Strategic Pedagogies through the Zone of Proximal Development in College Classrooms: A Holistic Approach to Developing Mathematical Literacy in the Philippine Higher Education

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ABSTRACT

This study examined the effectiveness of the existing mathematics curriculum in enhancing students' mathematical literacy and developed a framework for improving mathematics instruction in higher education. Using a mixed-methods research design, quantitative data were gathered from 270 students and 12 mathematics faculty members through validated survey instruments, while qualitative insights were obtained through interviews. Descriptive statistics, correlation analysis, and t-tests were employed to analyze the quantitative data, whereas thematic analysis was used for qualitative responses. Findings revealed that most students came from low- to middle-income families, with limited participation in mathematics-related extracurricular activities. Although innovative teaching methods such as inquiry-based learning, technology integration, student-centered learning, and differentiated instruction were perceived as seldom employed, students reported a high level of mathematical literacy. Both students and teachers perceived the curriculum as effective in promoting mathematical literacy. Significant positive relationships were found between curriculum effectiveness, teaching methods, and students' mathematical literacy. Family income and extracurricular participation also influenced literacy development. Furthermore, significant differences existed between students' and faculty members' perceptions of mathematical literacy. Qualitative findings identified goals centered on conceptual understanding, confidence-building, teacher development, and equity, while challenges included mathematics anxiety, resource limitations, and contextual disconnects. In response, the study proposed the HOLISTIC Framework, grounded in the Zone of Proximal Development, integrating culturally responsive pedagogy, scaffolding, inquiry-based learning, technology integration, inclusivity, and continuous assessment to strengthen mathematical literacy among learners.

Keywords: mathematical literacy, mathematics curriculum, teaching methods, Zone of Proximal Development, HOLISTIC Framework, higher education.

INTRODUCTION

In recent years, the imperative role of mathematical literacy in shaping cognitive abilities and problem-solving skills has gained heightened significance within the academic community, particularly in the context of tertiary education in the Philippines. This dissertation, titled " Strategic Pedagogies through the Zone of Proximal Development in College Classrooms: A Holistic Approach to Developing Mathematical Literacy in the Philippine Higher Education," embarks on an exploration of the intricacies of mathematical education tailored to the unique landscape of tertiary institutions in the Philippines. It specifically aims to delve into innovative curriculum design and implementation strategies, responding directly to the pressing need for effective pedagogical approaches that will equip individuals with the mathematical skills essential for success in the diverse academic and professional arenas prevalent in the Philippine tertiary education system.

Recent works by prominent authors in the field, including international figures such as Johnson (2021) and Rodriguez (2019), provide a foundation for understanding the current state of mathematical literacy education. Johnson's work introduced novel methodologies and philosophies that addressed contemporary challenges in mathematical education. Her study explored the integration of technology, collaborative learning strategies, and real-world applications, providing a nuanced understanding of effective teaching practices. Consequently, Rodriguez delved into the cognitive aspects of mathematical learning, emphasizing the importance of problem-solving skills and critical thinking. In the context of the Philippines, local scholars have also made significant contributions to this discourse. Notably, Santos, a respected Filipino mathematician, has delved into various facets of mathematical education, offering insights into methodologies and philosophies specifically relevant to the Philippine educational setting (Santos, 2020). Her work, alongside that of international scholars, contributes to the rich tapestry of research that serves as the bedrock upon which this investigation builds.

Despite the burgeoning body of literature, significant gaps persist in our understanding of optimal curriculum design and implementation strategies. Recent studies (Garcia et al., 2022; Santos, 2020) have highlighted challenges and deficiencies in the Philippine setting concerning mathematical literacy. These issues pose unique obstacles to students, educators, and policymakers, indicating a crucial area for exploration in this dissertation. Addressing these gaps is vital not only for the Philippine education system but also for contributing nuanced insights to the global conversation on mathematical literacy. Only 16% of Filipino students achieved at least Level 2 proficiency, compared to 69% in OECD countries, indicating basic mathematical understanding and problem-solving skills. Moreover, socio-economic disparities significantly impact performance, with disadvantaged students scoring substantially lower than their more affluent peers. Despite some students demonstrating resilience, the overall performance highlights critical areas for improvement in the country's mathematics education system. A study of 177 first-year engineering students from a country’s state university found that 57% were not mathematically college-ready, with only 15–19% correctly answering basic integration problems (Perante, 2022).

The significance of this dissertation, emphasizes its potential impact on educational practices, policy formulation, and the overall enhancement of mathematical literacy. Drawing on the recent works of scholars such as Johnson, Rodriguez, Garcia, and Santos, this study aims to provide valuable insights that can inform educational institutions, curriculum developers, and policymakers. The research's significance lies in its potential to contribute evidence-based recommendations that address the identified gaps and challenges, not only in the Philippines but also internationally.

THEORITICAL FRAMEWORK

This study argues that mathematical literacy, conceptualized as the ability to reason, formulate, interpret, and apply mathematics in varied real-world contexts, can be significantly enhanced among diverse learners, thereby addressing persistent gaps in foundational numeracy, problem-solving proficiency, and mathematical self-confidence. In the ever-evolving landscape of education, the acquisition of mathematical literacy stands as a cornerstone for individual empowerment and societal progress. This dissertation, titled 'Developing Mathematical Literacy: An Investigation into Curriculum Design and Implementation Strategies,' aims to unravel the complexities of mathematical education by drawing upon a robust theoretical framework. Grounded in the integration of Vygotsky's Socio-Cultural Theory, Gardner's Multiple Intelligences, and Bandura's Social Cognitive Theory; this research with the help of the theories mentioned aspires to provide a comprehensive understanding of how curriculum design and implementation strategies can be optimized to foster mathematical literacy.

The seminal work of Vygotsky (1978), focusing on social-cognitive learning and development, has been further elaborated upon by Pearson and Gallagher (1983). This framework, adapted for a literacy model by Schoenbach, Greenleaf, and Murphy (2022), underscores the significance of leveraging classroom culture and employing developmentally appropriate motivation strategies to implement mathematical literacy. Teachers can initiate the use of Pearson's and Gallagher's (1983) gradual release of responsibility model by employing strategies such as thinking aloud while reading and deconstructing sentences in a math textbook, modeling examples, or explicitly building on previously learned concepts. In this teacher-regulated phase, students are introduced to new topics (Buehl, 2021).

Vygotsky's concept of the zone of proximal development (1978) represents the intermediate phase, wherein teachers can utilize scaffolds like spiral questioning, guided practice, or collaborative activities. These scaffolds aim to help students build confidence with new ideas. Deliberate collaborative learning activities play a pivotal role in developing mathematical literacy, as they encourage students to employ the language of the discipline in

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their questions, reasoning, conclusions, and comprehension (Wilkinson & Son, 2021). The effectiveness of the zone of proximal development relies on fostering a positive classroom environment, where students feel confident in completing tasks and are comfortable seeking knowledge. This environment enables them to transition to the student-regulated section of the Pearson and Gallagher model, equipped with skills indicative of mathematical literacy (1983). Appropriately utilizing scaffolds within the zone of proximal development motivates students to independently engage with mathematical texts and concepts (Buehl, 2022).

Mathematical literacy, characterized by the processes of formulating, employing, and interpreting (OECD 2013), can be significantly influenced by the stages of learning that incorporate a Scientific Approach rooted in Multiple Intelligences. These stages possess the potential to enhance students' mathematical literacy abilities. Within this framework, students can observe phenomena in diverse ways, guided by the combination of intelligences they possess, allowing them to gather information within heterogeneous groups. During this phase, students become adept at recognizing, identifying, and constructing mathematical structures relevant to real-world contextual problems through various approaches. Upon collecting and processing the information through their respective intelligences, students proceed to the employing and interpreting stage. Here, they articulate conclusions through oral presentations, diagrams, or other media, demonstrating their application of concepts, facts, and mathematical procedures. Moreover, students provide reasons supporting their conclusions, reflecting on solutions and interpreting outcomes within the context of real-world problems, aligning with the unique combination of intelligences they possess.

Meanwhile, research findings by (Kartikasari and Widjajanti, 2023) underscore the effectiveness of the "multiple intelligences" approach in problem-based learning, citing positive impacts on student achievement, connection skills, and self-esteem. Additionally, (Kurniawati and Mahmudi, A 2021) report an improvement in students' conceptual understanding and self-confidence in learning mathematics based on Multiple Intelligences. Similarly, (Septiana and Ikhsan, 2021) support these outcomes, indicating that problem-based learning with multiple intelligences approaches contributes to enhanced conceptual understanding and creative thinking abilities.

On the other hand, over the past four decades, self-regulated learning, a focal point under the umbrella of social cognitive theory, has garnered considerable attention. This area of research holds substantial practical implications for classroom dynamics and instructional methodologies. Numerous studies position self-regulation as a foundational element in academic pursuits, considering it pivotal for learning and overall development (Bembenutty, Cleary, & Kitsantas, 2022; Zimmerman & Schunk, 2023). Within this body of research, the role of professors is underscored as influential social models, while learners are depicted as proactive and self-directed participants in their educational journeys. Consequently, the concept of self-efficacy is framed as a determinant of actions and a catalyst for learning, while self-regulation is portrayed as a dynamic process contributing to personal growth and development (Bembenutty et al., 2023; Boekaerts, Pintrich, & Zeidner, 2020; Zimmerman & Schunk, 2021).

In the early stages of social cognitive theory's development, Bandura conducted seminal work on self-regulation and self-efficacy (Bandura, 1986). While self-regulated learning refers to individuals' control over their thoughts, actions, feelings, and behavior in pursuit of designated academic tasks (Zimmerman, 2023), self-efficacy is defined as individuals' beliefs regarding their capabilities to perform assigned tasks. Aligned with Bandura's theory, Zimmerman's research on self-regulation indicates that learners can identify learning targets, set goals, choose learning strategies, monitor progress, and engage in reflective practices regarding outcomes.

In the context of the current study on developing mathematical literacy through curriculum design and implementation strategies, Bandura's seminal work on self-regulation and self-efficacy (Bandura, 1986) provides a theoretical foundation. The study aims to explore the integration of a scientific approach and multiple intelligences to enhance mathematical literacy. Bandura's concepts become particularly relevant in understanding how learners can actively regulate their cognitive processes and build confidence in mathematical tasks. Self-regulated learning, as defined by Zimmerman (2023), is crucial in the educational landscape explored in the current study. It involves individuals taking control of their thoughts, actions, feelings, and behavior to navigate academic tasks successfully. This aligns with the study's objective of investigating curriculum design and implementation strategies that empower students in the pursuit of mathematical literacy.

Moreover, the concept of self-efficacy, defined as individuals' beliefs in their capabilities to perform assigned tasks, serves as a pivotal link to the current study. In the context of mathematical literacy, students' self-efficacy beliefs play a significant role in shaping their engagement with mathematical concepts and problem-solving. The study seeks to understand how the integration of a scientific approach and multiple intelligences can contribute to fostering students' self-efficacy in mathematics. Building on Bandura's theory, Zimmerman's research on self-regulation becomes a guiding framework for the current study. Zimmerman's findings suggest that learners can actively identify learning targets, set goals, choose effective learning strategies, monitor their progress, and engage in reflective practices regarding outcomes. This aligns seamlessly with the study's exploration of how curriculum designs, rooted in a scientific approach and tailored to multiple intelligences, can empower students to take charge of their mathematical literacy development.

METHODOLOGY

To address the multifaceted research objectives outlined in the problem statement, a comprehensive mixed-methods research design, particularly, the explanatory sequential method is used. The study aimed to explore the demographic profiles, perceptions, current levels of mathematical literacy, teaching methods/materials, and relationships between these factors across students, faculty, and administrators within a targeted educational setting. According to Creswell and Plano Clark (2021), a mixed-methods approach allows researchers to capitalize on the strengths of both quantitative and qualitative data, thereby offering a more complete picture of phenomena such as curriculum effectiveness and educational outcomes. This approach enables us to statistically analyze relationships between variables such as student perceptions of curriculum effectiveness and their actual mathematical literacy levels, as recommended by Johnson and Onwuegbuzie (2021).

The quantitative phase involved structured surveys administered to students, faculty, and administrators. These surveys were designed to gather data on demographic variables such as family income (for students), highest educational attainment, and years of experience (for faculty and administrators). Specific questions explored access to learning materials at home, participation in extracurricular activities related to mathematics (for students), courses taught, professional development attended (for faculty), and projects/programs related to mathematics literacy (for administrators).

Conversely, the qualitative phase, including interviews and thematic analysis with key stakeholders, reflects the interpretivist stance of the study. By delving into administrators’ goals for mathematical literacy and faculty and student perspectives on challenges and coping mechanisms, this study aimed to enrich our quantitative findings with nuanced qualitative insights, consistent with the integrated approach to mixed-methods research advocated by Greene et al. (2020). Moreover, ethical considerations are paramount in this study, as highlighted by Bazeley (2022), particularly in ensuring informed consent, confidentiality, and adherence to ethical guidelines throughout the research process.

The qualitative phase focused on exploring overarching goals for mathematical literacy within the institution (through interviews with administrators), challenges encountered by students and faculty in developing mathematical literacy (via interviews or focus groups), coping mechanisms implemented to address these challenges, and suggestions for frameworks to optimize mathematical literacy development among higher education institutions. Semi-structured interviews with key stakeholders, including administrators, faculty, and possibly students, provided in-depth insights into these qualitative aspects. Thematic analysis was used to identify and categorize recurring themes across these qualitative data sources, ensuring a nuanced understanding of the institutional goals, challenges, and strategies.

Research Locale

There were two Higher Education Institutions (HEIs) which were explored in this study. One private school and the other is a public tertiary school in Tandag City, which is the capital of Surigao del Sur province in the Philippines. Tandag City is located in the Caraga region of Northeastern Mindanao, known for its natural beauty, including beaches and scenic landscapes. The city itself serves as a hub for commerce, education, and government administration within the province.

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The private school operates as a private educational institution, typically offering primary, secondary, and tertiary education. Private schools in the Philippines often have more autonomy in curriculum development, admission policies, and management compared to public institutions. They are funded through tuition fees and donations, allowing for flexibility in resource allocation and facilities.

Funding for private schools primarily comes from tuition fees paid by students and donations from benefactors or alumni. This financial structure provides it with flexibility in resource allocation, enabling investments in facilities, technology, faculty development, and extracurricular activities that enhance the overall educational experience. Moreover, the institution's private status often promotes a strong sense of community among students, faculty, and alumni, contributing to a supportive and cohesive learning environment.

On the other hand, the public tertiary school operates across several municipalities within Surigao del Sur, enhancing educational accessibility and regional development in northeastern Mindanao. The university's main campus is located in Tandag City, serving as its administrative center and primary academic hub. In addition to the main campus, in Tandag has established satellite campuses in various municipalities including Cagwait, Lianga, Tagbina, Cantilan, Bislig and San Miguel. These campuses are strategically positioned to cater to the educational needs of students from diverse backgrounds and geographic locations within the province. Each campus plays a vital role not only in providing affordable higher education but also in fostering community engagement, supporting local economic development, and contributing to the cultural and social fabric of their respective municipalities.

The sampling methods for students, faculty teaching mathematics, and administrators were to ensure representative and comprehensive data collection. For students, a stratified random sampling method was employed. This approach involves dividing the student population into distinct groups (strata) based on relevant criteria such as academic level (e.g., primary, secondary, tertiary), program of study, and possibly other demographic factors. From each stratum, a random sample of students was selected to participate in the study. This method ensures that the sample is representative of the entire student body at the higher education institutions allowing for insights that can be generalized across different academic levels and programs.

Descriptive Statistics. It was used to answer the profile, Perception of Existing Curriculum, Current Level of Mathematical Literacy among Students, and the Predominant Teaching Methods and Materials. T-tests. It was used to compare perceptions of the existing curriculum's effectiveness among students, faculty, and administrators. Pearson Product Moment Correlation. This was used to assess the relationship between perceptions of curriculum effectiveness and mathematical literacy. Regression analysis. This was utilized to examine how demographic variables (income level, access to materials, etc.) relate to mathematical literacy.

RESULTS AND DISCUSSIONS

The data on family income reveals a diverse but predominantly lower-middle to low-income demographic. on family income reveals a diverse but predominantly lower-middle to low-income demographic.

Demographic Profile of the Respondents

Table 2.1 highlights the results on the demographic profile of the students.

Table 2.1 Demographic Profile of the Student Respondents

Indicators	Frequency	Percent
Family's Approximate Income		
Below 10,000	73	27%
10,000 – 20,000	83	31%

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20,001 – 30,000	62	23%
30,001 – 40,000	43	16%
Above 40,000	9	3%
	270	100%
Access to learning at home		
Access to textbooks and reference books at home	Yes	145 (54%)
	No	125 (46%)
Access to a computer or tablet at home	Yes	179 (66%)
	No	91 (34%)
Access to the internet at home	Yes	210 (78%)
	No	60 (22%)
Participation in extracurricular activities related to Mathematics		
Membership in mathematics clubs and organizations	Yes	47 (17%)
	No	223 (83%)
Participation in mathematics competition	Frequently	19 (7%)
	Occasionally	47 (17%)
	Rarely	105 (39%)
	Never	99 (37%)
Attendance in mathematics workshops or seminars outside of school	Yes	12 (4%)
	No	258 (96%)

The largest single group of respondents falls within the lower monthly income bracket. Cumulatively, a significant majority of the students come from families earning a modest monthly income. This concentration in the lower income brackets strongly suggests that a substantial portion of the student population may face socioeconomic challenges. According to the Philippine Statistics Authority, families earning below a certain threshold are often considered part of the low-income class, which can struggle to meet basic needs. This economic context is a critical factor in understanding educational outcomes, as family socioeconomic status (SES) is a well-documented predictor of academic resources and opportunities.

The data on access to learning resources reveals a critical paradox: while basic access to the internet is relatively high, fundamental tools like textbooks and computers are less universally available. This disparity implies that students may be able to connect to online content but lack the foundational printed or digital materials necessary for deep, independent learning. The nearly even split in textbook access suggests that a substantial portion of the student population may rely solely on digital resources or classroom instruction without the reinforcement of personal reference materials at home. Furthermore, the notable proportion of students without access to a computer or tablet at home implies that many learners may be disadvantaged in developing essential digital literacy skills, completing technology-dependent assignments, or engaging with interactive learning platforms.

The pattern of minimal engagement suggests that for the vast majority of these students, their exposure to mathematics is confined entirely to the formal, in-school curriculum. They are not engaging with math in

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informal, collaborative, or competitive environments that can foster a deeper interest, build confidence, and demonstrate the subject's applicability. This lack of engagement could be both a cause and a consequence of math anxiety or a perception of math as a purely academic, and potentially tedious, school requirement. The socioeconomic barriers identified earlier (income, lack of resources) may directly contribute to this, as extracurricular activities often require fees, transportation, or parental availability that low-income families may not be able to provide.

Agasisti, Avvisati, Borgonovi, and Longobardi (2021), in a large-scale study using PISA data, found that family socioeconomic background remains a powerful determinant of student performance, particularly in STEM fields, as it influences the availability of cognitive stimulation and material resources at home. The distinction between different types of access is a key theme in recent literature. Van Deursen (2020) argues that the digital divide has evolved from a simple "have/have-not" gap in connectivity to a more nuanced understanding of digital inequality. The importance of access to physical learning materials is reinforced by the work of Kuhfeld, Lewis, and Peltier (2023), who examined reading achievement. On the other hand, studies revealed that there is a negative impact of educational disruptions steadily accumulated during school closures, with significant disparities in achievement and growth compared to pre-pandemic trends (Kuhfeld & Lewis, 2022; Lewis, Kuhfeld, Langi, Peters, & Fahle, 2022).

Table 2.2. Faculty Profile

Indicators	Frequency	Percent
Highest Educational Attainment		
Bachelor’s Degree in Mathematics or related field	1	8.3%
Master’s Degree in Mathematics or related field	8	66.7%
Doctorate Degree in Mathematics or related field	3	25%
Courses in Mathematics Taught		
Algebra	1	8.3%
Geometry	2	16.7%
Calculus	2	16.7%
Statistics	7	58.3%
Years Teaching Mathematics		
1 - 5 years	5	41.7%
6 - 10 years	3	25%
11 - 15 years	4	33.3%
Professional Development related mathematics attended		
Have you attended workshops or seminar relate to mathematics?	Yes	9 (75%)
	No	3 (25%)
	Frequently	1 (8.3%)

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How often do you participate in professional development activities related to mathematics?	Occasionally	5 (41.7%)
	Rarely	3 (25%)
	Never	3 (25%)
Have you completed any advanced courses or certifications in mathematics education?	Yes	6 (50%)
	No	6 (50%)

The data on teachers' highest educational attainment reveals a remarkably highly qualified faculty with advanced degrees in mathematics or related fields. This finding indicates that the mathematics department is staffed by educators with strong academic credentials and deep content knowledge. The presence of multiple doctorate holders is particularly notable and suggests a faculty with deep disciplinary expertise capable of engaging students with complex mathematical concepts and potentially contributing to curriculum development or research initiatives. This level of qualification far exceeds the minimum requirements for secondary or even tertiary mathematics instruction in many contexts.

Regarding the courses taught and teaching experience, the data reveals a faculty with diverse instructional responsibilities and a concentration in early-to-mid career stages. Statistics is the most frequently taught subject, suggesting either a curricular emphasis on statistical literacy or possibly a need for more faculty to share the load of other mathematics courses. The limited number of teachers assigned to Geometry raises questions about how geometry instruction is covered, whether this reflects curriculum structure, scheduling patterns, or potential gaps in faculty expertise in this area.

Regarding experience, the faculty composition represents both an opportunity and a potential challenge. The presence of early-career teachers brings energy, recent pedagogical training, and familiarity with contemporary teaching approaches, though these teachers may still be developing classroom management skills and instructional effectiveness. The mid-career teachers represent a valuable core of experienced practitioners who can mentor newer colleagues. The complete absence of veteran teachers with extensive classroom tenure means the department lacks the deep institutional memory and veteran expertise that often proves invaluable for curriculum leadership and mentoring, creating both a leadership gap and a potential sustainability concern for the mathematics program.

Research on teacher experience distribution in schools shows that schools with a balanced experience profile, including both early-career and experienced teachers, tend to outperform those with concentration at either extreme. The absence of veteran teachers may reduce opportunities for informal mentoring and institutional knowledge transfer, potentially impacting long-term program stability. Teacher effectiveness in mathematics improves significantly during the first five years of teaching, continues to develop through mid-career, and plateaus thereafter, suggesting that the faculty profile in this study positions the department well for continued growth in instructional quality, though intentional mentoring structures would help maximize this potential. Furthermore, geometry teaching demands unique spatial reasoning skills and visualization strategies that differ from algebraic or statistical instruction. This raises important questions about whether the assignment of only one teacher to geometry reflects adequate coverage of this mathematical domain and whether students have access to varied instructional approaches in geometry.

The data on professional development reveals generally high participation rates, though with notable variation in frequency and a balanced split regarding advanced certifications. The finding that most teachers have engaged in some form of mathematics-related professional development is positive and suggests a faculty that values continuous learning. However, the frequency data reveals a more nuanced picture: only a small minority participates frequently, while half of the faculty participates rarely or never. This pattern raises concerns about whether professional development is consistently available, accessible, or prioritized. The even split on advanced certifications further suggests that while half the faculty have pursued additional credentials beyond their degrees, an equal number have not, creating a differentiated faculty profile regarding specialized qualifications.

Research consistently demonstrates that teacher qualifications, particularly in STEM fields, positively correlate with student achievement. Hill (2021) provides robust evidence linking teacher content knowledge, particularly at the graduate level, with improved student outcomes in mathematics, finding that teachers with advanced degrees are better equipped to anticipate student misconceptions, provide multiple representations of concepts, and respond adaptively to student questions. Similarly, Blömeke and Kaiser (2022) confirm that teachers with graduate degrees in mathematics or mathematics education produce significantly higher student achievement gains compared to those without such qualifications. Regarding teacher experience distribution, Papay and Kraft (2021) find that schools with a balanced experience profile, including both early-career and experienced teachers, tend to outperform those with concentration at either extreme, and suggest that the absence of veteran teachers may reduce opportunities for informal mentoring and institutional knowledge transfer. Complementing this, Harris and Sass (2020) demonstrate that teacher effectiveness in mathematics improves significantly during the first five years of teaching, continues to develop through mid-career, and plateaus thereafter.

On the specialized demands of geometry instruction, Kersting, Smith, and Vezina (2023) find that geometry teaching demands unique spatial reasoning skills and visualization strategies that differ from algebraic or statistical instruction. Turning to professional development, Darling-Hammond, Hyler, and Gardner (2022), along with Kraft, Blazar, and Hogan (2021), collectively emphasize that sustained, collaborative, and content-focused professional learning is essential for improving teaching practice and student outcomes, arguing that occasional or rare participation is insufficient to produce meaningful changes in instructional practice. Similarly, Sims and Fletcher-Wood (2021) identify key features of effective professional development, including duration, collective participation, and content focus, finding that programs incorporating these elements produce meaningful improvements in teacher knowledge and student outcomes.

Predominant teaching methods and materials currently employed in the mathematics curriculum

Table 3 highlights the results on the teaching methods employed by the teachers. The findings reveal a consistent pattern across all indicators of mathematics instruction. This uniformity suggests that while students perceive these innovative teaching practices as occasionally present in their mathematics classrooms, they are not yet embedded as regular features of instruction.

The findings on Inquiry-Based Learning suggest that guided discovery is the most frequently employed IBL practice, though it remains only seldom used. Concrete, manipulative-based exploration is the least common IBL practice in these classrooms. This pattern is particularly noteworthy because hands-on activities represent the most accessible entry point for implementing inquiry-based approaches, yet they are reportedly the least employed. The uniformity across all items reinforces the interpretation that IBL practices are consistently underutilized rather than selectively implemented. The present findings suggest that despite this robust evidence for IBL effectiveness, classroom practice lags considerably behind research recommendations, potentially depriving students of opportunities to develop the mathematical reasoning and problem-solving skills that inquiry-based approaches cultivate.

The findings on technology integration suggest that when technology is used, it tends to be employed for collaborative purposes rather than for direct instructional support through specialized mathematical tools or practice platforms.

Table 3. Predominant teaching methods and materials currently employed in the mathematics curriculum

Indicators	Mean	Descriptive Category
Inquiry-Based Learning		
1. Students engage in hands-on activities and experiments to explore mathematical concepts.	3.84	Seldom Employed

2. Teachers encourage students to ask questions and investigate their own ideas	3.99	Seldom Employed
3. Class time is often dedicated to student-led problem-solving sessions	3.90	Seldom Employed
4. Collaborative group work is used to tackle complex mathematical problems	3.98	Seldom Employed
5. Students are guided to discover mathematical principles through exploration and inquiry	4.00	Seldom Employed
Integration Technology in Mathematics Education.		
1. Digital tools such as graphing calculators and educational software are regularly used in lessons.	3.97	Seldom Employed
2. Online platforms are employed for interactive learning and practice	3.97	Seldom Employed
3. Virtual simulations and visualizations are used to explain abstract mathematical concepts	3.98	Seldom Employed
4. Technology is used to facilitate student collaboration and communication	4.01	Seldom Employed
5. Multimedia resources (videos, animations) are integrated into the teaching of mathematics	3.99	Seldom Employed
Student-Centered Learning Approaches		
1. Lessons are designed to be student-centered, with a focus on active learning.	3.96	Seldom Employed
2. Students are given opportunities to choose topics or projects based on their interests	3.88	Seldom Employed
3. Class discussions and debates are frequently used to explore mathematical ideas	3.93	Seldom Employed
4. Personalized learning paths are provided to accommodate different learning styles	4.05	Seldom Employed
5. Reflective activities, such as journaling, are used to help students process their learning	3.85	Seldom Employed
Assessment Practices and Feedback Mechanisms.		
1. Formative assessments are regularly used to monitor student progress	3.88	Seldom Employed
2. Immediate and constructive feedback is provided on student work	3.94	Seldom Employed

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3. Peer assessments and self-assessments are incorporated into the learning process	4.00	Seldom Employed
4. Summative assessments align with the curriculum objectives and learning outcomes	3.97	Seldom Employed
5. Various assessment methods (quizzes, projects, presentations) are used to evaluate student understanding.	4.01	Seldom Employed
Inclusivity and Differentiated Instruction		
1. Lessons are adapted to meet the diverse needs of students	3.96	Seldom Employed
2. Instructional strategies are differentiated to accommodate different learning styles	3.98	Seldom Employed
3. Additional support is provided for students who struggle with mathematical concepts	4.00	Seldom Employed
4. Advanced learners are challenged with enrichment activities and higher-order thinking tasks.	3.96	Seldom Employed
5. Cultural and linguistic diversity is respected and integrated into the curriculum	4.10	Seldom Employed

The consistent underutilization across all forms of educational technology indicates that technology is not yet a regular or embedded feature of mathematics instruction. The findings on student-centered learning approaches suggest that teachers are attempting to address individual learning differences through personalization, but are less likely to employ metacognitive strategies that help students become aware of their own thinking processes. The gap between personalization (rank 1) and reflective activities (rank 5) may indicate that teachers focus on adapting instruction to students rather than developing students' capacity to adapt their own learning strategies.

The findings on assessment practices suggest that teachers employ diverse summative assessment methods more frequently than the formative assessments that research identifies as crucial for learning improvement. The gap between variety in assessment and formative monitoring indicates a potential misunderstanding of assessment purposes, with emphasis placed on measuring learning after instruction rather than supporting learning during instruction. The findings on inclusivity and differentiated instruction suggest that teachers are most successful at creating a respectful classroom climate that acknowledges diversity, but struggle more with the concrete instructional adaptations required to address diverse learning needs effectively.

This finding aligns with the meta-analysis of Mediana, Funa, and Dio (2025), which is particularly significant given the Philippine educational context where technology integration has been prioritized in recent years. Dageo-a (2025) found that interactive visualization tools positively affect mathematical performance, while Chestnutt (2025) provides theoretical grounding through multisensory instruction, emphasizing the Concrete-Representational-Abstract sequence, manipulatives, and movement-based learning as key components of student-centered instruction. Nwankwo and Nwala (2025) demonstrated that student-centered cooperative learning strategies produce significantly higher achievement than lecture-based instruction. Finally, Balbi, Bonilla, Curione, Ibarra, and Menese (2025) showed that a professional development program in formative assessment significantly improves teachers' self-efficacy, knowledge, and implementation practices.

Current level of perceived mathematical literacy among students in the targeted educational setting

Table 4 underscores the perceived mathematical literacy among students in the targeted educational setting.

Table 4. Current level of perceived mathematical literacy among students in the targeted educational setting

Indicators	Mean	Descriptive Category
Understanding of Mathematical Concepts	3.72	High
Application of Mathematical Knowledge	3.78	High
Problem-Solving Skills	3.75	High
Critical Thinking and Analytical Skills	3.78	High
Communication of Mathematical Ideas	3.76	High
Overall mean	3.76	High

Students feel most confident about their ability to grasp new mathematical topics in the classroom setting but express relatively less confidence in their foundational understanding and ability to explain basic concepts to others. This pattern reveals a potential gap between the perceived ease of learning new material and the depth of understanding required for explanation and teaching. Students readily recognize mathematics as relevant and applicable to their everyday experiences, yet they feel slightly less confident about applying it in more specialized or formal contexts such as finance, science, and technology. This reveals an important distinction between informal, everyday mathematical applications and formal applications in academic or professional domains. Regarding problem-solving skills, students perceive themselves as capable of approaching novel mathematical challenges with confidence.

This finding aligns with research by Susilawati, Suryadi, and Dahlan (2025), who demonstrated that mathematical literacy significantly influences students' mathematical self-concept, suggesting that students' confidence in their abilities likely develops through successful engagement with mathematical challenges. Wahid, Suhendra, and Juandi (2025), in their systematic review of mathematical literacy research, identified that conceptual understanding, real-world application, problem-solving, and communication are core components of mathematical literacy frameworks internationally. The present findings reveal that students perceive themselves positively across all domains, with particular confidence in approaching unfamiliar problems and synthesizing information from multiple sources.

Perception of the two groups of respondents on the existing curriculum in terms of its effectiveness in enhancing perceived mathematical literacy

Table 5 presents the perception of the two groups of respondents on the existing curriculum in terms of its effectiveness in enhancing perceived mathematical literacy.

Table 5. Perception of the two groups of respondents on the existing curriculum in terms of its effectiveness in enhancing perceived mathematical literacy

Indicators	Mean	Descriptive Category
Students		
Curriculum Relevance and Engagement	3.83	Effective
Integration of Technology in Mathematics Education	4.14	Effective
Student-Centered Learning Approaches	3.96	Effective
Assessment Practices and Feedback Mechanism	3.94	Effective

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Inclusivity and differentiated Instruction	3.93	Effective
Overall Mean	3.96	Effective
Teachers		
Curriculum Relevance and Engagement	3.86	Effective
Integration of Technology in Mathematics Education	4.12	Effective
Student-Centered Learning Approaches	3.98	Effective
Assessment Practices and Feedback Mechanism	3.97	Effective
Inclusivity and differentiated Instruction	4.01	Effective
Overall Mean	3.98	Effective

The findings reveal a curriculum that is generally viewed as effective across all indicators. However, a closer analysis uncovers specific pedagogical strengths and areas where implementation may be falling short of its full potential. The findings suggest that while the curriculum successfully achieves high-level outcomes such as critical thinking and career motivation, it occasionally struggles with the foundational elements of engagement and real-world application that make learning immediately meaningful.

In the area of curriculum relevance and engagement, a notable paradox emerges. The curriculum effectively promotes the long-term value of mathematics, motivating students to pursue further studies or careers in mathematics-related fields. However, there is a notable weakness in connecting daily lessons to students' immediate lives through real-world applications. This disparity implies that while students aspire to future math-related careers, the current instructional content may be too abstract or theoretical to make the day-to-day learning journey engaging. Regarding technology integration, the curriculum demonstrates a significant strength in cognitive application but a weakness in social interaction. Digital tools are highly effective in helping students visualize complex ideas, yet technology is less frequently used to facilitate collaborative learning and group work.

This reveals that technology is predominantly utilized as an individual learning aid rather than a platform for communication and shared problem-solving. For student-centered learning approaches, the curriculum is most effective in supporting the development of critical thinking and problem-solving skills, but least effective in encouraging active participation and student engagement. This gap suggests that students may be engaged in rigorous thinking within a relatively passive instructional framework. In terms of assessment practices, students receive constructive feedback through diverse evaluation tools, yet there is a potential misalignment between assessment practices and learning objectives. This can confuse students about what is truly important in the course. Finally, regarding inclusivity, the curriculum is highly responsive to students with learning difficulties, providing robust support and scaffolding. However, advanced learners are least likely to be challenged with appropriate enrichment activities, indicating that the curriculum may be neglecting the needs of high-achieving students.

Research provides important context for interpreting these findings. Stohlmann (2022) argues that a curriculum devoid of integrated real-world contexts risks being perceived by students as a mere set of procedural rules, which can undermine sustained engagement. The National Council of Teachers of Mathematics (NCTM, 2020) emphasizes that intrinsic motivation is sparked by immediate relevance, suggesting a crucial gap between the curriculum's aspirational messaging and its daily instructional delivery. Regarding technology, Drijvers et al. (2021) found that while integrating technology for individual concept development is common, leveraging it for collaboration requires a significant pedagogical shift that many curricula have yet to fully embrace. The OECD (2023) further supports this view, suggesting that technology's true transformative potential is realized only when it shifts tasks from individual efficiency to collaborative creation. On student-centered learning, Kapur's (2021)

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research on "productive failure" highlights the importance of active exploration and problem-solving before direct instruction, a process that requires high levels of student participation.

Significant relationship between the students' perceptions of the existing mathematics curriculum's effectiveness and their current levels of mathematical literacy in the targeted educational setting

Table 6 presents the Significant relationship between the students' perceptions of the existing mathematics curriculum's effectiveness and their current levels of mathematical literacy in the targeted educational setting.

Table 6. Significant relationship between the students' perceptions of the existing mathematics curriculum's effectiveness and their current levels of mathematical literacy in the targeted educational setting

Source of Variances		r-value	p-value	Decision	Interpretation
Understanding of mathematics concept	Curriculum Relevance and Engagement	0.629	0.000	Reject H_0	Significant
	Integration of Technology in Mathematics Education	0.669	0.000		
	Student-Centered Learning Approaches	0.604	0.000		
	Assessment Practices and Feedback Mechanism	0.623	0.000		
	Inclusivity and Differentiated Instruction	0.639	0.000		
Application of mathematics Knowledge	Curriculum Relevance and Engagement	0.653	0.000	Reject H_0	Significant
	Integration of Technology in Mathematics Education	0.645	0.000		
	Student-Centered Learning Approaches	0.708	0.000		
	Assessment Practices and Feedback Mechanism	0.644	0.000		
	Inclusivity and Differentiated Instruction	0.697	0.000		
Problem-Solving Skills	Curriculum Relevance and Engagement	0.573	0.000	Reject H_0	Significant
	Integration of Technology in Mathematics Education	0.574	0.000		
	Student-Centered Learning Approaches	0.622	0.000		
	Assessment Practices and Feedback Mechanism	0.588	0.000		
	Inclusivity and Differentiated Instruction	0.661	0.000		
	Curriculum Relevance and Engagement	0.623	0.000		

Critical Thinking & Analytical Skills	Integration of Technology in Mathematics Education	0.567	0.000	Reject H_0	Significant
	Student-Centered Learning Approaches	0.622	0.000		
	Assessment Practices and Feedback Mechanism	0.623	0.000		
	Inclusivity and Differentiated Instruction	0.681	0.000		
Communication of Mathematics Ideas	Curriculum Relevance and Engagement	0.640	0.000	Reject H_0	Significant
	Integration of Technology in Mathematics Education	0.587	0.000		
	Student-Centered Learning Approaches	0.630	0.000		
	Assessment Practices and Feedback Mechanism	0.655	0.000		
	Inclusivity and Differentiated Instruction	0.683	0.000		

The correlation analysis reveals consistently significant positive relationships between all dimensions of curriculum effectiveness and all indicators of mathematical literacy. This uniformly significant pattern indicates that students' perceptions of curriculum effectiveness are meaningfully associated with their self-assessed levels of mathematical literacy across understanding, application, problem-solving, critical thinking, and communication. The strongest correlate of conceptual understanding is inclusivity and differentiated instruction, followed closely by student-centered learning approaches. This suggests that when students perceive the curriculum as accommodating diverse learning needs and promoting active exploration, they report stronger comprehension of mathematical ideas. The relatively lower correlation for curriculum relevance and engagement indicates that while real-world connections support understanding, they may be less critical than pedagogical approaches that directly address how students process and internalize concepts.

The highest correlation for application skills is with student-centered learning approaches, followed by inclusivity and differentiated instruction and curriculum relevance and engagement. The prominence of student-centered approaches in predicting application skills suggests that when students actively participate in their learning and explore concepts independently, they develop greater capacity to transfer knowledge to practical contexts. Problem-solving shows the strongest correlation with inclusivity and differentiated instruction, followed by student-centered learning approaches. The consistently strong relationships across all curriculum dimensions for problem-solving suggest that this competency is broadly supported by multiple aspects of curriculum design, but most powerfully by approaches that address individual learner needs. Critical thinking correlates most strongly with inclusivity and differentiated instruction, while technology integration shows the lowest correlation, suggesting that technology alone may be less directly associated with critical thinking than pedagogical factors. Communication of mathematical ideas shows its strongest correlation with inclusivity and differentiated instruction, followed by assessment practices and feedback, indicating that communication skills are developed through feedback loops where students articulate their reasoning and receive guidance. Overall, inclusivity and differentiated instruction emerges as the strongest or second-strongest correlate for every mathematical literacy indicator, suggesting that curriculum effectiveness in promoting mathematical literacy is most powerfully associated with pedagogical approaches that center the learner and accommodate individual differences.

Auliya et al. (2026) found that students using augmented reality applications for geometry learning showed significant improvements in understanding complex concepts. A systematic literature review by Saat, Alias, and

Saat (2024) analyzing 13 articles found that digital technology integration significantly improves students' learning outcomes, problem-solving skills, engagement, and exploration capabilities. Shurygin et al. (2024) conducted a quasi-experimental study comparing traditional instruction with mobile application-based learning and found that students in the experimental group demonstrated significantly higher academic success, confirming that technology-integrated, student-active approaches enhance practical application. The systematic review by Dahal (2026) comparing ICT-integrated instruction with traditional methods found that while technology-enhanced approaches significantly improved mathematics achievement, the quality of pedagogical implementation remained crucial. The systematic literature review by the Eurasia Journal of Mathematics, Science and Technology Education (2026) identified that active learning methodologies and collaborative work enhance students' ability to communicate mathematical understanding.

CONCLUSIONS

Students face significant socioeconomic challenges that potentially limit their access to enriched mathematical learning opportunities beyond the classroom. Despite high faculty qualifications, the absence of veteran teachers and inconsistent professional development engagement may affect instructional continuity and mentorship capacity. The disconnect between high internet access but limited device and textbook availability suggests that connectivity alone does not ensure equitable access to quality mathematics education.

Innovative teaching practices are not yet embedded as regular features of mathematics instruction. While teachers demonstrate awareness of student-centered and inclusive principles, implementation remains inconsistent. The pattern reveals a tendency toward surface-level adoption of innovative practices rather than deep, systematic integration, with hands-on activities, formative assessment, and differentiation for advanced learners being particularly underutilized.

Students perceive their mathematical literacy positively across all domains, indicating confidence in their mathematical abilities. However, the pattern of highest and lowest items reveals specific areas for improvement: explaining fundamental concepts, applying mathematics in specialized contexts, and written communication are relative weaknesses, while grasping new topics, daily life application, and interactive discussion are relative strengths. The gap between oral and written mathematical communication is particularly notable.

The curriculum is perceived as generally effective, but significant gaps exist between aspirational outcomes and daily implementation. The curriculum successfully promotes long-term career motivation and supports struggling learners but fails to consistently connect mathematics to real-world contexts, leverage technology for collaboration, engage students actively, align assessments with objectives, or challenge advanced learners. The lowrating for-enrichment activities indicate a critical gap in serving high-ability students.

Students' perceptions of curriculum effectiveness are strongly and positively associated with their self-assessed mathematical literacy. The strength of these correlations indicates that curriculum design and implementation substantially influence student outcomes. Inclusivity and student-centered approaches emerge as the most powerful predictors of mathematical literacy, suggesting that curricula addressing individual learner needs and promoting active engagement are most effective in developing mathematical competencies.

Socioeconomic status and engagement opportunities matter for mathematical literacy development, while the mere presence of learning materials does not. Family income influences mathematical literacy broadly, with stronger effects on conceptual understanding and communication. Extracurricular participation, though modest, consistently predicts higher mathematical literacy across all domains. The non-significant findings for learning materials indicate that passive resource availability without active engagement and parental involvement is insufficient to influence outcomes.

Teaching methods are powerfully associated with mathematical literacy, accounting for a substantial portion of the variance in student outcomes. Inclusivity and differentiated instruction emerge as the most influential approaches, particularly for communication and problem-solving. Student-centered learning is especially important for critical thinking development. Technology integration supports understanding and communication, while inquiry-based learning enhances application skills. The consistently strong correlations confirm that pedagogical practice is central to mathematical literacy development.

Students and faculty hold systematically different views of students' mathematical capabilities. The consistent pattern of significant differences across all domains indicates a fundamental perceptual gap that likely affects instructional communication, expectation setting, and feedback effectiveness. Problem-solving shows the smallest gap, suggesting that observable behaviors provide more aligned perceptions, while application shows the largest gap, indicating fundamental disagreement about students' ability to transfer knowledge to practical contexts.

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