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Evaluating the Cognitive Demand of Trigonometry and Mensuration Unit in Class X Mathematics: A Study of Mizoram Board's Textbook

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Abstract
This study evaluates the cognitive demand of end-of-chapter exercises in the Trigonometry and Mensuration units of the Class X Mathematics textbook prescribed by the Mizoram Board of School Education. Using Revised Bloom's Taxonomy (RBT), end of chapter questions were analyzed to determine the distribution of lower-order (LOTS) and higher-order thinking skills (HOTS). Results revealed a dominance of LOTS (72.4% in Trigonometry, 75.8% in Mensuration), with "Applying" (C3) being the most frequent cognitive level. HOTS questions constituted only 27.6% and 24.2%, respectively, with minimal representation of "Evaluating" (C5) and no "Creating" (C6) tasks. The findings highlight a need for curriculum revisions to incorporate more HOTS-focused questions, fostering critical thinking and creativity.

Keywords: Cognitive demand, Revised Bloom's Taxonomy, Mathematics textbook, Higher Order thinking skills, Mizoram Board

1. INTRODUCTION

Mathematics serves as the foundation for developing logical reasoning, problem-solving abilities, and creative thinking among secondary school students. Within this discipline, Trigonometry and Mensuration hold particular significance as they bridge abstract mathematical concepts with real-world applications. Trigonometry, with its study of angles, triangles, and periodic functions, forms the basis for advanced fields like physics, engineering, and architecture (Gravemeijer et al., 2017). Mensuration, focusing on geometric shapes and their measurements, cultivates spatial reasoning and precision—skills essential for careers in design, construction, and technology (Boaler, 2016).

At the secondary level, these units are not merely about memorizing formulas but about nurturing higher-order cognitive skills. When students engage with Trigonometry, they learn to model real-life scenarios—calculating heights of buildings, navigating using bearings, or understanding wave patterns—which enhances their analytical and creative thinking (NCTM, 2020). Similarly, Mensuration

challenges students to visualize and manipulate shapes, fostering spatial intelligence and innovative problem-solving (Bruner, 1960). For instance, designing a park layout with specific area constraints or optimizing material use in packaging requires both logical reasoning and creativity.

Despite their potential, the effectiveness of these units depends heavily on how they are presented in textbooks. A well-designed curriculum should balance procedural fluency with opportunities for exploration, evaluation, and creation (Anderson & Krathwohl, 2001). However, studies indicate that many textbooks emphasize rote application over deeper cognitive engagement (Nithya & Malathy, 2020). This gap weakens students' ability to think rationally, critically and adapt knowledge to new circumstances, a necessity in today's rapidly evolving world.

This study evaluates the cognitive demand of exercises in the Trigonometry and Mensuration units of the Class X Mathematics textbook prescribed by the Mizoram Board, using Revised Bloom's Taxonomy (RBT). By analyzing the distribution of lower-order (LOTS) and higher-order thinking skills (HOTS), it aims to identify whether the current pedagogical approach aligns with the goals of fostering creativity and logical reasoning. The findings will inform recommendations for curriculum enhancements, ensuring that students not only master essential skills but also develop the ability to innovate and apply knowledge meaningfully.

2. RESEARCH OBJECTIVES

1. To analyze the textual questions of class X Mathematics textbook prescribe by Mizoram Board of School Education using Revised Bloom's Taxonomy based on cognitive dimension.
2. To analyse the thinking skill order among the Units in class X Mathematics textbook prescribe by Mizoram Board of School Education.

3. REVIEW OF RELATED STUDIES

Gholami et al. (2021) conducted study on "Analysis of the Mathematics Function Chapter in a Malaysian Foundation Level Textbook Adopted by a Public University". They examined the quality of the function chapter, mainly the section on problem solving, in the Mathematics 1 textbook of a Malaysian public university's foundation center. The results showed that roughly 6% of tasks dealt with higher order thinking and 94% of tasks dealt with lower order thinking. The comprehension level accounted for 55.79% of the tasks, while the recall, evaluation, and creation levels were 0% for 37.8%.

Mita et al. (2021) studied on "Cognitive Level Analysis of Problems in Mathematics Textbook Class XII Revision 2018 Materials of Congress and Construction Based on the Revised Bloom TaxonomyThe 2018 Revised Class XII Mathematics Textbook for Congruence and Similarity Based on Bloom's Taxonomy's question distribution has been described in this study. The findings demonstrated that the cognitive levels of the questions—which exclude the cognitive levels of remembering, assessing, and creating—were understanding 18.2%, applying 50%, and analyzing 31.8%.

Samsudi et al. (2023) studied on research title, “Bloom Anderson's Taxonomy-Based Cognitive Level Analysis of Grade 10 Interactive Mathematics Book Questions”. In this study, the distribution of cognitive abilities in the 10th-grade interactive mathematics textbook is examined. It describes each cognitive skill and groups them based on Bloom's taxonomy using a qualitative research methodology. The results show that the cognitive skills in both chapters are not evenly divided. While questions requiring higher-order thinking, such creativity (C6), are limited (3.59%), application-related (C3) questions (78.8%) predominate.

Lira et al. (2024) worked on a research titled “Descriptive Analysis of Questions in the 2013 Curriculum Textbook (2018 Revised Edition) for Grade IX SMP/MTs Mathematics Lessons”. Initially, the researcher independently analyzed the questions in the grade IX SMP/MTs mathematics student book to start the research procedure. The findings point out that the "knowing" cognitive domain accounted for 37.68% of the items. In the book, 52.21% of the cognitive domain is used for "applying."

Anisya and Jailani (2024) studied on research titled, “Cognitive level of word problems in high school mathematics textbooks class X”. According to the findings, the cognitive level of mathematics word problems is analyzing procedural knowledge (45.61%), followed by applying procedural knowledge (19.30%), understanding conceptual knowledge (10.53%), analyzing conceptual knowledge (7.02%), understanding factual knowledge (3.51%), remembering conceptual knowledge and assessing metacognitive knowledge (3.51%), analyzing factual knowledge, analyzing conceptual knowledge, understanding procedural knowledge, and creating procedural knowledge in that order (1.75%).

4. METHODOLOGY

Research Design

The study adopts document analysis as its primary qualitative research methodology. This approach involves the systematic examination, interpretation, and evaluation of written materials to uncover underlying meanings, patterns, and insights. As a well-established research technique, document analysis enables researchers to critically assess textual content while maintaining the integrity of the original sources. The method proves particularly valuable when studying educational materials like textbooks, as it allows for comprehensive evaluation of content structure, cognitive demands, and pedagogical approaches without direct interaction with human subjects.

In this investigation, document analysis serves as the foundation for assessing the Class X Mathematics textbook's Trigonometry and Mensuration units. The methodology follows a rigorous process of content examination, beginning with initial familiarization of the materials, followed by detailed coding of exercises based on Revised Bloom's Taxonomy.

Sample

The sample of the study is Trigonometry and Mensuration Unit of Class X Mathematics Textbook named LEARNING MATHS, 2022 Mizoram Edition published by Frank Education Aids Pvt. Ltd., prescribed by Mizoram Board of School Education.

Table 1: Sample of the Study

Unit	Chapter	Topic	Exercise	MCQ	Total
Trigonometry	12	Trigonometric Identities	49	9	58
	13	Trigonometric Ratios of Complementary Angles	18	10	28
	14	Heights and Distances	25	5	30
Mensuration	15	Areas Related to Circles	32	8	40
	16	Surface Areas and Volumes	49	10	59

Tool Used

The analysis of textual questions was carried out by referring to the framework of the revised edition of Bloom's taxonomy (Anderson & Krathwohl, 2001). In the Bloom's revised taxonomy, there are two dimensions of the framework, namely the dimensions of cognitive processes and knowledge. For this study only cognitive dimension is considered. RBT's (Revised Bloom's Taxonomy) cognitive dimension includes Remembering (C1), Understanding (C2), Applying (C3), Analyzing (C4), Evaluating (C5), and Creating (C6).

5. ANALYSIS AND FINDINGS

5.1 Finding on the analysis of textual questions using Revised Bloom's Taxonomy's Cognitive domain.

Table 2: Distribution of *Unit VI Exercises in the Six Levels of Cognitive Dimensions*.

Chapter	Level of Cognitive Dimension						Total
	C1	C2	C3	C4	C5	C6	
12	-	5 (8.6%)	28 (48.3%)	24 (41.4%)	1 (1.7%)	-	58
13	-	5 (17.8%)	22 (78.6%)	1 (3.6%)	-	-	28
14	-	-	24 (80.0%)	5 (16.7%)	1 (3.3%)	-	30
Total		10	74	30	2	-	116
Percentage		8.6%	63.8%	25.9%	1.7%	-	100%

Figure 1: Exercise across chapters in Unit VI in the Six Levels of Cognitive Dimensions.

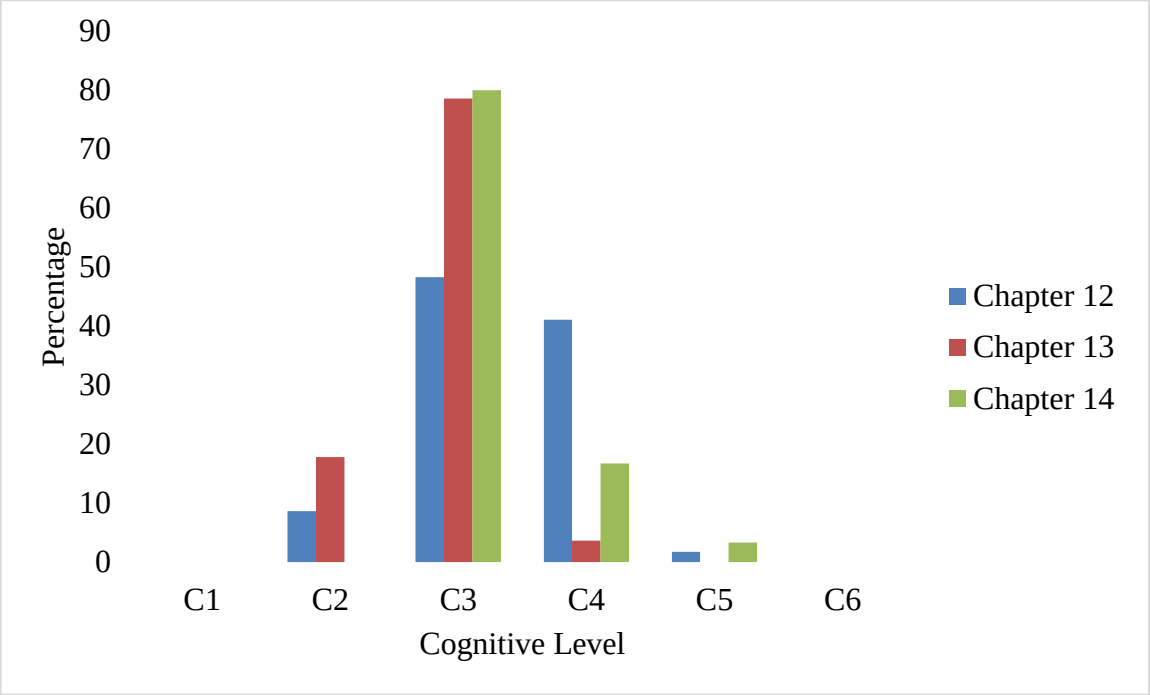


Table 2 shows that in Chapter 12 (Trigonometric Identities), C3 (Applying) level dominate the chapter's exercise with 48.3% belong to this level, requiring students to use identities. C4 (Analyzing) level has 41.4% of the exercises, which involve breaking down complex problems. C2 (Understanding) level comprise of 8.6% of the exercise that assess comprehension, such as interpreting identities or simplifying expressions. C5 (Evaluating) level has 1.7% only which targets judgment based problems. While, C1 (Remembering) level and C6 (Creating) level are absent among the exercise in this chapter.

From the table above, Table 2 and Figure 1 it can be seen that in Chapter 13 (Trigonometric ratio of complementary angles) 78.6% of the exercise belongs to C3 (Applying) level, requiring students to use complementary angles to solve equations. 17.8% are of C2 (Understanding) level, which seems adequate for introducing the concept. 3.6% of the exercise C4 (Analysing) level. Further, C1 (Remembering) level exercise is not included along with C5 (Evaluating) and C6 (Creating) level. The omission of C5 and C6 may stifle metacognitive and innovative thinking.

The table above, Table 2 shows that in Chapter 14 (Height and Distances) C3 (Applying) level dominate the exercise with 80.0% lies in this level, which require applying trigonometry to solve real-world related problems. C4 (Analyzing) level has 16.7% of the exercise which involve analysis. C5 (Evaluating) level includes only 3.3%, that assesses evaluation. Its rarity misses chances to develop judgment and metacognition. While, C1 (Remembering), C2 (Understanding), and C6 (Creating) level exercises are not found among the exercises. The absent of C6 level question indicate the neglects of creativity and real-world relevance.

Table 3: Distribution of the Unit VII Exercises in the Six Levels of Cognitive Dimensions.

Chapter	Level of Cognitive Dimension						Total
	C1	C2	C3	C4	C5	C6	
15	-	1 (2.5%)	24 (60.0%)	13 (32.5%)	2 (5.0%)	-	40
16	-	2 (3.3%)	48 (81.4%)	9 (15.3%)	-	-	59
Total	-	3	72	22	2	-	99
Percentage		3.0%	72.8%	22.2%	2.0%	-	100%

Figure 2: Exercise across chapters in Unit VII in the Six Levels of Cognitive Dimensions.

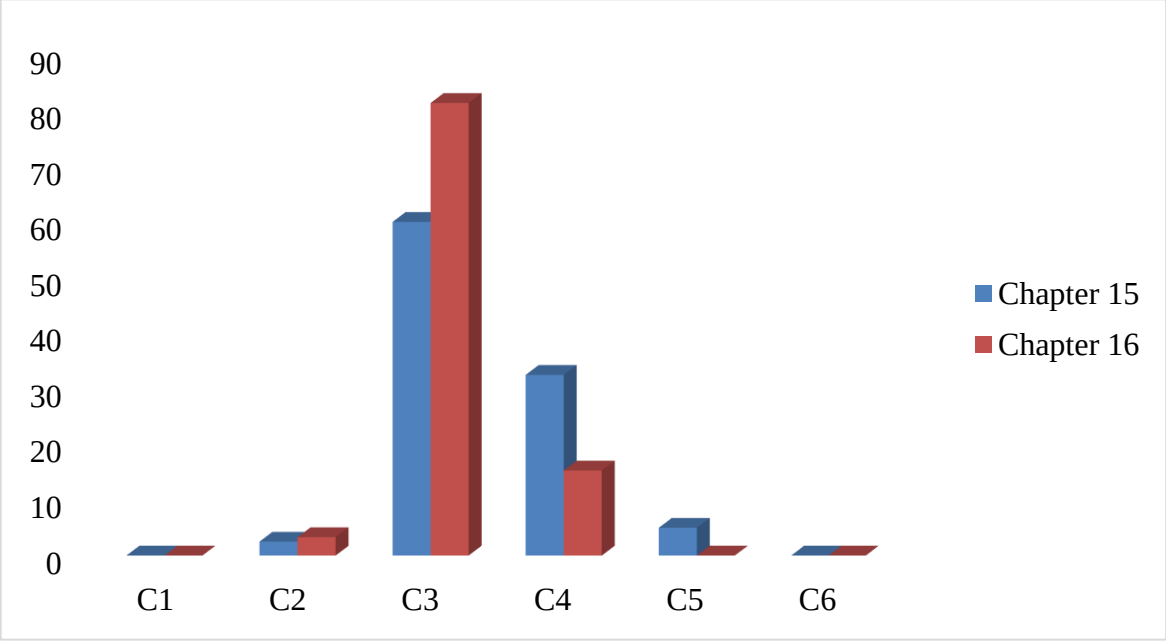


Table 3 shows that in Chapter 15 (Areas Related to Circles) C3 (Applying) level dominates the exercises with 60.0% from this level. This heavy focus reflects the chapter's goal of enabling students to use formulas and methods in practical scenarios. C4 (Analyzing) level accounts 32.5% of the exercises. While, C5 (Evaluating) level has only 5.0% of the exercise and C2 (Understanding) level includes only 2.5%. There is an absent of C1 (Remembering) and C6 (Creating) level exercise within the chapter. The lack of C6 level exercises indicates a missed opportunity for students to engage in innovative tasks.

From the table, Table 3 Chapter 16 (Surface Areas and Volumes) has 81.4% of its exercise from C3 (Applying) level, reflecting a strong focus on using formulas to compute surface areas and volumes of various solids. 15.3% of the exercise belong to C4 (Analyzing) level, involving tasks such as converting solids from one shape to another or solving composite figure problems. Only 3.3% fall within C2 (Understanding) which are mostly from multiple choice questions. C1 (Remembering) level exercise is

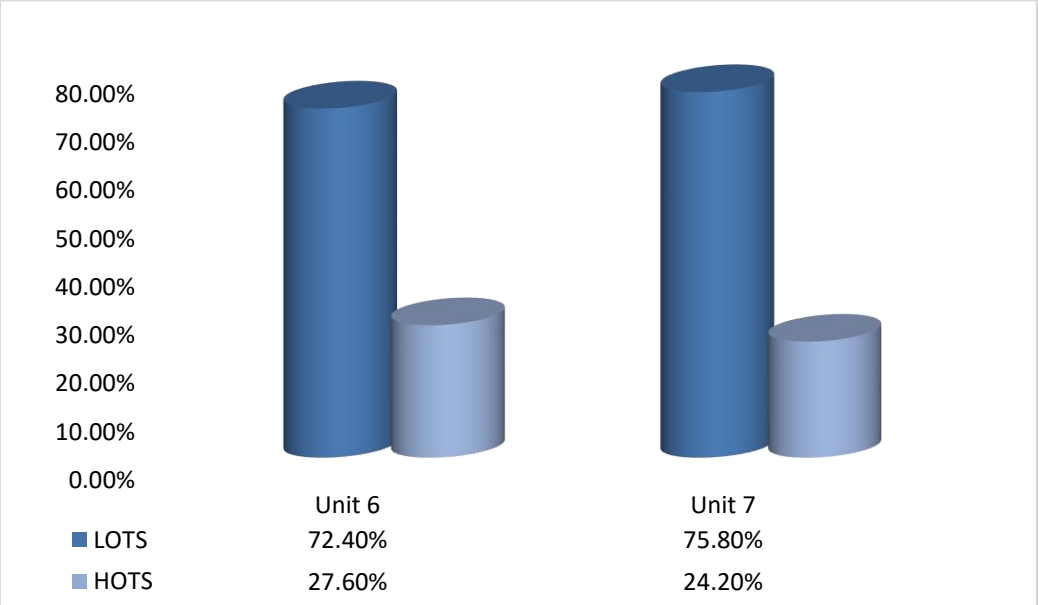
absent. Further, C5 (Evaluating) and C6 (Creating) level are absent, demonstrating no opportunities for students to critique methods, compare solutions, or design original problems.

5.2 Finding on the analysis of textual questions using Revised Bloom's Taxonomy's Cognitive domain.

Table 4: Comparison of Thinking Skills Order in each units.

Sl. No.	Unit	Lower Order Thinking Skills		Higher Order Thinking Skills	
		No. of items	Proportion	No. of items	Proportion
1	Trigonometry	84	72.4%	32	27.6%
2	Mensuration	75	75.8%	24	24.2%

Figure 3: Distribution between HOTS and LOTS in each unit



The analysis of table, Table 4 reveals that Trigonometry has 27.6% HOTS questions, suggesting minimal opportunities for critical analysis or creative problem-solving, while Mensuration has 24.2% HOTS with no questions at the "Creating" (C6) level, highlighting a gap in fostering innovation or real-world application. Further, Trigonometry has 72.4% of questions focus on LOTS base end of chapter questions and Mensuration Unit possess an even higher proportion 75.8% which targets LOTS, reinforcing rote application of formulas and basic concepts.

6. DISCUSSION

The disproportionate distribution between LOTS and HOTS suggests that the textbook primarily serves as a vehicle for reinforcing fundamental knowledge and procedural fluency rather than cultivating more advanced cognitive abilities. While such an approach may ensure students achieve competency in basic

mathematical operations, it fails to adequately address the development of critical analytical skills and creative problem-solving capacities that are increasingly demanded in modern educational paradigms and professional environments. A comparative study by Nithya and Malathy (2020) on Indian school textbooks found a similar trend—most questions were concentrated at the lower cognitive levels (Remembering, Understanding, Applying), with few opportunities for critical analysis or innovation. This suggests a systemic issue in curriculum design, where exam-driven assessment systems prioritize rote memorization and formulaic problem-solving over deep conceptual engagement

The scarcity of higher-order thinking questions, particularly evident in the complete absence of creation-level (C6) tasks, represents a significant pedagogical limitation. This omission deprives students of opportunities to engage in the kind of innovative thinking and knowledge synthesis that characterizes authentic mathematical practice. The current structure, which overwhelmingly favors routine problem-solving over exploratory or evaluative tasks, may inadvertently reinforce a narrow, computation-centric view of mathematics rather than promoting it as a dynamic discipline for modeling and interpreting real-world phenomena.

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