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Engagement, Understanding, and Problem-Solving in Number and Algebra

RONNA Y. MAGTO
Mindanao State University - Iligan Institute of Technology
ronna.magto@g.msuiit.edu.ph

DOUGLAS A. SALAZAR, Ph.D.
Mindanao State University - Iligan Institute of Technology

Abstract — Grade 7 mathematics presents critical challenges as learners transition from concrete arithmetic to abstract algebraic thinking, with rational numbers consistently identified as a significant obstacle to conceptual understanding and problem-solving skills (Jarrah et al., 2022 & Singh et al., 2021). This study presents the needs assessment phase of a three-phase research project investigating how tangible mathematics can enhance grade 7 learners' engagement, understanding, and problem-solving in number and algebra. Using a mixed-methods approach, data were collected from 17 mathematics teachers and 84 grade 7 learners through surveys, interviews, classroom observations, and learner assessments to identify the least mastered topics and evaluate current instructional approaches. Findings revealed unanimous agreement (100% of teachers) that operations with rational numbers represent the most challenging topic for Grade 7 learners, with 78.6% rating these operations as "very difficult" compared to strong performance in geometry topics. Analysis showed a sharp contrast between learners' confidence with visual-spatial concepts (mean rating 4.77/5.00) versus rational numbers (1.12/5.00). Despite experienced teachers (averaging 15.35 years), large class sizes (average of 49 learners) and a complete absence of manipulative use in current instruction were identified as significant barriers. All learners (100%) preferred visual aids and hands-on materials. These findings provide a clear direction for developing targeted tangible mathematics interventions for rational number concepts, addressing the identified content challenges and learners' preferred learning modalities.

Keywords — Tangible mathematics, learners, needs assessment, rational numbers, understanding, problem-solving, engagement.

I. Introduction

The transition to grade 7 mathematics represents a critical juncture in students' mathematical development, characterized by significant shifts from concrete to abstract thinking. During this period, learners face increasing cognitive demands as they navigate the bridge between arithmetic and algebraic reasoning (Wilkie & Sullivan, 2017). Despite ongoing curricular reforms, persistent challenges in mathematical understanding continue to impact learner achievement, particularly in fundamental areas such as rational numbers and algebraic concepts (OECD, 2023).

This study presents the needs assessment phase of a three-phase research project investigating how tangible mathematics can enhance grade 7 learners' engagement, understanding,

and problem-solving skills. The research addresses a significant gap in current educational practice – while manipulatives and tangible approaches have demonstrated effectiveness in early mathematics education, their systematic implementation at the grade 7 level remains limited, particularly for abstract concepts like rational numbers. By identifying specific mathematical challenges and resource needs, this study establishes a foundation for developing targeted interventions that bridge concrete and abstract understanding.

Literature Review

Challenges in Grade 7 Mathematics Education

The transition to grade 7 mathematics presents unique challenges requiring careful investigation and intervention. Research by Wilkie and Sullivan (2017) demonstrates this period is particularly challenging as learners move from concrete arithmetic operations to abstract algebraic thinking. Their study identified specific difficulties learners face during this transition, including conceptual leaps required for algebraic thinking, struggles with symbolic representation, and difficulties connecting arithmetic knowledge to algebraic concepts.

Recent research provides targeted insights into specific grade 7 mathematical competencies requiring intervention. Ramos and Ronia (2024) conducted a quantitative-descriptive study assessing Grade 7 learners' mathematical learning competencies in the Philippines. Their research identified significant deficiencies in fundamental mathematical areas including integers and polynomials, providing concrete evidence of specific competency gaps requiring targeted instructional materials. Similarly, Magnanlac et al. (2024) documented achievement gaps in rational number operations and algebraic reasoning, with students demonstrating notably stronger performance in geometric concepts compared to abstract numerical operations. Their findings highlight the importance of targeted instructional materials designed to address specific competency deficits rather than general mathematical remediation.

The relationship between affective factors and mathematics performance has been examined by Escarez Jr and Ching (2022), who investigated the connection between math anxiety and mathematical representations among Grade 7 students. Their research revealed significant negative correlations between anxiety levels and students' ability to work with different mathematical representations, particularly in abstract numerical contexts. This suggests that affective barriers compound cognitive challenges, creating multi-dimensional obstacles to mathematical learning.

Resource and Instructional Needs

Research has identified several critical gaps in current mathematics instruction resources and methods. Marshall and Swan (2008) revealed consistent challenges in accessing appropriate manipulative materials. Their study highlighted significant gaps between available resources and

curriculum needs, as well as inconsistent quality of existing teaching materials. These resource limitations directly impact teachers' ability to implement effective mathematics instruction.

The importance of manipulatives in mathematics education has been established through various studies. Carbonneau et al. (2013) conducted a meta-analysis examining the efficacy of teaching mathematics with concrete manipulatives, finding moderate to large effects on student learning outcomes, particularly for rational number concepts. Their research demonstrated that hands-on materials provide significant advantages for conceptual understanding when implemented with appropriate instructional support.

II. Methodology

This study employed a comprehensive mixed-methods approach to identify the least mastered topics in grade 7 mathematics and evaluate current teaching resources, methods, and instructional challenges.

Research Design

The needs assessment phase utilized an exploratory mixed-methods design, combining quantitative and qualitative approaches to provide a comprehensive understanding of learning challenges. Data collection methods included teacher surveys to gather professional insights, interviews to obtain detailed perspectives on mathematical learning difficulties, and learner assessments to measure current performance levels.

Participants and Setting

The study involved seventeen (17) mathematics teachers from public high schools, possessing teaching experience ranging from 10 to 31 years (mean = 15.35 years). Each teacher managed 2-4 sections (mode = 2 sections) with an average class size of 49 learners. Additionally, eighty-four (84) grade 7 learners participated in the assessment component of the study.

Instruments and Data Collection

Teacher surveys included structured sections for topic difficulty ratings, resource availability assessment, and teaching methods evaluation. Learner assessments combined mathematical understanding evaluations with topic difficulty self-assessments and learning preferences questionnaires. Interview protocols for teachers and focus group guides for learners enabled in-depth exploration of learning challenges and potential solutions.

Data collection spanned one month, providing sufficient time for thorough gathering and systematic analysis of findings. All ethical considerations were maintained, including informed consent from teachers, parental permission alongside learner assent, and confidentiality of all responses.

III. Results and Discussion

Teacher Assessment of Topic Difficulty

Table 1. *Teacher Ratings of Geometry Topics*

Competency	Easy	Moderate	Difficult	Very Difficult
Drawing regular polygons	16 (94.1%)	1 (5.9%)	-	-
Drawing irregular polygons	10 (58.8%)	7 (41.2%)	-	-
Measuring angles	9 (52.9%)	8 (47.1%)	-	-
Describing angle relationships	9 (52.9%)	8 (47.1%)	-	-
Classifying polygons	12 (70.6%)	5 (29.4%)	-	-

Analysis of teacher survey data revealed distinct patterns in topic difficulty across different mathematical domains. As shown in Table 1 for Measurement and Geometry, teachers generally reported positive learner performance, with no geometry topics rated as "Difficult" or "Very Difficult." Drawing regular polygons emerged as the most accessible topic, with 94.1% of teachers rating it as "Easy."

Table 2. *Teacher Ratings of Number and Algebra Topics*

Competency	Easy	Moderate	Difficult	Very Difficult
Percentage increase	10 (58.8%)	5 (29.4%)	2 (11.8%)	-
Percentage decrease	10 (58.8%)	4 (23.5%)	3 (17.7%)	-
Discounts and tax	8 (47.1%)	4 (23.5%)	5 (29.4%)	-
Commission and interest	5 (29.4%)	5 (29.4%)	7 (41.2%)	-
Understanding rates	9 (52.9%)	4 (23.5%)	5 (29.4%)	-
Fraction to decimal conversion	8 (47.1%)	5 (29.4%)	4 (23.5%)	-
Operations with rational numbers	-	4 (23.5%)	5 (29.4%)	8 (47.1%)

In contrast, as shown in Table 2, operations with rational numbers stood out as the most challenging area, with no teachers rating it as "Easy," and 47.1% rating it as "Very Difficult." All seventeen teachers (100%) reported that their learners struggled with fraction operations, with a common error pattern being the treatment of numerators and denominators as separate numbers.

Resource Analysis

Table 3 shows the current state of resource utilization, which revealed significant limitations in teaching materials. While all teachers (100%) relied on textbooks as their primary teaching resource, there was limited use of supplementary materials. Only 58.8% of teachers utilized worksheets, and a mere 29.4% incorporated online materials. Most notably, none of the teachers currently used manipulatives in their mathematics instruction.

Table 3. *Current and Needed Resources*

Resource Type	Currently Using	Requesting	Priority Level
Textbook	17 (100%)	-	-
Worksheets	10 (58.8%)	16 (94.1%)	2nd
Online materials	5 (29.4%)	-	
Visual aids	-	16 (94.1%)	2nd
Teaching guides	-	16 (94.1%)	2nd
Manipulatives	-	17 (100%)	1st

The assessment of resource needs showed clear priorities, with all teachers (100%) expressing a need for manipulatives, indicating universal recognition of their importance in mathematics instruction. There was also a strong demand for visual aids and teaching guides, with 94.1% of teachers requesting these as first-priority resources.

Learner Assessment

Learner survey results in Table 4 revealed significant patterns in topic difficulty. Geometry topics consistently received the highest ratings, with understanding angle pair relationships emerging as the most accessible topic (mean rating = 4.55). In contrast, operations with rational numbers showed the lowest mean rating of 1.21, with 78.6% of learners rating these as "Very Difficult" as shown in Table 5.

Table 4. *Learner Ratings of Measurement and Geometry*

Topic	Very Easy (5)	Easy (4)	Moderate (3)	Difficult (2)	Very Difficult (1)	Mean Rating	Descriptive Interpretation
Drawing regular/irregular polygons	45 (53.6%)	35 (41.7%)	4 (4.8%)	-	-	4.49	Very Easy
Measuring sides and angles	45 (53.6%)	35 (41.7%)	4 (4.8%)	-	-	4.49	Very Easy
Understanding angle pairs	46 (54.8%)	38 (45.2%)	-	-	-	4.55	Very Easy
Classifying polygons	35 (41.7%)	49 (58.3%)	-	-	-	4.42	Very Easy
Understanding angles	25 (29.8%)	59 (70.2%)	-	-	-	4.30	Very Easy

1.00-1.80 = Very Difficult; 1.81-2.60 = Difficult; 2.61-3.40 = Moderate; 3.41-4.20 = Easy; 4.21-5.00 = Very Easy

Table 5. *Learner Ratings of Number and Algebra (N=84)*

Topic	Very Easy (5)	Easy (4)	Moderate (3)	Difficult (2)	Very Difficult (1)	Mean Rating	Descriptive Interpretation
Percentage increase	-	3 (3.6%) 3 (3.6%)	69 (82.1%)	10 (11.9%) 10 (11.9%)	2 (2.4%)	2.87	Moderate
Percentage decrease	-	3 (3.6%) 3 (3.6%)	69 (82.1%)	16 (19.0%) 16 (19.0%)	2 (2.4%)	2.87	Moderate
Discounts and tax	-	3 (3.6%) 1 (1.2%)	63 (75.0%)	18 (21.4%) 18 (21.4%)	2 (2.4%)	2.80	Moderate
Commission and interest	-	-	63 (75.0%)	45 (53.6%) 45 (53.6%)	2 (2.4%)	2.80	Moderate
Financial plans	-	-	61 (72.6%)	18 (21.4%) 18 (21.4%)	2 (2.4%)	2.77	Moderate
Rates	-	-	63 (75.0%)		2 (2.4%)	2.75	Moderate
Fractions to decimals	-	-	21 (25.0%)		18 (21.4%) 18 (21.4%)	2.04	Difficult
Decimals to percentages	-		21 (25.0%)		66 (78.6%) 66 (78.6%)	2.04	Difficult
Ordering rational numbers	-		-			1.21	Very Difficult
Operations with rational numbers	-		-			1.21	Very Difficult

1.00-1.80 = Very Difficult; 1.81-2.60 = Difficult; 2.61-3.40 = Moderate; 3.41-4.20 = Easy; 4.21-5.00 = Very Easy

The self-assessment portion shown in Table 6 revealed that learners demonstrated strongest confidence in geometry, with 100% rating themselves as either "Very Confident" (77.4%) or "Confident" (22.6%) in drawing and describing features of polygons. However, working with rational numbers emerged as the area of lowest confidence, with 88.1% of learners rating themselves as "Not Confident."

Table 6. *Learner Self-Assessment Confidence Ratings*

Statement	Very Confident (5)	Confident (4)	Moderately Confident (3)	Slightly Confident (2)	Not Confident (1)	Mean Rating	Descriptive Interpretation
Drawing and describing features of polygons	65 (77.4%)	19 (22.6%)	-	-	-	4.77	Very Confident
Using percentages in different contexts	-	64 (76.2%)	19 (22.6%)	1 (1.2%)	-	3.75	Confident
Identifying and using rates	-	-	82 (97.6%)	2 (2.4%)	-	2.98	Moderately Confident
Creating a financial plan	60 (71.4%)	20 (23.8%)	3 (3.6%)	1 (1.2%)	-	4.65	Very Confident
Working with rational numbers	-	-	-	10 (11.9%)	74 (88.1%)	1.12	Not Confident

1.00-1.80 = Not Confident; 1.81-2.60 = Slightly Confident; 2.61-3.40 = Moderately Confident; 3.41-4.20 = Confident; 4.21-5.00 = Very Confident.

Regarding learning preferences, as shown in Table 7, all learners (100%) indicated preference for both visual aids/drawings and hands-on materials/tools. A significant majority also valued structured learning approaches, with 95.2% preferring step-by-step examples and teacher explanations.

Table 7. *Learner Preferences for Learning Methods*

Learning Method	Number of Learners	Percentage	Descriptive Interpretation
Visual aids/drawings	84	100%	Very High Preference
Hands-on materials/tools	84	100%	Very High Preference
Step-by-step examples	80	95.2%	Very High Preference
Teacher explanation	80	95.2%	Very High Preference
Practice problems	60	71.4%	High Preference
Group activities	50	59.5%	Moderate Preference
Others (Study at home, read books, practice more)	10	11.9%	Low Preference

0-20% = Very Low Preference; 21-40% = Low Preference; 41-60% = Moderate Preference;
61-80% = High Preference; 81-100% = Very High Preference

Comparative Analysis

The comparative analysis revealed strong alignment between teacher observations and learner self-reported difficulties, particularly in identifying rational numbers as the most challenging topic. Both groups consistently identified a progressive difficulty pattern from basic to complex topics. However, some perception gaps emerged, particularly in percentage topics, where teachers viewed operations more positively than learners reported experiencing them.

IV. Conclusion

This needs assessment study revealed significant insights into the grade 7 mathematics instruction challenges. Rational numbers emerged as the least mastered topic, with unanimous agreement among teachers and clear confirmation from learner assessments. The stark contrast between strong performance in geometry and significant difficulties with rational numbers suggests that visual and hands-on approaches might benefit learner understanding of abstract concepts.

The findings emphasize the urgent need for comprehensive support in three key areas: resource development (particularly manipulatives and visual aids), professional development (focusing on conceptual teaching strategies), and curriculum enhancement (ensuring proper topic sequencing). These implications suggest that improving the grade 7 mathematics instruction requires a coordinated effort involving curriculum developers, school administrators, and teachers.

These findings provide clear direction for the subsequent phases of this research, particularly the development of tangible mathematics approaches specifically targeting rational number operations. By addressing both the identified content challenges and aligning with learners' preferred learning modalities, such interventions have significant potential to enhance engagement, understanding, and problem-solving skills in grade 7 mathematics.

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