Formative Assessment Practices in a Mathematics Classroom

Jevalyn A. Lucas-Mendiola, Myrna E. Lahoylahoy, Joy T. Magsayo, Joan Rose R. Luib
Mindanao State University – Iligan Institute of Technology, Bonifacio Ave., Tibanga, Iligan City, 9200, Philippines
*Corresponding author email: jevalyn.lucas@g.msuiit.edu.ph

Abstract

Formative assessment plays a pivotal role in promoting student achievement, particularly in mathematics education, where it supports conceptual understanding, procedural fluency, and problem-solving skills. Despite its known benefits, consistent implementation remains a challenge. This qualitative instrumental case study examines how junior high school mathematics teachers implement formative assessment strategies in mathematics classrooms. Three case studies were conducted in a private Philippine secondary school involving classroom observations. Findings reveal the integration of diagnostic questioning, Claim-Evidence-Reasoning (CER) strategies, technology-enhanced assessments, and reflection practices are commonly used as formative assessments by the teachers. The study identifies patterns in teacher actions and student responses, underscores the benefits of formative assessment, and highlights challenges such as time constraints and professional development needs. Recommendations are provided to enhance formative assessment implementation across mathematics classrooms.

Keywords: Formative Assessment, Mathematics Classroom, Practice, Insights

1. Introduction

Formative assessment plays a pivotal role in improving teaching and learning, especially in mathematics education where it supports the development of students' mathematical proficiency—including conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick, Swafford, & Findell, 2001). As an ongoing instructional process, formative assessment allows teachers to gather timely evidence of student understanding and adjust instruction accordingly. Likewise, it empowers learners to monitor their own progress through reflective and responsive engagement (Black & Wiliam, 1998; Heritage, 2010; Wiliam, 2011).

Despite its established benefits, the consistent implementation of formative assessment in the Philippine classroom remains challenging. While the K to 12 curriculum promotes learner-centered and outcomes-based instruction, formative assessment is often

eclipsed by summative assessment pressures and constrained by limited teacher training, curriculum overload, and inconsistent school-based support systems (Clark, 2012; DepEd, 2015; Kingston & Nash, 2011). Teachers in private and public settings alike face difficulties in integrating formative strategies in daily practice, particularly when managing large class sizes, rigid pacing guides, or limited access to digital tools. This situation underscores the need for contextspecific research to understand how Filipino educators operationalize formative assessment in actual classroom settings.

In this light, the present study seeks to explore the lived instructional practices of three junior high school mathematics teachers from a private PAASCU-accredited school in Iligan City, Philippines. It aims to describe how these teachers design, integrate, and adapt formative assessment strategies to support student learning. Grounded in theoretical frameworks such as constructivism (Piaget, 1977; Vygotsky, 1978), Bloom's Taxonomy (1956), and feedback/self-regulation models (Hattie & Timperley, 2007; Nicol & Macfarlane-Dick, 2006), the study positions formative assessment as a reflective, dynamic practice that bridges teaching and learning through active feedback loops.

To guide this investigation, the study was framed around the following research questions:

1. What formative assessment strategies do mathematics teachers implement in classroom practice?

2. How do these strategies influence student responses, engagement, and learning behavior?

By focusing on actual classroom implementation, this study contributes to a growing body of empirical work that highlights how formative assessment can be localized and contextualized. It offers practical insights for teachers, instructional leaders, and policymakers seeking to enhance formative assessment in mathematics instruction.

2. Methodology

2.1 Research Design

Qualitative instrumental case study design was chosen to explore and describe the formative assessment practices employed by mathematics teachers. The focus was on understanding how teachers implement these practices in a mathematics classroom.

2.2 Participants of the Study

This study investigated how three junior high school mathematics teachers in a PAASCU-accredited private school in Iligan City utilized formative assessment strategies. The teachers were purposefully selected based on their active use of these strategies, willingness to participate, and diverse teaching experiences. The first participant (T1) was a female teacher with ten years of experience, holding a permanent position and serving as the Mathematics Department head. She taught three Grade 10 homerooms. The second participant (T2) was a male teacher in his first year of probationary employment, teaching Grades 9 and 10 across six homerooms. The third participant (T3) was also a male teacher in his third year of teaching, assigned to six Grade 7 homerooms.

The research design involved observing each teacher in one homeroom, consisting of 40 to 45 students, for three 50-minute sessions. By including teachers with varied experience levels—from a seasoned department head to a new teacher and one during professional development—the study aimed to gain a comprehensive understanding of how formative assessments are conceptualized and put into practice within a junior high school mathematics environment.

2.3 Instrumentation

To gather triangulated data on formative assessment practices, the study utilized classroom observations, lesson plans, and semi-structured interviews. A thematic coding framework was developed to systematically categorize teacher actions and student responses related to formative assessment. These instruments and the coding scheme supported the analysis of instructional practices and student learning outcomes in mathematics.

1) *Classroom Observations:* In-depth classroom observations were conducted to understand how formative assessments are implemented in practice. These observations will focus on the types of formative assessments used, the nature of feedback provided, and the interaction between teachers and students during the assessment process.

2) *Thematic Coding Framework:* In addition to interviews, instructional materials, and classroom observations, a thematic coding framework was developed to systematically identify recurring teacher actions and student responses related to formative assessment. These codes emerged from inductive analysis of classroom observation data across the three case studies and were refined as new patterns surfaced.

3) Codes were grouped into two primary categories: Teacher's Actions (TA) and Student's Responses (SR). Each code was accompanied by a short label, description, and a sample classroom exchange. For instance, TA-RP (Rephrasing for Clarity) captured the teacher's strategy of rewording questions to enhance comprehension, while SR-CER (Structured Explanation via CER) represented students' use of the Claim-Evidence Reasoning format in problem justification. This framework supported a structured analysis of how formative assessments influenced the development of mathematical proficiency and problem-solving skills.

3. Results and Discussion

Three mathematics teachers observed over a period of 50 minutes for three days to explore their formative assessment practices in the classroom. Each teacher represented a distinct case: one from Grade 10 Case Study 1, one from Grade 9 Case Study 2, and one from Grade 7 Case Study 3. These observations focused specifically on the implementation of formative assessment strategies during mathematical instruction, particularly in the development of learners' problemsolving skills and overall mathematical proficiency.

3.1 Case Study 1

Case Study 1 was conducted in a Grade 10 mathematics class composed of fortytwo (42) learners under the instruction of a female teacher (T1) with a decade of teaching experience in junior high school. She holds a regular permanent status and concurrently serves as the Subject Area Head of the Mathematics Department, supervising instructional planning and implementation from Grade 2 to Grade 10. Her dual role as classroom teacher and curriculum leader provided a valuable perspective on both pedagogical execution and departmental alignment.

T1 is part of the day high school program and handles three Grade 10 homerooms. Her professional background includes involvement in school-based training programs and the facilitation of professional learning sessions on assessment strategies, including the use of digital tools and the Claim-Evidence-Reasoning (CER) strategies. Given her expertise, she was purposively selected to represent experienced teachers who actively integrate formative assessment into their daily instruction.

The classroom environment was characterized by structured routines and active student participation. Observations were conducted across three days, with each session lasting approximately 50 minutes. These observations focused on the teacher's

implementation of formative assessment strategies, the nature of feedback delivered, and how students responded to assessment prompts within the lesson flow. The rich classroom data generated from Case Study 1 offered insight into how formative assessment is operationalized by an experienced teacher with instructional leadership responsibilities.

The table 1 in the next page illustrated the teacher-student interaction in Case Study 1. This demonstrated a well-structured integration of formative assessment across the lesson flow.

The use of diagnostic questioning at the start of instruction enabled the teacher to identify prior knowledge and surface misconceptions early. Notably, students responded confidently with prior knowledge, showing that they recognized the role of these prompts in guiding their learning process.

The Claim-Evidence-Reasoning (CER) framework was a key feature in promoting student accountability and precision in mathematical justifications. While the framework itself is not new, its consistent application revealed a classroom culture where structured reasoning was normalized. Students did not merely provide answers; they explained their thinking processes, often referencing diagrams or peer suggestions. One student shared, "*The radius is perpendicular because it touches the center... that's why it makes 90 degrees,*" which reflected an evolving capacity for logical justification.

Technology also played a supportive role, particularly using GeoGebra, which facilitated exploratory manipulation of figures. Unlike more passive tools, the teacher's implementation prompted active engagement—students made conjectures, adjusted variables, and tested ideas in real time. One student remarked, "*When I move the point, the angle still stays. That helped me prove it.*" This type of response points not only to conceptual understanding but to the empowerment of learners as sense-makers.

Beyond the tools and strategies, what stood out was how students reflected on their learning. Through teacher-guided prompts like "*On a scale of 1 to 5, how do you feel about this lesson?*", learners engaged in self-assessment. Several students candidly expressed changes in confidence levels: "*At first I wasn't sure... but I realized I understood when I explained it to my group.*" These moments signified the emotional and metacognitive gains that emerged from a supportive feedback loop in an area often underrepresented in formative assessment research.

Table 1. Teacher-Student Interactions in Case Study 1

Practices	Teacher Action	Students Response
1. Diagnostic Questioning	The teacher initiated the lesson by eliciting students' prior knowledge to inform instruction. For example, the prompt *"How do you describe a tangent line?"* aimed to activate foundational concepts. (TA-DQ)	Students responded by recalling relevant concepts, indicating prior learning retrieval. As one student said, *I remember that a triangle line only touches the circle at one point."* This practice shows the teacher's role in identifying existing knowledge and misconceptions as a springboard for deeper learning. (SR-RC)
2. Concept Development	The teacher used scaffolded questions to probe reasoning, e.g., *"What makes you say that the angle is 90 degrees?"* (TA-PG) Students were prompted to construct claims supported by evidence, a hallmark of the CER approach, as in *"State your claim and support it with what you see in the diagram."* (TA-CER)	These responses included making logical claims (*"The radius is perpendicular..."*), clarifying ideas (*"These two base fragments are equal..."*), and engaging in peer explanation.

Table 1. (Cont')

Practices	Teacher Action	Students Response
	The teacher encouraged students to discuss ideas with peers before sharing to the class, enhancing collaborative reasoning. (TA-PI)	
3.Integrating Technology for Assessment	The use of digital tools like GeoGebra enabled visual learning and immediate assessment of understanding. A prompt such as *"Show your GeoGebra diagram…"* directed students to apply technology meaningfully. (TA-TECH)	Students interacted with tools to manipulate geometric elements, e.g., *"When I move the point in GeoGebra, the angle still stays 90 degrees."* (SR-TU)
4.Reflection and Feedback	The teacher gave timely feedback, guiding students to revise thinking, e.g., *"Let's go back—what operation did you apply in this step?"* (TA-FB) The teacher also facilitated reflective thinking with prompts like *"On a scale of 1 to 5, how do you feel about this lesson?"* (TA-REF)	Students responded with evidence of reflection and growth. They acknowledged misconceptions (*"I see now. I added instead of subtracting…"*) and articulated confidence (*"I wasn't confident before, but now I think I always learn a lot from this class."*) (SR-EF, SR-RF, SR-CF)

3.2 Case Study 2

Case Study 2 was conducted in a Grade 9 mathematics class composed of forty-five (45) learners under the instruction of a male teacher (T2) in his first year of teaching. He holds probationary status and is assigned to the day high school program. T2 teaches six (6) homerooms and represents a beginning teacher who is actively building his instructional foundation while exploring strategies aligned with formative assessment practices. Despite being new to the teaching profession, T2 has shown initiative in integrating formative assessment approaches into his lessons. His practices reflect an early effort to adopt digital tools such as Quizizz, as well as the Claim-Evidence-Reasoning (CER) strategy, to facilitate student understanding and monitor learning. His participation in the study was purposively determined to reflect how novice teachers approach formative assessment while adjusting to classroom realities and pedagogical expectations. The classroom environment was characterized using educational technology, structured questioning, and an emerging routine of feedback and reflection. Observations were carried out across three days, with each session lasting approximately 50 minutes. The observation focused on his application of formative assessment tools, his use of feedback to support student learning, and the responses of students to his instructional strategies. The data gathered from Case Study 2 offers valuable insight into how formative assessment is interpreted and implemented by a first-year teacher striving to establish effective instructional practices.

Table 2 below presents a structured thematic coding framework that captures the interaction between the teacher's formative assessment strategies and the corresponding student responses observed during classroom instruction in Case Study 2. These codes were grouped into five core practices reflective of formative assessment principles: (1) Scaffolding Learning, (2) Diagnostic Teaching, (3) Introduction of New Concepts, (4) Real-World Application and Technology Integration, and (5) Evaluation, Justification, and Reflection.

Table 2. Teacher-Student Interactions in Case Study 2

Practices	Teacher Action (TA)	Students Response (SR)
1. Scaffolding Learning	The teacher began the lesson by prompting a recall of previous mathematical concepts to reinforce foundational understanding. For example, the prompt *"Let's recall how to compute the area of a parallelogram. Who remembers the formula?"* served to prepare students for new tasks by activating relevant prior knowledge. (TA-RV)	Students responded by retrieving geometric formulas or definitions from memory, as in *"The formula for the area of a rectangle is length times width."* (SR-KR)
2. Diagnostic teaching	The teacher also posed follow-up questions to address potential misinterpretations, such as *"Do you think the diagonal represents the whole length or just half?"* (TA-CL)	Students responded by analyzing relationships and identifying errors in interpretation, as illustrated by *"I misread the question—it's asking for the width, not the length."* (SR-AN, SR-ER)
3. Introduction of New Concepts	New content was introduced using explicit examples and guided demonstrations. The teacher broke down solution steps while students observed and attempted to replicate the process. (TA-MD) The teacher employed scaffolded questions to guide students toward key mathematical relationships and to check conceptual clarity. One guiding prompt was *"Why do we cross multiply in this proportion? What does it help us find?"* (TA-GQ)	Students responded by articulating the rationale behind their solutions: *"I divided 48 by 6 to get the scale factor because those are the corresponding sides."* (SR-EX) Students practiced identifying the means and extremes in different equations, using a step-by-step approach. (SRKR)
4. Real-World Application and Technology Integration	The teacher integrated technology through QR codes and interactive tasks related to proportional reasoning and geometry. For example, *"Scan this QR code to access today's interactive material on proportions."* (TAINT)	Students were encouraged to relate mathematical concepts to daily life, with responses such as *"We use ratios in recipes when adjusting servings."* (SR-APP)
5. Evaluation, Justification, and Reflection	The teacher provided real-time feedback, correcting errors and encouraging collaborative checks (e.g., *"Identify and differentiate between ratios and proportions ..* (TA-FB) Reflection was encouraged at the end of tasks through prompts like *"How can you apply what we learned about scale factor in a real-life situation?"* (TA-REF)	Student responses showed evidence of peer interaction, justification of procedures, and personal reflection: *"Using cross-multiplication really helped me solve the missing side faster."* (SR-CW, SR-RF, SR-EX)

In Case Study 2, the novice teacher's approach reflected an emerging but promising understanding of formative assessment. His lessons relied on structured questioning, feedback loops, and integration of digital tools such as Quizizz and QR codes. What made this case noteworthy was not the tools themselves but how students reacted to them.

The teacher scaffolded learning by prompting recall (e.g., *"What's the area of a parallelogram again?"),* followed by guided demonstrations that encouraged students to verbalize the logic of their computations. Students were not just repeating formulas; they were connecting them to real-world contexts. One student stated, *"We use ratios in recipes... like when changing the servings,"* showing an ability to transfer knowledge to daily life situations.

Although the teacher was still developing his facilitation style, he showed a strong tendency to adjust based on student misunderstanding, which students openly acknowledged. One noted, *"I misread the question... I thought it was asking for length."* The fact that students felt comfortable expressing mistakes suggests a psychologically safe environment—an essential condition for effective formative assessment.

Peer work and reflection also emerged, particularly during scale factor tasks. Students explained procedures to one another and, through real-time feedback, refined their understanding. These interactions became formative moments in themselves, blurring the line between assessment and instruction. As one student reflected, *"Cross-multiplying helped me... I saw where I messed up after checking with my partner.*

3.3 Case Study 3

Case Study 3 was conducted in a Grade 7 mathematics class facilitated by a male teacher (T3) in his third year of teaching. He holds a probationary status and is part of the junior high school day program. T3 manages six (6) homerooms and was selected to represent teachers in the early stage of professional development who have had sufficient exposure to instructional innovations and formative assessment practices. With three years of classroom experience, T3 demonstrated growing confidence in integrating technology and student-centered strategies in his instruction. His lessons emphasized foundational mathematical skills such as integer operations, descriptive statistics, and basic arithmetic. These were delivered through a variety of formative assessment approaches including the use of GeoGebra, collaborative group tasks, and structured reflection activities. T3 also adopted the Claim-Evidence-Reasoning (CER) framework to develop students' problem-solving skills and mathematical reasoning.

The classroom environment observed in this case study was characterized by active student engagement, frequent feedback loops, and the use of visual and interactive tools. Observations were conducted across three consecutive days, with each session lasting approximately 50 minutes. The observation focused on how the teacher incorporated formative assessment strategies into instruction, facilitated peer interaction, addressed learning gaps, and responded to student outputs. Case Study 3 offered insight into how a developing teacher applies a range of formative assessment strategies to support conceptual understanding and learner growth in a lower grade level mathematics setting.

Table 3 below presents the thematic codes used in the flowchart (figure 3), which represent recurring teacher actions and student responses observed during the Grade 7 mathematics lessons. These codes were developed through thematic analysis and used to map formative assessment strategies and their influence on student learning behaviors. The codes are grouped into four instructional practices aligned with formative assessment: (1) Checking Prior Knowledge and Goal Setting, (2) Gamified and Visual Reinforcement, (3) Concept Application and CER, and (4) Collaborative Problem Solving.

In Case Study 3, formative assessment was intentionally woven into every phase of instruction, especially in relation to younger learners' cognitive and emotional development. The teacher began by simplifying language and rephrasing questions, prompting clearer responses and reducing anxiety. One Grade 7 student replied, "*Oh, now I get it. Same sign, you add!"*—a simple yet powerful indication of comprehension through accessible questioning.

Table 3. Teacher-Student Interactions in Case Study 3

Practices	Teacher Action (TA)	Students Response (SR)
1. Checking Prior Knowledge and Goal Setting	The teacher began by rewording questions to enhance comprehension and student engagement. An example prompt was, *"Let's rephrase it—what are the rules for adding integers?"* (TA-RP)The teacher introduced the lesson's goals, helping students anticipate the content and structure: *"These are our goals today—what do you think we'll be focusing on?"*(TA-LT)	Students responded with improved clarity and accuracy when questions were simplified, such as *"Oh, the rule is: if both signs are the same, you add."* (SR-REPH)
2. Gamified and Visual Reinforcement	The teacher used tools like Quizizz to make skill review interactive and enjoyable: *"Connect to Quizizz and let's see how well you remember integer rules."* (TA-GM) Video clips were employed to strengthen conceptual understanding: *"Let's watch this short video to better understand how integers are used in real-life."* (TA-VIS)	Students showed enthusiasm for gamified tasks and gained conceptual clarity from multimedia, as reflected in comments like *"We got that one right! Let's beat the other group"* *and* "I understand now that integers include negative temperatures too." *(SR-GM, SR-VIS)*
3. Concept Application and CER	The teacher implemented the Claim-Evidence-Reasoning framework, prompting students to justify solutions: *"What is your claim? What evidence do you have? And what's your reasoning?"* (TA-CER) More complex problems were assigned to deepen understanding: *"Try applying the same strategy to this new problem with different data."* *(*TA-EXT)	The teacher implemented the Claim-Evidence-Reasoning framework, prompting students to justify solutions: *"What is your claim? What evidence do you have? And what's your reasoning?"*(TA-CER) More complex problems were assigned to deepen understanding: *"Try applying the same strategy to this new problem with different data."* *(*TA-EXT)
4. Collaborative Problem Solving	These strategies were revisited during collaborative group tasks, where students discussed solutions and refined their understanding with peer support. (TA-CER, TA-EXT)	Student explanations demonstrated growing confidence in using structured reasoning, while group work allowed them to verbalize their thought processes and reconsider their strategies. (SR-CER, SR-REF)

This case also showcased gamified assessments and visual strategies. Quizizz activities sparked excitement, while video clips connected abstract math concepts to real life. Students responded with heightened engagement and stronger conceptual clarity. One group cheered, *"We beat the other group!"* while another commented, "*Now I understand how negatives work with temperature.*" These statements reflected both motivation and cognitive alignment.

The Claim-Evidence-Reasoning strategy was again evident here, but with a difference: students were more tentative in early justifications, gradually gaining fluency.

Through peer discussion and teacher feedback, students began to articulate not just the "what," but the "why" behind their solutions. A student explained, "*At first, I thought subtraction… but combining means adding. So, I changed my answer.*" This growth in metacognitive reasoning signaled increasing autonomy.

Finally, the collaborative problem-solving phase allowed students to verbalize strategies and make decisions as a group. Reflection wasn't just teacher-directed; it became an internalized habit among students who were beginning to see learning as a process, not just a task.

3.4 Common Formative Assessments Used

Across the three case studies, a consistent pattern of formative assessment emerged: clear goal setting, diagnostic questioning, structured reasoning tasks, real-time feedback, and reflective closure. While the strategies themselves align with established models, what distinguishes this study are the students' responses—both cognitive and affective—and the localized adaptations by teachers at different career stages.

All three teachers used Claim-Evidence-Reasoning, but the contexts differed: the veteran teacher used it to deepen conceptual rigor, the novice teacher to encourage logical expression, and the developing teacher to support foundational skills. Likewise, technology integration ranged from advanced tools like GeoGebra to gamified platforms like Quizizz, each prompting different types of learner engagement. These variations point to a flexible, context-driven approach to formative assessment.

Most critically, students across all grade levels demonstrated ownership of their learning. They reflected on mistakes, justified reasoning, collaborated with peers, and adjusted thinking in response to feedback. These behaviors were not imposed that they emerged organically from instructional conditions that valued dialogue, exploration, and iterative improvement.

Figure 1 in the next page illustrates a common and general process of formative assessment observed across the three case studies. This model encapsulates the key steps that characterize the implementation of formative assessment in mathematics classrooms and reflects a continuous, cyclical learning and assessment loop. It draws directly from the observed teaching practices of the three teachers, regardless of differences in grade level, years of experience, or instructional style.

Moreover, the diagram not only reinforces the empirical findings from the classroom observations and interviews but also offers a practical lens through which educators can reflect on and enhance their own formative assessment practices. It serves as a model for designing instruction that places assessment at the core of learning—where evidence of student thinking informs next teaching steps, and students are active participants in evaluating their progress. By visualizing the relationship between assessment strategies and student engagement, this synthesis provides both theoretical and applied contributions to understanding formative assessment in mathematics education.

Figure 1 presents a common schematic version of the detailed flow, illustrating the continuous loop of learning and assessment in simpler, more abstract terms. It breaks the process into seven clear steps:
1. Identify the Target Skill
2. Implement FA Strategies
3. Engage Students in the Learning Process
4. Interpret Learning Evidence
5. Make Learning Gap Decisions
6. Modify Instruction Based on Evidence
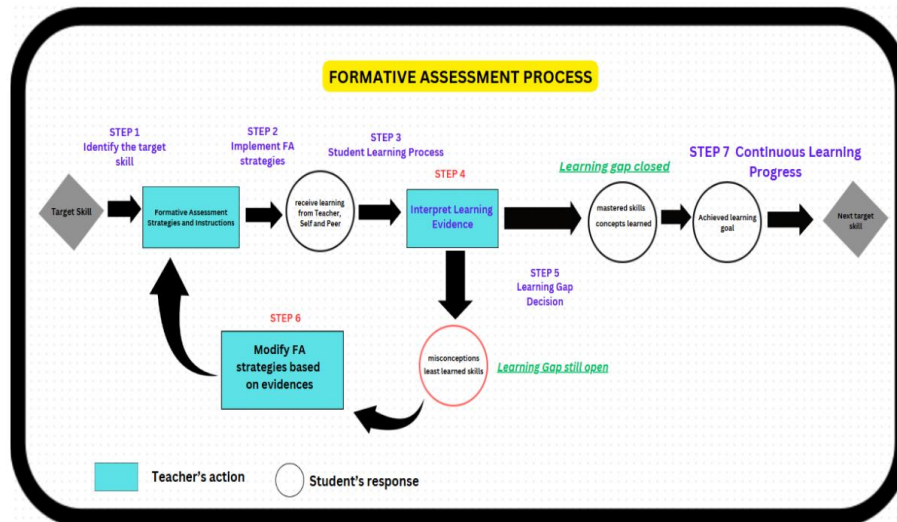7. Ensure Continuous Learning Progress

Figure 1: Schematic Diagram: Visualizing Formative Assessment Process

The icons and arrows represent teacher actions (blue rectangles) and student responses (white circles), with red nodes indicating decision points based on evidence. When learning gaps are identified, instruction loops back to Step 2. If mastery is confirmed, students advance toward the next learning objective. This model aligns with the best practices in formative assessment, supporting literature by Black & Wiliam (1998), McMillan & Hearn (2008), and Derivita (2023), emphasizing that effective Formative Assessment requires continuous evidence collection, interpretation, and adaptation to meet learner needs. The schematic diagram above illustrates the step-by-step process of implementing formative assessment in a mathematics classroom. It visually represents how teachers and students engage in a continuous cycle of assessment, feedback, and instructional modifications to enhance learning.

Key Elements

● Teacher's Actions (blue rectangles) represent instructional strategies and modifications.

● Student's Response (white circles) indicate their learning progress based on formative assessments.

● Decision Points (red circles and arrows) guide the teacher in determining whether students have mastered the skill or need further intervention.

● Final Goal (gray diamonds) highlights student mastery and transition to the next learning objective.

Step 1: Identifying the Target Skills

The process begins by clearly defining the mathematical skill or concept that students need to learn. Learning objectives should be aligned with curriculum standards and instructional goals (Wiggins & McTighe, 2000). In mathematics, these skills range from basic arithmetic operations to complex problem-solving strategies.

For example, in *case studies* the teacher shows the target skills to set clear goals for the learners. Before designing formative assessment activities, educators must ensure that the target skill is explicitly communicated to students, as clear goals enhance motivation and learning outcomes (McMillan & Hearn, 2008).

Step 2: Implementing Formative Assessment Strategies

Once the target skill is defined, the teacher integrates formative assessment strategies into instructional delivery. These strategies involve various techniques such as:

● Think-Pair-Share – Students discuss their thought process with peers before sharing with the class.

● Digital Assessment Tool – Students write answers on interactive quiz platforms (e.g., Quizizz.com), this enabled real-time tracking of student progress, provided immediate feedback, and addressed misconceptions through embedded instructional videos.

● Exit Tickets – Short questions that gauge student understanding at the end of a lesson. Observational Findings:

● Classrooms where teachers implemented these strategies showed higher engagement and participation levels.

● Case studies revealed that students who engaged in peer discussions and immediate feedback cycles demonstrated better retention and conceptual understanding compared to those in traditional lecture-based instruction.

Step 3: Student Learning Process

In this phase, students engage in the learning process through:

● Teacher-Guided Instruction – Direct explanation and modeling.

● Self-Assessment – Reflection on their progress.

● Peer Collaboration – Discussions and problem-solving with classmates. According to Heritage and Heritage (2013), student interaction plays a vital role in deepening mathematical understanding. By actively participating in their learning, students develop self-regulation skills and gain confidence in their problem-solving abilities.

Step 4: Interpreting Learning Evidence

The teacher analyzes student responses from formative assessment activities to determine whether students have grasped the mathematical concept. This evidence can be collected through:

● Observation of student work.

● Class discussions and verbal explanations.

● Written responses on worksheets or digital platforms.

Observational Findings:

● Teachers who systematically collected and analyzed formative assessment data were able to identify learning gaps earlier.

● Case studies showed that when students received timely feedback, their performance in subsequent assessments improved significantly.

Step 5: Evaluating the Gaps

At this stage, teachers decide whether students have mastered the skill or if learning gaps still exist. Two possible outcomes arise:

A. Learning Gap Closed:

If students demonstrate proficiency in the target skill, they progress to the next learning goal. This confirms that formative assessment strategies were effective in facilitating understanding.

B. Learning Gap Still Open: If misconceptions or partial understanding persist, further intervention is required. Research indicates that addressing misconceptions early prevents the accumulation of gaps that hinder future learning (Bennett, 2011).

Step 6: Modifying Instructions Based on Evidence

If learning gaps persist, teachers must adjust instruction based on formative assessment data. Modifications may include:

● Re-explaining concepts using alternative methods (visual models, real-life applications).

● Providing additional guided practice (scaffolded exercises).

● Implementing targeted interventions for struggling students.

Studies have shown that classrooms where teachers adapted instruction based on formative assessment data demonstrated higher student success rates in mastering concepts. One study on higher-order thinking skills (HOTS) in mathematics revealed that formative assessment interventions enhance teaching effectiveness and significantly

improve students' performance in mathematics (Frontiers in Education, 2022). This finding aligns with best practices in mathematics education, where timely feedback and instructional adjustments ensure better concept mastery. Formative assessments also contribute to boosting students' confidence in problem-solving. Research indicates that verbal formative assessments enable educators to provide immediate feedback and tailored interventions, allowing students to strengthen their understanding and feel more confident in solving mathematical problems (Derivita, 2023). By addressing misconceptions in real time and providing personalized learning experiences, students become more engaged and less intimidated by complex problem-solving tasks.

Observational Findings:

● Teachers who systematically adjusted their instruction based on formative assessment data observed that students were better able to retain mathematical concepts and apply them in problem-solving scenarios.

● Case studies confirmed that students who received targeted interventions based on their specific learning needs exhibited increased confidence and a more positive attitude toward learning mathematics.

Step 7: Continuous Learning Progress

After modifications are made, students re-engage with the learning material. The cycle repeats until:

● The student closes the learning gap and successfully master the concept.

● The teacher confirms proficiency through further formative assessment.

● The student is ready to progress to the next target skill.

The findings show that formative assessments significantly enhanced student learning outcomes, particularly in:

● Building mathematical proficiency – Students developed a deeper conceptual understanding of mathematical concepts.

● Developing problem-solving skills – Students learned to analyze and approach problems systematically.

● Increasing engagement and motivation – Formative assessment encouraged active participation and self-regulated learning.

● Reducing misconceptions and learning gaps – Through targeted feedback, students corrected errors before progressing to higher-level content. The observations and case studies confirm that the systematic use of formative assessment leads to improved academic performance, greater student autonomy, and more effective classroom learning experiences.

3.5 Students' and Teachers' Reflection on Formative Assessment Practices and Student Learning

To ensure the credibility of findings, data were triangulated across classroom observations, student engagement, and teacher and student interviews from three distinct grade levels. This cross-case triangulation allowed for the convergence of themes and validation of patterns in formative assessment practices in mathematics. Data was collected through three distinct yet interconnected sources: (1) classroom observation, (2) student engagement evidence observed during formative assessment activities, and (3) interviews with both the teacher and students.

Through triangulation of data from classroom observations, teacher interviews, and student feedback, nine thematic categories emerged that demonstrate the consistent and diverse application of formative assessments to enhance student learning.

1. Addressing Misconceptions

Across all three cases, teachers used diagnostic tools such as online quizzes, real-time questioning, and drills to surface prior knowledge and misconceptions. These initial assessments served as baseline references for instruction. For instance, in Case 1, a mix of quizzes and student reflections were used, while in Case 3, teachers-initiated sessions with drills and clarified misunderstandings post-assessment. Students acknowledged these practices helped them recognize and correct their errors, leading to deeper comprehension.

"Teacher shows us a solved math problem, and we analyze the mistake."-(S4G7) "We were doing a practice CER… our teacher helped us correct it by showing us how." – (S2G9)

2. Develop Problem Solving Skills

All three teachers emphasized the use of structured strategies such as ClaimEvidence-Reasoning (CER) and real-life problems to hone students' problemsolving and analytical abilities. Students engaged in reflective thinking, explored alternative solutions, and expressed increased confidence in solving mathematical tasks.

"Formative assessments are a form of exercise of your current knowledge." – (S4G10) "Formative assessment helps me solve problems faster and more accurately." – (S5G7)

3. Collaborative Learning

Peer interactions were highly valued. Teachers deliberately designed tasks such as Think-Pair-Share, group discussions, and peer tutoring. These collaborative structures enabled knowledge sharing and deeper engagement, particularly among students needing more support.

"We did the Think-Pair-Share, and my seatmate helped me understand the topic."-(S6G10) "In group settings… I gave tasks individually, so they'd really discover the topic." – (T3)

4. Integration of Technology Tools

Technology was widely used to facilitate formative assessment. Platforms such as GeoGebra and Quizziz provided immediate feedback, reinforced concepts visually, and allowed for analytics-based instructional decisions. This technological integration catered to diverse learning preferences and increased student motivation.

"Online platforms give immediate feedback and record scores automatically."- (T1) "Quizziz… it is competitive and fun." – (S2G9)

5. Constructive Feedback

Teachers across cases practiced timely and specific feedback. Individual conferences, post-quiz reflections, and real-time correction opportunities allowed students to adjust their strategies. Students consistently reported that feedback made them feel supported and capable of improving.

"When I approach [teacher], she gives feedback." – (S2G10) "Yes, it makes me learn from my mistakes." – (S3G9)

6. Real-World Application of Mathematical Concepts

Linking abstract concepts to tangible experiences increased student motivation and understanding. Teachers incorporated examples such as billiard ball trajectories and fan blades, and designed scenarios where students had to use mathematical reasoning in everyday contexts.

"They give us hands-on experience… apply lessons to real-life scenarios." – (S8G10) "Lesson tasks required identifying operations in reallife problems." – (Case Study 3)

7. Confidence and Motivation Building

Students across all cases indicated that engaging formative assessments contributed to their self-confidence. Self-assessment tools, supportive feedback, and meaningful challenges cultivated a learning environment where students felt motivated to improve.

"I feel encouraged because feedback helps me improve." -(S10G10) "Every time I get a problem right, it makes me feel like I can almost solve anything." – (S2G9)

8. Addressing Learning Gaps

Teachers were attentive to students' varying needs, often adjusting instruction or assigning differentiated tasks. This responsiveness ensured that struggling learners were not left behind and were instead scaffolded towards mastery.

"Students who struggled were given additional clarification and tasks."
– (Case Study 1) "I assign specific tasks for struggling students; sometimes peer tutorials work." –(T1)

9. Overall Improvement in Learning Outcomes

Cumulatively, the embedded formative assessment strategies led to noticeable improvement in student performance, understanding, and engagement. Students increasingly sought more problem-solving opportunities and expressed positive attitudes towards mathematics.

"Formative assessments for easier learning and understanding." – (S15G10) "Students are more engaged with formative tasks; less pressure, more learning." – (T1)

The cross-case triangulation reveals that formative assessment is not a singular technique but a multifaceted approach that includes diagnostic tools, feedback, collaboration, and reflection. These practices, when strategically implemented, not only support cognitive development but also enhance affective and metacognitive domains of student learning. The interplay between student agency, teacher adaptability, and contextualized assessment practices defines the effectiveness of formative assessment in mathematics education.

4. Conclusion

In conclusion, the study affirmed that formative assessment, when consistently and reflectively embedded in mathematics instruction, significantly enhances students' mathematical proficiency and problem-solving skills. Across the three case studies, formative strategies such as diagnostic questioning, real-time feedback, the Claim-Evidence-Reasoning (CER) strategy, and the use of digital tools fostered a learning environment that was student-centered, inquiry-driven, and responsive to individual learning needs. The cyclical nature of formative assessment— comprising goal setting, evidence gathering, interpretation, and instructional adjustment—was evident in all classrooms and served as a catalyst for active engagement and continuous learning. These findings validate the premise that formative assessment is a powerful pedagogical tool not only for informing instruction but also for empowering learners to become self-regulated thinkers and problem solvers.

Considering these findings, it is recommended that formative assessment be strategically embedded in mathematics instruction at all levels. Teachers are encouraged to integrate reflective and interactive assessment strategies such as CER, digital platforms, and collaborative tasks throughout the lesson cycle. Professional development initiatives should be prioritized to build teacher capacity, particularly in the areas of reasoning-based assessment and technology integration. School leaders must ensure structural support by allocating time for planning, feedback, and data-informed instructional shifts, while also providing mentoring for novice teachers. Students, likewise, should be guided toward self-

assessment and active engagement in the feedback process to foster autonomy and resilience in learning. Finally, future research should further investigate the longitudinal effects of formative assessment, explore its cross-disciplinary applications, and amplify student perspectives to enrich the understanding of its impact on both cognitive and affective learning outcomes.

5. References

Andrade, H., & Valtcheva, A. (2009). Promoting learning and achievement through self-assessment. *Theory Into Practice, 48*(1), 12-19.

Bell, B., & Cowie, B. (2001). *Formative assessment and science education.* Kluwer Academic Publishers.

Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice, 18*(1), 5-25.

Bernardo, A. B. I. (2010). Extending the Vygotskian concept of the zone of proximal development to the discussion of pedagogical assumptions in language and education. *Asia Pacific Education Review, 11*(1), 58-67.

Black, P., & Wiliam, D. (1998). *Assessment and classroom learning. Assessment in Education: Principles, Policy & Practice*, 5(1), 7-74. https://doi.org/10.1080/0969595980050102.

Black, P., & Wiliam, D. (2018). *Assessment for learning in the mathematics classroom*. Mathematics Teaching, 245, 32-38. https://doi.org/10.1080/0969595980050202

Boaler, J. (2008). Promoting 'relational equity' and high mathematics achievement through an innovative mixed-media curriculum. The Journal of Educational Research, 102(2), 129-142.

Clark, I. (2012). Formative assessment: Assessment is for self-regulated learning. *Educational Psychology Review, 24*(2), 205-249.

David, A., & Dizon, L. (2017). Formative assessment in large mathematics classes: Challenges and strategies. *Philippine Educational Research Journal, 3*(2), 21-34.

Dayal, H. C. (2021). How Teachers use Formative Assessment Strategies during Teaching: Evidence from the Classroom. Australian Journal of Teacher Education, 46(7).

Department of Education. (2015). *K to 12 assessment guidelines* (DepEd Order No. 8, s. 2015). Retrieved May 25, 2025, from https://www.deped.gov.ph.

Derivita, R. A. (2023). *Assessment in learning 1: An outcomes-based approach*. Lorimar Publishing, Inc.

Drijvers, P., Doorman, M., Boon, P., Reed, H., & Gravemeijer, K. (2010). The teacher and the tool: Instrumental orchestrations in the technology-rich mathematics classroom. *Educational Studies in Mathematics, 75*(2), 213– 234. https://doi.org/10.1007/s10649-010-9254-5.

Furtak, E. M., Kunter, M., & Klusmann, U. (2012). The relationship between formative assessment and student achievement: A meta-analysis. *Educational Psychology Review, 24*(3), 469-497.

Gay, G. (2000). Culturally responsive teaching: Theory, research, and practice. Teachers College Press.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77(1), 81-112.* https://doi.org/10.3102/003465430298487.

Heritage, M. (2010). *Formative assessment: Making it happen in the classroom.* Corwin Press.

Heritage, M. (2019). *Formative assessment in mathematics: Teacher knowledge and student learning outcomes*. Journal of Mathematics Teacher Education, 22(4), 383-405. https://doi.org/10.1007/s10857-018-9403-x.

Humes, A. (2021). *Formative Assessment and Technology in the Mathematics Classroom.* Master's Thesis, Northwestern College, Iowa.

Kenney, R. H., Shoffner, M. B., & Lin, P. (2023). Strengthening formative assessment practices in mathematics through qualitative synthesis. *Journal of Mathematics Teacher Education, 26*(1), 25–45. https://doi.org/10.1007/s10857-022-09557-3.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics.* National Academy Press.

Kingston, N., & Nash, B. (2011). Formative assessment: A meta-analysis and a call for research. *Educational Measurement: Issues and Practice, 30*(4), 28-37.

Kültür, Y. Z., & Kutlu, M. O. (2021). The effect of formative assessment on high school students' mathematics achievement and attitudes 7. Journal of Pedagogical Research, 5(4), 155-171 1. https://doi.org/10.33902/JPR.2021474302 1.

Kynigos, C. (2015). Constructionism: Theory of learning or theory of design? In S. J. Cho (Ed.), *The proceedings of the 12th International Congress on Mathematical Education* (pp. 417–436). Springer. https://doi.org/10.1007/978-3-319-17187-6_24.

Labrador, S. R. (2022). Individualized feedback strategies in Philippine math classrooms. *Mathematics Education Review, 14*(1), 23–34.

Manalo, M. (2019). Teacher perspectives on formative assessment in mathematics classrooms: Balancing curriculum demands and student engagement. *Philippine Journal of Education, 95*(1), 45-60.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.

McMillan, J. H., & Hearn, J. (2008). Student self-assessment: The key to stronger student motivation and higher achievement. *Educational Horizons, 87*(1), 40–49.

McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *The Journal of the Learning Sciences, 15*(2), 153–191. https://doi.org/10.1207/s15327809jls1502_1.

Mendoza, R. (2020). The role of formative assessment in student engagement in the Philippine context. *Education Quarterly, 67*(3), 123–135.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers College Record, 108(6), 1017-1054.

National Council of Teachers of Mathematics. (2018). Catalyzing change in high school mathematics: Initiating critical conversations. Reston, VA: Author.

Nicol, D., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31*(2), 199-218.

Ocampo, D. (2017). Educational reform and the Philippine K to 12 curriculum. *Philippine Journal of Development, 44*(2), 1–20.

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures*. Viking Press.

Polya, G. (1957). *How to solve it: A new aspect of mathematical method* (2nd ed.). Princeton University Press.

Popham, W. J. (2008). *Transformative assessment*. ASCD.

Puentedura, R. R. (2006). Transformation, technology, and education. Retrieved from http://hippasus.com/resources/tte/. Rathje, A. (2018). *A qualitative case study of mathematics teachers' formative assessment feedback* [Doctoral dissertation, Concordia University Chicago].

Ruiz-Primo, M. A., & Furtak, E. M. (2007). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57–84. https://doi.org/10.1002/tea.20163.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*(2), 119–144. https://doi.org/10.1007/BF00117714.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. Academic Press.

Schoenfeld, A. H. (2013). Mathematical problem solving. *Mathematics and Cognition, 3*(1), 335-359.

Schoenfeld, A. H. (2013). Reflections on problem solving and metacognition. *ZDM Mathematics Education, 45*(2), 211–213. https://doi.org/10.1007/s11858-012-0453-1.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153–189. https://doi.org/10.3102/0034654307313795.

Sison, A. (2014). Formative assessment practices in Philippine secondary schools. *Philippine Journal of Education, 93*(1), 34-48.

Stroup, W. M., Ares, N., Hurford, A., & Wilensky, U. (2017). The evolution of integrated assessment in project-based curricula. International Journal of STEM Education, 4(1), 1-15.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257-285.

Tanyag, R. M., & Garcia, J. M. (2021). Impact of formative assessment on math performance. *Asian Journal of Education and Learning, 12*(3), 111–124.

Wiggins, G., & McTighe, J. (2000). *Understanding by design*. ASCD.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Wiliam, D. (2011). *Embedded formative assessment.* Solution Tree Press.

Wiliam, D., & Thompson, M. (2017). *Integrating formative assessment in mathematics classrooms: A framework for increasing student learning outcomes*. Educational Assessment, Evaluation and Accountability, 29(1), 5-25. https://doi.org/10.1007/s11092-016-9257-3.