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Cognitive Demand In Mizoram Board's Class X Mathematics Algebra Unit: A Revised Bloom's Taxonomy Analysis

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Abstract: This study evaluates the cognitive level of textual questions in the Algebra unit of the Class X Mathematics textbook prescribed by the Mizoram Board of School Education, using Revised Bloom's Taxonomy (RBT). A content analysis of end-of-chapter questions across five chapters (Polynomials, Linear Equations in Two Variables, Quadratic Equations, Arithmetic Progression, and Sets) was conducted. Results indicate a predominant focus on lower-order thinking skills (LOTS), with 81.9% of questions categorized as "Applying" (C3), while higher-order thinking skills (HOTS) such as "Analyzing" (C4) and "Evaluating" (C5) constituted only 18.1%. Notably, "Creating" (C6) questions were absent. The findings highlight an imbalance in cognitive demand, underscoring the need for curriculum revisions to incorporate more HOTS-based questions to foster critical thinking and problem-solving abilities among students.

Index Terms - Algebra, Cognitive Level, Revised Bloom's Taxonomy, Mathematics Textbook, Mizoram Board.

I. INTRODUCTION

Mathematics education aims to foster the logical thinking and problem-solving abilities that are crucial for success in both academic and professional aspect. Textbooks, as primary instructional tools, play a pivotal role in shaping students' cognitive development. However, the effectiveness of textbooks depends on the alignment of their questions with higher-order cognitive skills (Fan et al., 2018). This study analyzes the cognitive level of questions in the Algebra unit of the Class X Mathematics textbook prescribed by the Mizoram Board of School Education, using Revised Bloom's Taxonomy. Algebra, a foundational branch of mathematics, serves as a gateway to abstract reasoning and problem-solving by introducing variables, equations, and functions to represent real-world relationships symbolically. Having its roots in arithmetic but extending beyond numerical computation, algebra gives students the ability to model situations, analyze structures, and generalize patterns—skills essential for advanced mathematics, science, and engineering. Its emphasis on logical progression and symbolic manipulation fosters cognitive abilities such as critical thinking, analytical reasoning, and systematic problem-solving (Boaler, 2016). For instance, students must deconstruct problems, generate solutions, and assess methods in order to solve quadratic equations or polynomial functions, which engaged higher-order cognitive processes.

Despite its pedagogical significance, the efficacy of algebra instruction hinges on the cognitive demand of learning materials, particularly textbooks. Research underscores that textbooks prioritizing procedural fluency over conceptual depth or creative application may limit students' ability to transfer knowledge to novel contexts (Fan et al., 2018). In Mizoram, where the Learning Maths textbook is a primary resource for Class X students, to make sure that the algebraic questions are in line with 21st-century skills like logical reasoning, creativity, and adaptability, it is crucial to assess their cognitive rigor.

This study uses Revised Bloom's Taxonomy (RBT) to analyze the cognitive level of the algebra unit problems in the textbook that is required for students in Mizoram. The analysis finds gaps in cognitive engagement and suggests ways to improve the textbook's ability to foster advanced mathematical cognition by classifying questions into lower-order (remembering, understanding, applying) and higher-order (analyzing, evaluating, creating) thinking skills.

1.1 Rational of the Study

Despite the critical role of Algebra in developing abstract thinking, limited research examines the cognitive rigor of textbook questions in Mizoram's context. Although textbook questions are an important tool for reiterating knowledge, they frequently lack a systematic approach to fostering higher-order thinking abilities. By assessing the cognitive levels and diversity of problems included in algebra unit of mathematics textbooks, this study aims to close this gap and offer empirical information to curriculum designers, teachers, and legislators. The need of this study lies in its potential to inform evidence-based improvements in textbook design, ensuring that they foster mathematical proficiency in alignment with modern educational standards.

1.2 Objectives of the Study

- To analyze the distribution of textual questions in the Algebra unit using cognitive dimensions in Revised Bloom's Taxonomy.
- To compare the proportion of LOTS (Remembering, Understanding, Applying) and HOTS (Analyzing, Evaluating, Creating) questions in Algebra Unit.

II. REVIEW OF RELATED LITERATURE

Tanujaya et al. (2017) studied on, "Mathematics instruction, problems, challenges and opportunities: a case study in Manokwari Regency, Indonesia." Their findings revealed that the problems in mathematics textbooks were largely designed without a focus on enhancing students' higher-order thinking abilities. The majority (96.35%) of the questions aligned with Bloom's taxonomy, with a heavy emphasis on lower-order skills: remembering (35.52%), understanding (41.35%), and applying (19.48%).

Afifah et al. (2019) in their research titled, "Analysis of student mathematics textbook for second grade of Senior High School based on Curriculum 2013" compared exercises from the government-issued Electronic School Book (BSE) and a privately published textbook (Intan Pariwara) using Bloom's Taxonomy. The analysis showed that the Intan Pariwara textbook contained 40.08% lower-order thinking skills (LOTS) and 59.92% higher-order thinking skills (HOTS), whereas the BSE had a slightly higher LOTS proportion at 50.96% and HOTS at 49.04%.

Mita et al. (2021) conducted a study on, "Cognitive Level Analysis of Problems in Mathematics Textbook Class XII Revision 2018 Materials of Congress and Construction Based on the Revised Bloom Taxonomy." The study assessed the cognitive distribution of questions in the textbook's congruence and similarity section, revealing that 18.2% were at the understanding level, 50% at applying, and 31.8% at analyzing. However, no questions were found at the remembering, evaluating, or creating levels, indicating an imbalanced representation of cognitive skills.

Samsudi et al. (2023) conducted a research on, "Bloom Anderson's Taxonomy-Based Cognitive Level Analysis of Grade 10 Interactive Mathematics Book Questions." The study explored the cognitive skill distribution in a 10th-grade interactive math textbook, using qualitative methods to classify questions according to Bloom's taxonomy. Results showed a disproportionate emphasis on application-level questions (C3) at 78.8%, while higher-order tasks like creation (C6) were scarce (3.59%). This imbalance highlights the need for a more varied and equitable distribution of cognitive-level questions.

III. RESEARCH METHODOLOGY

3.1Research Design

The study uses document analysis, one of the qualitative research techniques. The term document analysis refers to a qualitative research technique used to examine various written documents. This approach entails methodically looking over, interpreting, and evaluating documents in order to derive meaning, comprehend, and generate insights.

3.2 Sample

The sample of the study is Algebra 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
Algebra	3	Polynomials	47	12	59
	4	Linear Equation in Two Variables	86	12	98
	5	Quadratic Equations	85	11	96
	6	Arithmetic Progression	56	10	66
	7	Sets	30	10	40

3.3 Tool Used

The framework of Bloom's taxonomy's revised edition (Anderson & Krathwohl, 2001) was used to analyze the textual questions. There are two framework dimensions in Bloom's revised taxonomy: the dimensions of knowledge and cognitive processes. Only the cognitive dimension is taken into account in this study. Remembering (C1), Understanding (C2), Applying (C3), Analyzing (C4), Evaluating (C5), and Creating (C6) are the cognitive dimensions of RBT (Revised Bloom's Taxonomy).

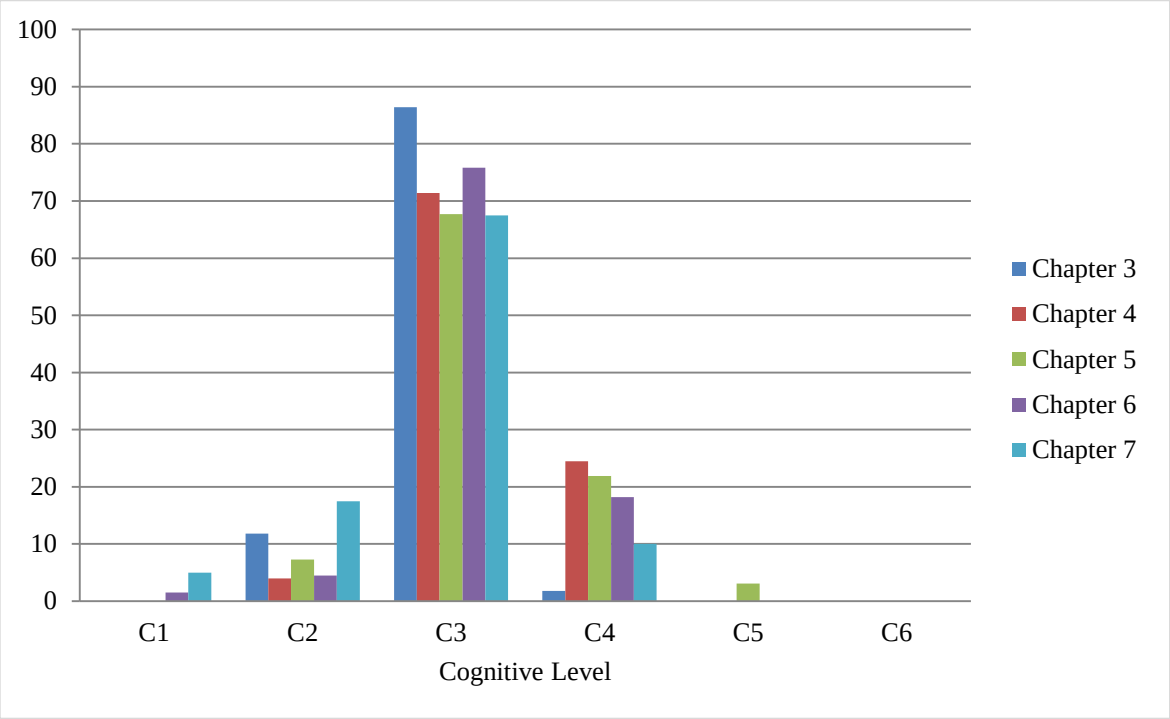
IV. ANALYSIS AND FINDINGS

4.1 Distribution of end of chapter questions in cognitive dimensions of Revised Bloom's Taxonomy.

Table 2: Distribution of Unit III exercises in the Cognitive Dimensions

Chapter	Level of Cognitive Dimension						Total
	C1	C2	C3	C4	C5	C6	
3	-	7 (11.8%)	51 (86.4%)	1 (1.8%)	-	-	59
4	-	4 (4.1%)	70 (71.4%)	24 (24.5%)	-	-	98
5	-	7 (7.3%)	65 (67.7%)	21 (21.9%)	3 (3.1%)	-	96
6	1 (1.5%)	3 (4.5%)	50 (75.8%)	12 (18.2%)	-	-	66
7	2 (5.0%)	7 (17.5%)	27 (67.5%)	4 (10.0%)	-	-	40
Total	3	28	263	62	3	-	359
Percentage	0.8%	7.8%	73.3%	17.3%	0.8%	-	100%

Figure 1: Distribution of the exercise across chapters in Unit III in the Six Levels of Cognitive Dimensions.



From the analysis of the above table, Table 2 it can be seen that in Chapter 3 (Polynomial) 86.4% of exercises fall under C3 (Applying) level, indicating a strong stress on problem-solving and procedural skills. C2 (Understanding) level constitutes 11.8%. While, C1, C5, and C6 are entirely absent, highlighting a gap in exercises requiring recall, evaluation or creativity. The present of 1.8% of exercises targeting C4 (Analyzing) level reflecting scant attention to critical analysis.

The Analysis of Table 2 and Figure 1 gives the nature of Chapter 4 (Linear Equation in Two Variable) where 71.4% of exercises fall under C3 (Applying) level, indicating a strong emphasis on procedural skills, C4 (Analyzing) level constitutes 24.5%, suggesting minimal focus on critical analysis. Only 4.1% of exercises target C2 (Understanding) level, shimmering inadequate consideration to conceptual clarity. Additionally, C1, C5, and C6 levels are entirely absent, underlining a significant gap in exercises requiring recall, evaluation, or creativity.

From Table 2 and Figure 1 it is clear that in Chapter 5 (Quadratic Equation) there is a vast focus on apply (C3) level, where 67.7% of exercises target this specific level, reflecting heavy weight on procedural tasks. It can be seen that there is increasing focus on C4 (Analyzing) level with 21.9.1% of the exercise and C5 (Evaluating) level has marginal focus with 3.1% and C2 (Understanding) levels with 6.2% and 7.3% of exercises. The absent of C6 (Creating) level entirely, shows missing opportunities for innovation for students

Analysis of Chapter 6 (Arithmetic Progression) as shown in Table 2 gives overwhelming emphasis on applying (C3) level with 75.8% of exercises belonging to this level. There is a limited higher-order thinking exercise with 18.2% of exercises being C4 (Analyzing) level and C5 (Evaluating) and C6 (Creating) level entirely absent. There exist a minimal focus on C1 (Remembering) level with 1.5% and C2 (Understanding) level with 4.5% of the exercises, suggesting negligible emphasis on recalling basic facts and comprehension.

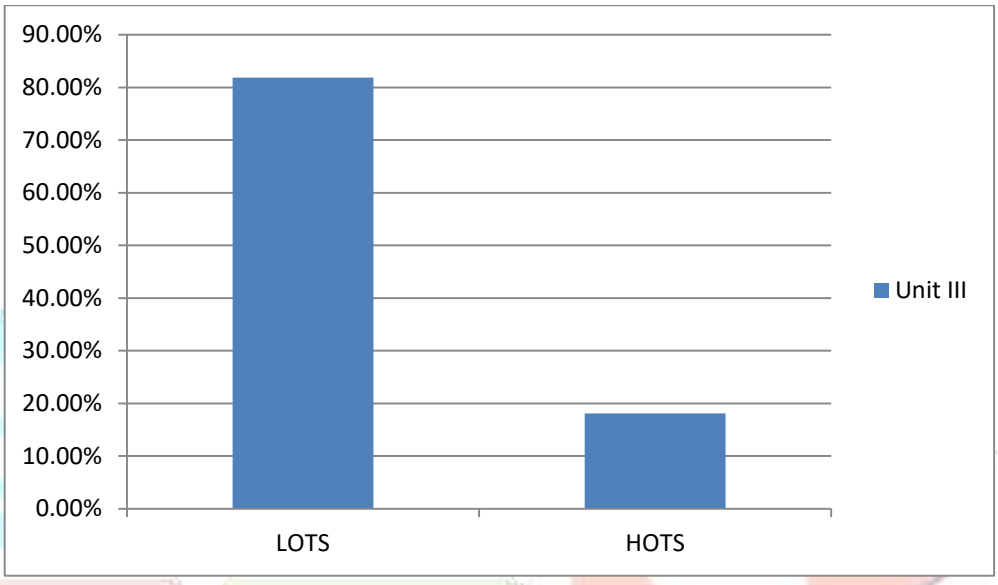
As presented in Table 2, Chapter 7 (Sets) also stretches robust emphasis on C3 (Apply) level with 67.5% of exercises, focusing heavily on procedural tasks. It has 5.0% of the exercise belonging to C1 (Remembering) level and 17.5% to C2 (Understanding) level showing minimal focus on foundational recall and conceptual clarity. Further, Only 10.0% of exercises falls in C4 (Analyzing) level with C5 (Evaluating) and C6 (Creating) levels entirely absent, indicating no opportunities for students to evaluate solutions or innovate.

4.2 Proportion of LOTS (Lower Order Thinking Skills) and HOTS (Higher Order Thinking Skills) questions in Algebra Unit.

Table 3: Comparison of Thinking Skills Order in Algebra Unit.

Unit	Lower Order Thinking Skills		Higher Order Thinking Skills	
	No. of items	Proportion	No. of items	Proportion
Algebra	294	81.9%	65	18.1%

Figure 2: Distribution between HOTS and LOTS in Algebra unit



The analysis of table, Table 3 reveals that Algebra unit has 18.1% HOTS integration in its end of chapter questions. Further, the analysis shows that Algebra unit has 81.9% LOTS base end of chapter question. This show that Lower Order Thinking Skills (LOTS) question has much higher portion compared to Higher Order Thinking Skills (HOTS) question in Algebra unit's Chapters. Figure 2 clearly shows the unbalanced representation between LOTS and HOTS questions in Algebra unit.

V. Discussion

The findings of this study are consistent with prior international research, such as the work of Samsudi et al. (2023), which highlight a disproportionate focus on routine, procedural tasks (C3) and minimal emphasis on evaluation (C5) or creativity (C6). This uneven distribution in instructional emphasis restricts students' ability to cultivate essential skills like analytical reasoning and innovative problem-solving competencies that are increasingly vital in today's complex world, as discussed by Trilling and Fadel (2009).

The overrepresentation of Lower Order Thinking Skills (Remembering, Understanding, and Applying) reflects a traditional, exam-centric pedagogy that emphasizes recall and procedural fluency over critical analysis and innovation, which aligns with Rahman et al. (2019) works. The scarcity of Higher Order Thinking Skills (Analyzing, Evaluating, and Creating) contradicts constructivist learning theories (Bruner, 1966), which advocate for active, inquiry-based learning. Brookhart (2010) argues that students' problem-solving abilities stagnate when assessments lack higher-order cognitive challenges.

To foster well-rounded cognitive development, educators must strive for a more balanced integration of both Lower Order Thinking Skills (LOTS) such as recalling and understanding and Higher Order Thinking Skills (HOTS), including analysis, evaluation, and creation. Such an approach would better equip students with the logical and critical thinking abilities necessary for academic and real-world challenges. The current

textbook structure, however, fails to scaffold students toward these advanced skills, potentially limiting their academic and professional growth.

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