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From Community Issues to Mathematical Modeling: A Qualitative Study of Junior High School Learners' and Teachers' Experiences

Marlita O. Pimentel[1], Rolly G. Salvaleon[2]
[1]Student, Graduate School, North Eastern Mindanao State University
[2]Faculty, Graduate School, North Eastern Mindanao State University

Abstract*—This study explored the experiences of junior high school learners and teachers in implementing community-based mathematical modeling and examined its influence on student engagement, mathematical learning, problem-solving, and civic awareness. Using a qualitative research design, data were collected through semi-structured interviews with selected learners and mathematics teachers and analyzed using thematic analysis. The findings revealed that learners perceived mathematical modeling as a meaningful and engaging learning experience that connected mathematical concepts to authentic community issues, including budgeting, water conservation, waste management, traffic management, and disaster preparedness. The analysis generated themes highlighting authentic learning through real-world contexts, enhanced engagement and participation, development of mathematical modeling competencies, and growing civic awareness and community responsibility. Teachers likewise observed increased student motivation, active participation, critical thinking, and conceptual understanding. Despite challenges related to time constraints, curriculum demands, and access to authentic local data, community-based mathematical modeling was found to be an effective instructional approach that transforms mathematics into a practical tool for addressing real-life community concerns and developing socially responsible learners.*

***Keywords*—** *Community-based mathematical modeling, mathematics education, qualitative research, learner engagement, mathematical competencies.*

I. Introduction

Despite numerous reforms in mathematics education, a persistent challenge remains: students often learn mathematics as a set of procedures detached from meaningful real-world contexts. Consequently, many learners can perform calculations yet struggle to apply mathematical reasoning to everyday and community-based problems. This disconnect has become increasingly problematic in a society where mathematical thinking plays a crucial role in addressing environmental concerns, managing resources, and making local decisions. In response, mathematical modeling has re-emerged as a promising pedagogical approach that connects mathematical concepts to authentic situations, enabling learners to use mathematics as a tool for understanding and addressing real-world issues [1] [15]. Recent studies emphasize that effective mathematical modeling extends beyond the application of learned formulas and procedures. Instead, it involves an iterative process in which learners interpret real situations, develop assumptions, construct mathematical representations, and evaluate solutions within meaningful contexts [2]. Scholars increasingly advocate for modeling tasks grounded in community issues because such contexts are believed to enhance [3] [16]. However, findings remain inconclusive. While authentic tasks can stimulate interest and participation, students often perceive socially oriented problems as ambiguous and inconsistent with traditional views of mathematics, whereas teachers encounter difficulties implementing open-ended activities within standardized curricula and assessment systems [4] [5]

Although substantial research has documented the intended benefits of mathematical modeling, including the development of problem-solving, transfer, and interdisciplinary competencies, limited attention has been paid to how learners and teachers experience modeling activities connected to community concerns [6] [7] [8]. Translating local issues into mathematical representations requires interpretation, judgment, and selective reasoning, making modeling a complex and often uncertain process. Moreover, student voices remain underrepresented in literature, particularly in studies examining engagement and civic awareness, where conclusions are frequently based on inferred outcomes rather than participants' direct experiences [9] [10] [11].

Addressing this gap, the present study investigates the experiences of junior high school learners and teachers in implementing socially relevant mathematical modeling tasks grounded in community issues. Specifically, it explores participants' perceptions of the value of these tasks, the challenges encountered during implementation, and their influence on engagement, motivation, problem-solving, and civic awareness. Rather than presuming the effectiveness of modeling, the study examines how such practices are enacted and experienced within actual classroom settings. By providing an evidence-based understanding of socially relevant mathematical modeling, this research contributes to ongoing discussions on how mathematics education can foster both mathematical competence and meaningful participation in community life [12] [13] [14].

II. Methodology

This section presents the research design, respondents, instruments, and statistical methods used to examine the relationships among the study's key variables.

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A. Research Design

This study adopts a qualitative multiple-case study design to explore how junior high school students and teachers make sense of socially relevant mathematical modeling within the context of real community issues. The choice of a multi-case approach is deliberate. It allows the researcher to move beyond a single classroom narrative and instead examine patterns, contrasts, and tensions across different educational settings, while still respecting the uniqueness of each case.

B. Respondents

Participants were selected using purposive maximum variation sampling, not because it sounds sophisticated in a methods section, but because it works when the goal is to capture diverse experiences. The study involved 6 junior high school learners (aged 13–15) in grade 8 class and 4 mathematics teachers drawn from school contexts.

Teachers were selected based on their teaching experience and their openness to integrating community-based mathematical modeling. Learners, on the other hand, were chosen to reflect a range of abilities, engagement levels, and socio-economic backgrounds. This was intentional. A study like this loses its value the moment it listens only to the articulate or the high performing.

Qualitative research does not chase large numbers for the sake of statistical comfort. Instead, it seeks depth, nuance, and insight. The sample size in this study is therefore justified by its capacity to generate meaningful, context-rich data rather than generalizable claims [25]

C. Instrumentation

An interview guide for one–on–one interviews was used to assess the level of integration of livelihood skills, the availability of sustainable and context-specific livelihood opportunities, students' entrepreneurial mindset, and metacognitive skills.

D. Data Analysis

The qualitative data gathered from the semi-structured interviews were analyzed using thematic analysis, following the procedures [24]. Interview responses were transcribed, coded, and examined to identify recurring patterns, similarities, and meanings related to learners' experiences with community-based mathematical modeling activities. The generated codes were then organized into categories, themes, and subthemes, which served as the basis for interpreting participants' perceptions, engagement, and application of mathematics in addressing community issues.

E. Ethical Considerations

Ethical approval was secured before data collection, and all procedures adhered to established standards for research involving human participants. These included voluntary participation, confidentiality, secure data handling, and the right to withdraw at any time.

Special attention was given to the ethical complexity of discussing community issues, particularly those involving socio-economic challenges. The researcher ensured that such discussions were handled with sensitivity, avoiding harm or discomfort to participants.

III. Results and Discussion

This section presents and discusses the study's findings from a thematic analysis of interview data gathered from junior high school learners and teachers.

3.1 Learners' Perceptions of Community-Based Mathematical Modeling

TABLE 1. Thematic Analysis of Junior High School Learners' Experiences in Community-Based Mathematical

Category	Themes	Sub-themes
Experiencing Mathematics as Meaningful and Engaging	Authentic Learning Through Real-World Contexts	Working with actual community data Connecting mathematics to everyday life Seeing mathematics beyond textbook exercises
	Enhanced Engagement and Active Participation	Increased interest and enjoyment in mathematics Sense of responsibility and ownership Greater classroom participation and collaboration
Using Mathematics as a Tool for Community Problem Solving	Development of Mathematical Modeling Competencies	Collecting and organizing community data Applying mathematical concepts to analyze issues Interpreting patterns, trends, and relationships
	Growing Civic Awareness and Community Responsibility	Awareness of local issues and challenges Recognizing mathematics as a decision-making tool Desire to contribute solutions to community problems

Category One: Experiencing Mathematics as Meaningful and Engaging

Theme One: Authentic Learning Through Real-World Contexts

This theme highlights how learners developed a deeper appreciation of mathematics by engaging with real-world community issues and data rather than hypothetical textbook problems. By applying mathematical concepts to authentic situations such as barangay budgeting and household water consumption, students perceived mathematics as more meaningful, relevant, and connected to their everyday experiences.

SP 1: "We were working with real numbers from our barangay."

SP 2: "We measured how much water we actually use at home."

SP 3: "We watched real traffic and used math to think of ways to fix it."

SP 5: "It made the math feel meaningful."

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The findings indicate that authentic community-based mathematical modeling enhanced learners' understanding of mathematics by connecting abstract concepts to meaningful real-world situations. Students demonstrated greater engagement and relevance when mathematical tasks involved actual community concerns, supporting the view that authentic contexts foster deeper mathematical understanding and promote the application of knowledge beyond the classroom. Furthermore, learners' experiences suggest that real-world modeling activities strengthen the connection between mathematics and everyday decision-making, making learning more purposeful and socially relevant [17] [18].

Theme Two: Enhanced Engagement and Active Participation

This theme reflects how community-based mathematical modeling increased learners' interest, involvement, and participation in mathematics activities. Students became more engaged because they perceived the tasks as relevant to their lives and communities.

SP1: "I felt excited and responsible."
SP4: "I felt engaged and clever."
SP6: "I participated more because using real data made me feel like my input mattered." (

The findings suggest that authentic mathematical modeling activities fostered emotional and cognitive engagement, as learners expressed excitement, a sense of responsibility, and greater ownership of their learning. The opportunity to analyze real community issues encouraged active participation and collaboration, allowing students to view themselves as contributors rather than passive recipients of knowledge. These results support the assertion that meaningful and context-based learning experiences enhance student motivation, engagement, and active involvement in mathematical problem-solving [18] [19] [20]

Category Two: Using Mathematics as a Tool for Community Problem Solving

Theme One: Development of Mathematical Modeling Competencies

This theme highlights how learners developed essential mathematical modeling skills by applying mathematical concepts to authentic community issues. Their experiences demonstrate the ability to collect, organize, analyze, and interpret real-world data to generate practical solutions.

SP 8: "Use of percentages, averages, graphs, ratios, equations, charts, and mapping."
SP 9: "Organizing, analyzing, and interpreting community data to generate solutions."

The findings reveal that students employed various mathematical tools, including percentages, averages, graphs, ratios, equations, charts, and mapping techniques, to examine community concerns such as budgeting, water conservation, traffic management, waste segregation, and flood preparedness. Through these activities, learners strengthened their analytical and problem-solving abilities by transforming real-life situations into mathematical representations and using evidence-based reasoning to draw conclusions. This supports the view that mathematical modeling promotes higher-order thinking and develops learners' capacity to apply mathematics as a tool for investigating and addressing complex societal issues [21] [22] [23].

Theme Two: Growing Civic Awareness and Community Responsibility

This theme reflects how learners developed a greater awareness of community issues and recognized mathematics' potential as a tool for informed decision-making and social improvement. Through mathematical modeling activities, students became more conscious of their role in addressing local concerns and contributing to community well-being.

SP4: "Math can help manage community budgets."
SP 7: "Math can help solve everyday problems like traffic."
SP 10 "Math can help predict dangers like flooding."

The findings indicate that learners moved beyond viewing mathematics as merely an academic subject and began to perceive it as a practical means of understanding and responding to societal challenges. Their willingness to address issues such as water conservation, waste management, traffic congestion, budgeting, and disaster preparedness demonstrates the development of civic consciousness and a sense of responsibility toward their communities. These experiences align with research suggesting that socially relevant mathematical modeling fosters civic engagement by enabling learners to critically examine community problems and use quantitative reasoning to propose meaningful solutions [21] [22]

3.2 Teacher's Perception of Community-Based Mathematical Modeling

This section presents the themes and subthemes that emerged from the interviews, highlighting teachers' perceptions of community-based mathematical modeling and its influence on mathematics instruction, student learning, and civic awareness.

TABLE 2. Thematic Analysis of Junior High School teachers' Experiences in Community-Based Mathematical

Category	Themes	Subthemes
Transforming Mathematics Learning Through Community-Based Mathematical Modeling	Enhanced Student Learning and Engagement	Increased student motivation and interest Active participation and collaboration Improved critical thinking and problem-solving skills Greater relevance and meaningfulness of mathematics
	Challenges and Opportunities in Implementing Mathematical Modeling	• Time and curriculum constraints Difficulties in accessing authentic local data Complexity of real-world problem solving Development of civic awareness and social responsibility

Theme One: Enhanced Student Learning and Engagement

This theme reflects teachers' observations that community-based mathematical modeling increased students' motivation, participation, critical thinking, and appreciation of mathematics by connecting lessons to authentic community issues.

TP1: "Students were highly enthusiastic and more vocal than usual. They appreciated the data's realness, which moved the lesson from abstract theory to a tangible community concern they could visualize."

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TP2: "One of the most significant changes observed is the shift from passive to active."

TP3: "Students responded with high interest and active participation, as they could directly relate the activities to issues they encounter in their own neighborhood."

The teachers consistently observed that integrating community issues into mathematical modeling enhanced students' engagement by making learning more relevant, authentic, and meaningful. Learners demonstrated increased motivation, active participation, and collaboration by directly connecting mathematical concepts to real-life situations affecting their communities, moving beyond passive learning toward active inquiry and problem-solving. These findings support constructivist perspectives, which hold that authentic learning experiences foster deeper engagement, improve critical thinking, and strengthen students' understanding of mathematics by situating knowledge within meaningful social contexts [18] [20] [21]

Theme Two: Challenges and Opportunities in Implementing Mathematical Modeling

This theme reflects teachers' experiences regarding the barriers and possibilities encountered when integrating community-based mathematical modeling into mathematics instruction.

TP4: *"The main challenges were the time-intensive nature of data collection and the difficulty of finding local data sets that were simplified enough for Junior High School levels without losing their authenticity."*

TP2: *"The biggest challenges I experience are data messiness and time. It takes more preparation time to find relevant local data sets and facilitate open-ended investigation."*

TP5: *"Students begin to see Math as a tool for justice and problem-solving, which fosters deeper critical thinking and improves retention of complex concepts."*

The findings reveal that, while community-based mathematical modeling presents implementation challenges such as limited instructional time, curricular constraints, and difficulties accessing authentic local data, teachers recognized its substantial educational benefits. Despite these barriers, educators observed that engaging students in real-world problem-solving activities enhanced critical thinking, strengthened analytical skills, and fostered deeper understanding of mathematical concepts through meaningful application. Moreover, the approach provided opportunities to develop civic awareness and social responsibility by encouraging learners to examine community issues, evaluate evidence, and propose data-driven solutions, thereby positioning mathematics as a tool for social understanding and action [17] [18] [22]

IV. Conclusion

The study revealed that community-based mathematical modeling is an effective approach to connecting mathematical concepts to authentic community issues, making mathematics more meaningful, relevant, and engaging for both learners and teachers. The findings showed that learners developed greater motivation, active participation, mathematical modeling competencies, critical thinking skills, and civic awareness as they applied mathematics to real-world concerns such as budgeting, water conservation, waste management, traffic flow, and disaster preparedness. Teachers likewise perceived that this approach promotes deeper conceptual understanding, problem-solving abilities, and social responsibility, although challenges related to time constraints, curriculum demands, and access to authentic local data remain. Overall, the study highlights that community-based mathematical modeling transforms mathematics from a purely academic subject into a practical tool for understanding, analyzing, and addressing community issues, thereby fostering mathematically competent and socially responsible learners.

Recommendations

Based on the study's findings, it is recommended that mathematics teachers integrate more community-based mathematical modeling activities into their instruction to enhance students' engagement, critical thinking, problem-solving skills, and civic awareness. Schools and educational leaders should provide support through relevant training, instructional resources, and opportunities for teachers to design authentic learning experiences grounded in local community issues. Curriculum planners may consider incorporating community-based modeling tasks into mathematics programs to strengthen the connection between mathematical concepts and real-world applications. Furthermore, collaboration among schools, local government units, and community stakeholders is encouraged to facilitate access to authentic data and community concerns that can serve as meaningful contexts for mathematical investigations. Future researchers may conduct similar studies involving larger participant groups, different educational levels, and diverse community settings to further explore the effectiveness and long-term impact of community-based mathematical modeling on students' mathematical learning and social responsibility.

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