school level, math education aims to build computational skills alongside conceptual understanding, reasoning, and an appreciation for the beauty and importance of mathematical ideas (NCTM, 2014). For middle school students, especially those in Class VIII, this stage marks an important shift from basic arithmetic to advanced reasoning involving algebra, geometry, and data analysis (Mullis et al., 2016). Establishing a strong foundation at this stage ensures readiness for further education and sustained numeracy (Anthony & Walshaw, 2009). Additionally, math fosters persistence, creativity, and metacognitive awareness—traits vital for academic success and personal growth (Boaler, 2016).

Mathematics, despite its global importance, is often regarded as a challenging and anxiety-provoking discipline by students (Ashcraft & Krause, 2007). Ineffective pedagogy, insufficient conceptual clarity, cultural attitudes, and poor learning assistance contribute to disparate accomplishment levels (Singh & Agarwal, 2017). International assessments such as PISA and TIMSS demonstrate enduring disparities in mathematics achievement, highlighting the necessity for evidence-based teaching and assessment methodologies (OECD, 2019; Mullis et al., 2016). Therefore, enhancing mathematics learning outcomes necessitates both new pedagogical approaches and reliable, accurate assessments to track student advancement and guide curricular development.

In this perspective, understanding mathematical achievement is crucial for improving the overall quality of schooling. By recognizing learning patterns and areas of difficulty, instructors can develop focused interventions that help improve knowledge. Enhancing mathematics proficiency at the basic level is essential for developing critical, creative, and flexible thinkers capable of succeeding in a progressively data-driven and technology environment.

Mathematics Achievement

Mathematics achievement defines the degree to which students attain knowledge, abilities, and comprehension in mathematics through instruction and educational experiences (Mullis et al., 2016). It serves as a measure of student cognitive development and

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is a crucial element of academic achievement. Success in mathematics is linked not just to academic skill but also to the capacity for logical thinking, problem-solving, and the application of mathematical reasoning in practical contexts (Kilpatrick, Swafford, & Findell, 2001). In the educational setting, mathematical proficiency is frequently assessed through tests and examinations aimed at evaluating students' understanding of curriculum objectives across several domains, including number systems, algebra, geometry, and statistics.

Numerous factors affect mathematics accomplishment, such as cognitive abilities, motivation, teacher effectiveness, instructional methodologies, socio-economic status, and cultural setting (OECD, 2019). Studies show that students engaged in concept-based and problem-oriented training have superior mathematical comprehension relative to those subjected to rote learning techniques (Boaler, 2016). Also, continuous assessment using valid and reliable tools allows educators to identify learning weaknesses and apply interventions to improve student performance (Nitko & Brookhart, 2014). Thus, accurately assessing mathematics achievement is essential for instructional enhancement and policy development.

In India, mathematics achievement is a significant issue due to noticeable performance disparities among students from different socio-economic and linguistic backgrounds (NCERT, 2021). The National Achievement Survey (NAS) and other national assessments indicate that numerous middle school students experience difficulties with conceptual understanding and application-oriented problem solving. Therefore, developing a standardized and psychometrically sound Test of Mathematics Achievement (TMA) is vital for ensuring objective evaluation along with equitable assessment processes. This tool assists teachers in identifying students' learning challenges and promotes effective teaching methods that improve overall proficiency in mathematics.

Need for the test of Mathematics achievement

In the field of educational research, the validity and reliability of assessment tools play a critical role in accurately measuring students' learning outcomes. The present study was designed to assess the effectiveness of ethnomathematical teaching strategies on the mathematics achievement of Class VIII students. To achieve this, the investigator developed the Test of Mathematics Achievement (TMA) specifically aligned with the objectives and context of the study. During the preliminary review of existing tools, it was observed that several standardized mathematics achievement tests have been developed for various educational levels; however, these tools were either based on different curricula or focused on cognitive dimensions that did not correspond to the present study's focus on ethnomathematics. Most of these available instruments primarily assess procedural and computational skills, neglecting the cultural and contextual aspects of mathematics learning (D'Ambrosio, 1985).

Given that the ethnomathematical approach emphasizes the integration of cultural practices, indigenous knowledge systems, and local problem-solving methods into the mathematics classroom, it became evident that conventional tests would not effectively measure the outcomes of such a pedagogy (Bishop, 1988; Rosa & Orey, 2016). The curriculum content, contextual relevance, and expected learning outcomes of Class VIII students in this study required an assessment tool that reflected both academic and cultural dimensions of mathematical understanding. Hence, the development of a new Test of Mathematics Achievement (TMA) was necessary to ensure content validity and to provide a comprehensive evaluation of students' conceptual understanding, problem-solving skills, and application of mathematical ideas within their cultural contexts. The construction of this test thus serves as a vital step in aligning assessment methods with the pedagogical innovation introduced through ethnomathematical strategies.

Purpose of the Study

The purpose of the study was to develop and validate a test of mathematics achievement (TMA) to evaluate mathematics achievement for class VIII students, carry out item analysis (difficulty and discrimination index), and estimate the reliability coefficient of the test of mathematics achievement.

Research Method

The present study is basically to design, develop, and validate a test of mathematics achievement. In the present study, an analysis of textbooks and syllabi was conducted, content selection was done, and items based on it were developed. Basically, it was an instrument in nature, and it was suitable to assess the mathematics achievement among the class VIII students. The descriptive survey research method is considered appropriate for this study as it would help to obtain first-hand information regarding the level of acquisition of mathematics achievement. The population comprised class VIII students of the Mizoram Board of School Education (MBSE) School in Mizoram state. The research sample used was made up of one hundred (100) students from the secondary school of the Aizawl district of Mizoram state.

Development and Standardization of Test of Mathematics Achievement (TMA).

EXPLORATORY STAGE

A. Selection of content for the test of mathematics achievement.

To determine the subject for mathematical achievement, the researcher examined the Mizoram board syllabus. After reviewing the curriculum and the textbook, the researcher identified the chapters and their respective content.

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Table:1
Selected Content

S.No.		Contents	No of items
1		**Understanding Quadrilaterals**	**6**
	a	Convex and concave polygons	1
	b	Angle sum property	1
	c	Sum of measures of exterior angles of a polygon	1
	d	Kind of quadrilaterals	1
	e	Angles of a parallelogram	1
	f	Some special parallelogram	1
2		**Practical Geometry: Constructing a Quadrilateral when**	**6**
	a	Length of four sides and the diagonal given	2
	b	Two diagonals and three sides given	1
	c	Two adjacent sides and three angles are known	1
	d	Three sides and two included angles are given	1
	e	Some special cases	1
3		**Data Handling**	**5**
	a	Grouping data	1
	b	Bar graph	1
	c	Circular graph	1
	d	Linking chance to probability	1
	e	Outcomes of an event	1
4		**Visualising Solid Shapes**	**6**
	a	Views of 3-D	3
	b	Faces, Edges, and Vertices	3
5		**Mensuration**	**6**
	a	Area of quadrilaterals	2
	b	Surface area of cube, cuboid, and cylinder	2
	c	Volume area of cube, cuboid, and cylinder	2
6		**Introduction to Graphs**	**6**
	a	A bar graph	1
	b	A line graph	1
	c	A pie graph (Circular graph)	1
	d	A histogram	1
	e	Co-ordinates	1
	f	quadrant	1
		Total	**35**

B. Identification of the Dimensions for the Construction of Items of Test of Mathematics Achievement.

Six dimensions of mathematical achievements were selected for the development of a test of mathematics achievement, and these dimensions have been previously discussed. Each item was prepared based on these dimensions from the selected contents.

PREPARATORY STAGE

A. Preparation of the items:

The primary objective of the mathematics achievement test is to assess the mathematical performance of eighth-grade students. The students' achievement is influenced by the teaching practices; therefore, measures were implemented to ensure that the items are designed to cover the topic selected for the test. The subsequent action was implemented in this context, and items were directly associated with the topic and aligned with the objectives of each unit. Items were specifically constructed in accordance with Bloom's taxonomy. All items were structured as multiple-choice questions, each presenting four distinct responses, of which one was correct.

Each question contains one accurate answer among four provided options. Upon completion of the test items, the initial copy was presented to specialists in mathematics education and educators instructing at the higher secondary level for their comments, feedback, and recommendations. Following expert suggestions and input, solutions to certain questions were revised, and the language was modified to enhance comprehension for learners; fortunately, all 35 items were retained in the second draft.

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B. Scoring

A scoring key was developed with the help of a mathematics teacher (PGT) by solving each question and determining the right answers, which the investigator later verified. Scoring was carried out carefully, assigning '1' for correct answers and '0' for incorrect answers.

C. Pilot Study

The initial draft of the Test of Mathematics Achievement (TMA) was carried out with a sample of 30 pupils in class VIII. The purpose of conducting the TMA was to examine the suitability of item difficulty, linguistic clarity, content adequacy, item design, statement simplicity, and learner accessibility.

After the administration of the TMA, the difficulties encountered by the students were documented to enhance the final draft. The pre-trial made it evident that the respondent provided instructions and clearly comprehended the language of the items. The perspectives of subject teachers about each item were also taken into account. All the items from the first drafts were retained in the second draft.

D. Second Draft of the Test

All items from the initial draft of the mathematics achievement test were retained in the second draft, with slight modifications to the language of those items considered unclear or difficult during the pre-try-out phase. The second draft of the tool comprised the following components:

- **Instructions for Administration**

An introductory statement was provided to articulate the objective and significance of the study, along with essential instructions for completing the test.

- **The Title of the Test**

The test was designed to assess mathematical achievement based on its content. A suitable title for the test was selected: **"Test of Mathematics Achievement (TMA)."**

THE DEVELOPMENT STAGE

A. Second Try Out of the Items

The test was administered to 100 students in person. The test instructions were read after they had been distributed. Examples were employed to illustrate the marking procedures. It was highlighted that no item should be omitted during the administration of TMA, and the respondents were requested and encouraged to provide an authentic response to each item.

B. Item analysis

Item analysis is a crucial step in the standardisation of any tool. Item analysis is a statistical method employed to choose or reject test items based on their discriminatory efficacy. Following pilot testing, the test underwent item analysis to identify which items were easy or difficult, as well as those that were malfunctioning (Stanley et al., 1978). Besides relevance, a commonly sought attribute for a test item is discrimination analysis. To obtain suitable items via item analysis, the researcher utilised 100 answer sheets from the selected sample. The individual's scores for all 100 samples were determined and organised from highest to lowest. The researcher subsequently selected the top 27% of the sample, comprising the high scorers, and the bottom 27%, consisting of the low scorers.

C. Item Selections

Difficulty Index of an Item

The difficulty index of an item is shown by the percentage of students who answered it correctly. The formula is given below.

D.I. = U + L/2N

Where, U is the number of correct answers in the upper group

L is the number of correct answers in the lower group

N is the number of students in both groups.

Discrimination Power of an Item

The discriminating power of an item measures its ability to differentiate between individuals who perform well on the overall test and those who do not. It distinguishes between those possessing the measured attribute and those lacking it. In this particular situation, the characteristic is " mathematics achievement. The item's discriminative power was computed using the formula.

D.P. = U – L/N

Where, U is the number of correct answers in the upper group

L is the number of correct answers in the lower group

N is the number of students in both groups.

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Selection of Items

From the above-mentioned reasons and formulas, the difficulty index and discrimination power of each TMA item were calculated. Any item with a discriminating power over 0.30 should be regarded as a sufficiently effective item (Ebel, 1966). In this experiment, only items with difficulty indices between 0.25 and 0.75 and a discriminating power over 0.40 were selected. Table 2 lists the specifics of this exercise.

Table:2

Table showing the 'D.I.' and 'D.P. Values obtained from Item analysis and selected items for the test of mathematics achievement

Item	D.I.	A/R (0.25-0.75)	D.P.	A/R (0.40 and above)	Result
Item no. 1	0.26	**A**	0.44	**A**	**A**
Item no. 2	0.65	**A**	0.41	**A**	**A**
Item no. 3	0.44	**A**	0.52	**A**	**A**
Item no. 4	0.54	**A**	0.41	**A**	**A**
Item no. 5	0.46	**A**	0.48	**A**	**A**
Item no. 6	0.78	**R**	0.07	**R**	**R**
Item no. 7	0.46	**A**	0.41	**A**	**A**
Item no. 8	0.54	**A**	0.48	**A**	**A**
Item no. 9	0.44	**A**	0.59	**A**	**A**
Item no. 10	0.56	**A**	0.44	**A**	**A**
Item no. 11	0.91	**R**	-0.11	**R**	**R**
Item no. 12	0.26	**A**	0.52	**A**	**A**
Item no. 13	0.52	**A**	0.44	**A**	**A**
Item no. 14	0.61	**A**	0.41	**A**	**A**
Item no. 15	0.35	**A**	0.41	**R**	**A**
Item no. 16	0.59	**A**	0.59	**A**	**A**
Item no. 17	0.96	**R**	-0.07	**R**	**R**
Item no. 18	0.48	**A**	0.52	**A**	**A**
Item no. 19	0.46	**A**	0.41	**A**	**A**
Item no. 20	0.61	**A**	0.41	**A**	**A**
Item no. 21	0.93	**R**	0.15	**R**	**R**
Item no. 22	0.69	**A**	0.41	**A**	**A**
Item no. 23	0.52	**A**	0.44	**A**	**A**
Item no. 24	0.61	**A**	0.41	**A**	**A**
Item no. 25	0.50	**A**	0.41	**A**	**A**
Item no. 26	0.54	**A**	0.41	**A**	**A**
Item no. 27	0.59	**A**	0.44	**A**	**A**
Item no. 28	0.31	**A**	0.48	**A**	**A**
Item no. 29	0.48	**A**	0.59	**A**	**A**
Item no. 30	0.50	**A**	0.41	**A**	**A**
Item no. 31	0.57	**A**	0.41	**A**	**A**
Item no. 32	0.80	**R**	0.26	**R**	**R**
Item no. 33	0.65	**A**	0.41	**A**	**A**
Item no. 34	0.61	**A**	0.48	**A**	**A**
Item no. 35	0.50	**A**	0.41	**A**	**A**

Note: A- denotes the items accepted; R- denotes the items not selected/rejected.

The table indicates that precisely 30 items were selected and retained for the final test. Therefore, after the item was analysed, a total of 5 items were removed from the test, resulting in a final draft of the TMA comprising 30 items.

FINAL STAGE

A. Time Limit

During the exploratory phase, respondents were allocated 40 minutes. During the administration of the second draft, it was observed that the majority of respondents completed the questions within 30 minutes. Consequently, a duration of 35 minutes was designated for the last stage of the test.

Reliability and Validity of the Test of Mathematics Achievement

In the present study reliability of the test of mathematics achievement (TMA) has been established with the help of two methods, split half reliability method and K-R 20 reliability method. The results are presented below.

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Table:3

Measuring tool	Reliability coefficient	
Test of Mathematics Achievement	Split-half	K-R 20
Value of reliability coefficient	0.78	0.79

Validity of Test of Mathematics Achievement

Reliability denotes the precision of a measurement, while validity addresses whether a measurement accurately assesses what it purports to measure. Kerlinger (1973) identified content validity as the most significant among the three categories of validity, since they relate to the extent to which specific explanatory constructs may account for respondents' performance on a particular measure. Consequently, to ascertain the validity of the TMA, content validity was established.

(a) Content validity

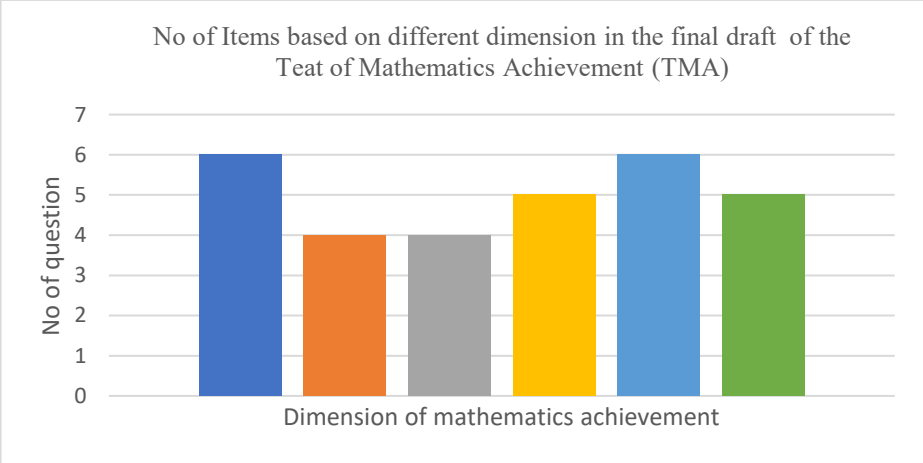
Content validity is a primary indicator that enables us to assert the purpose of the test's content, specifically what the test assesses. The extent to which a test's content accurately reflects the domain it is intended to assess. Content validity fundamentally relies on the assessment of experts within the discipline. The content validity of the test of mathematics achievement was determined based on the judgments and feedback of specialists in education, mathematics, and mathematics education. The primary objective of an achievement test is to assess the extent to which students have acquired the content. So, according to Best & Kahn (2006), content validity is deemed optimal for these categories of tests. Experts from each discipline were selected to validate the test. All items were evaluated by experts from various fields, who assessed their content relevance and deemed them appropriate. Additionally, the significance of the items was tested during the initial trial.

Therefore, the 'Test of Mathematics Achievement' might be considered to have sufficient content validity.

Number of Items Based on Different Dimensions in Final Draft of Test of Mathematics Achievement (TMA)

Table:4

S.No.	Contents	No of items
1	Understanding Quadrilaterals	**6**
2	Practical Geometry	**4**
3	Data Handling	**4**
4	Visualising Solid Shapes	**5**
5	Mensuration	**6**
6	Introduction to Graphs	**5**



Final Draft of the Test of Mathematics Achievement (TMA)

The final format of the mathematics achievement test comprises 30 multiple-choice questions. One mark is awarded for each correct answer and zero marks for each incorrect response. The test has a maximum score of 30 and a minimum score of 0. The time limit for completing the full test is 35 minutes.

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