BUKTI KORESPONDENSI

REZA OKTIANA AKBAR, M.Pd.

TITLE: The Role of Formative Assessment in Enhancing Students' Numeracy Literacy: A Qualitative Evaluation

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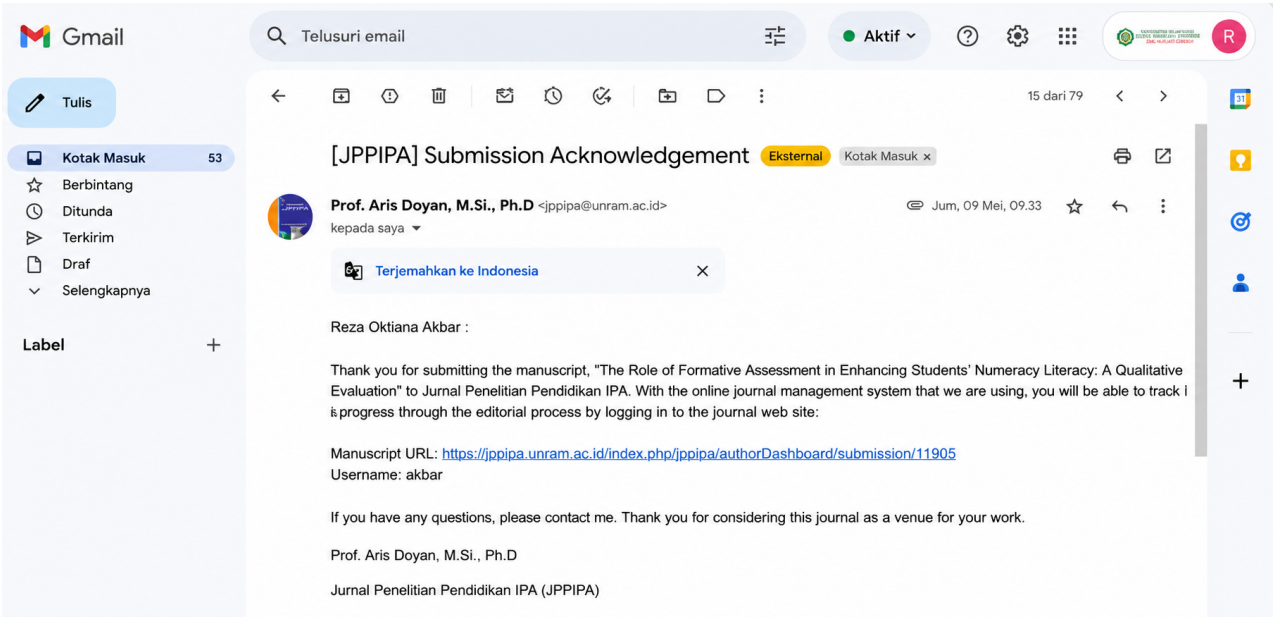

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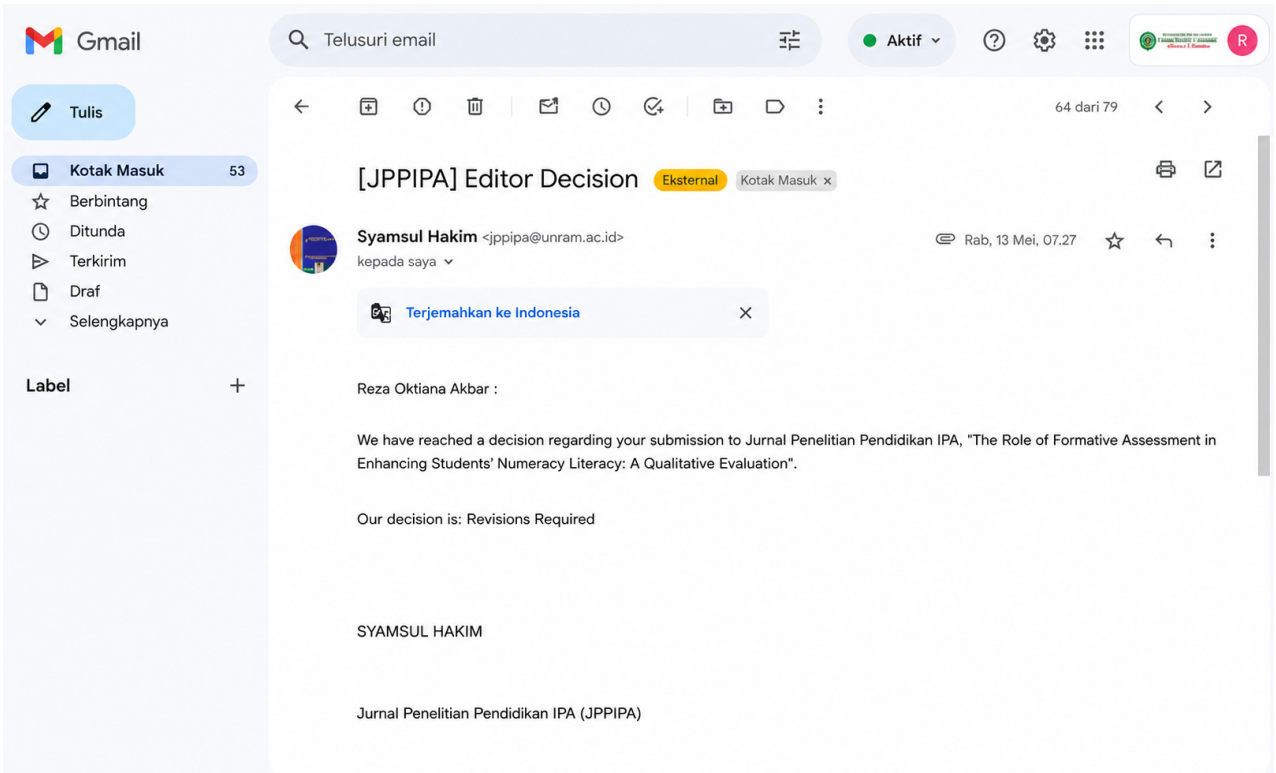

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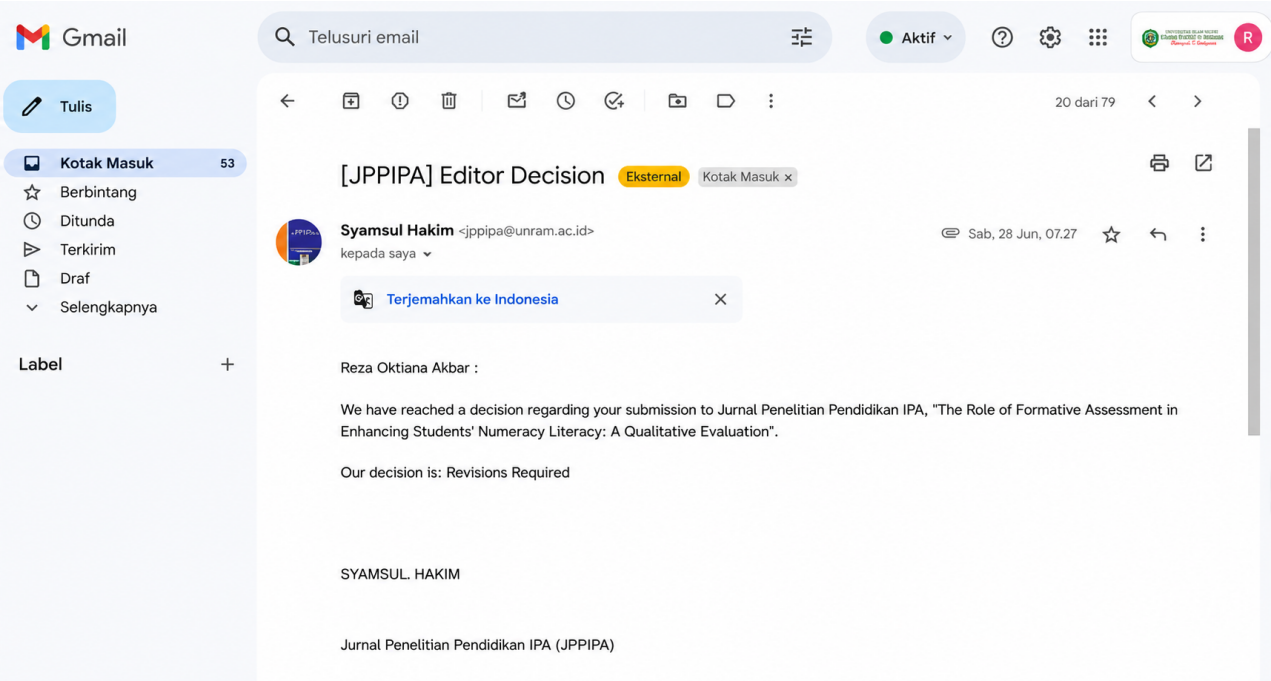

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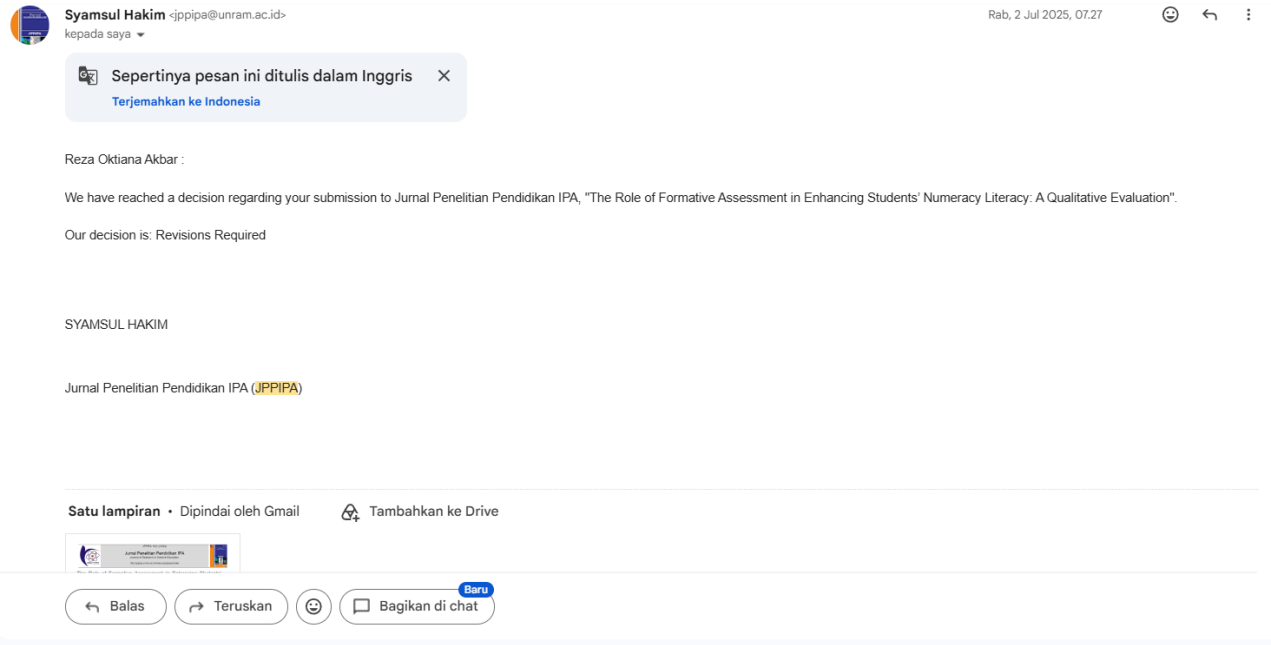

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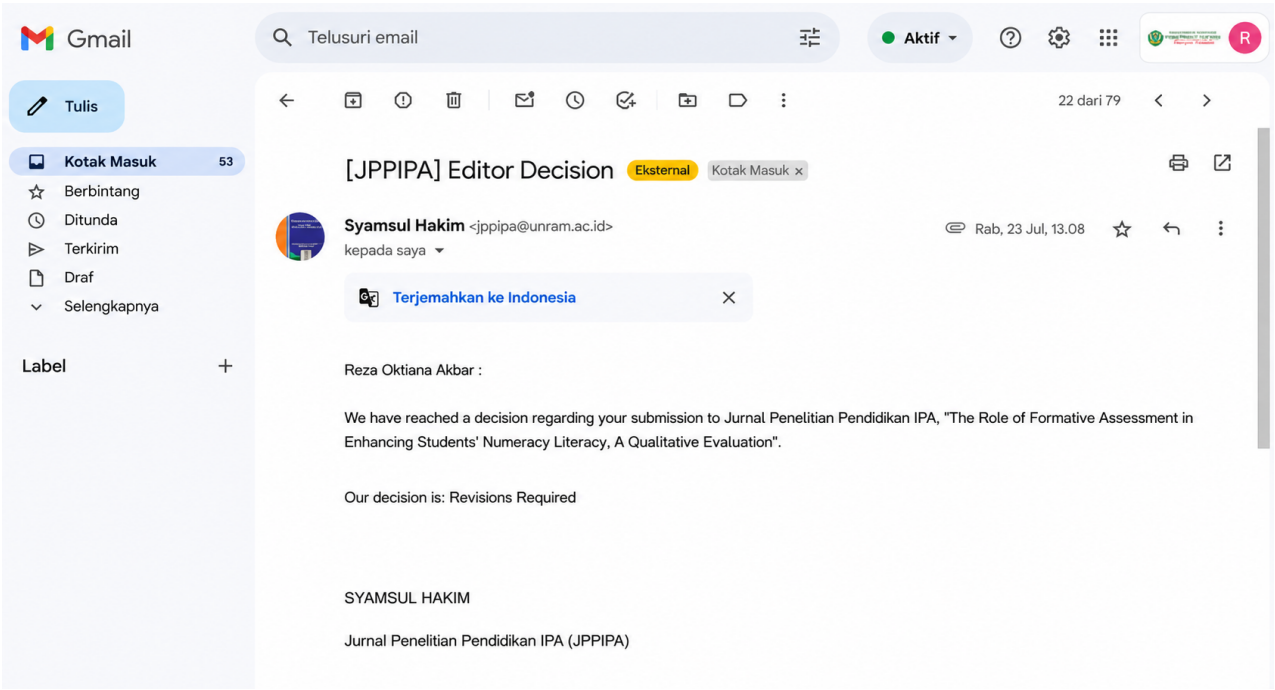

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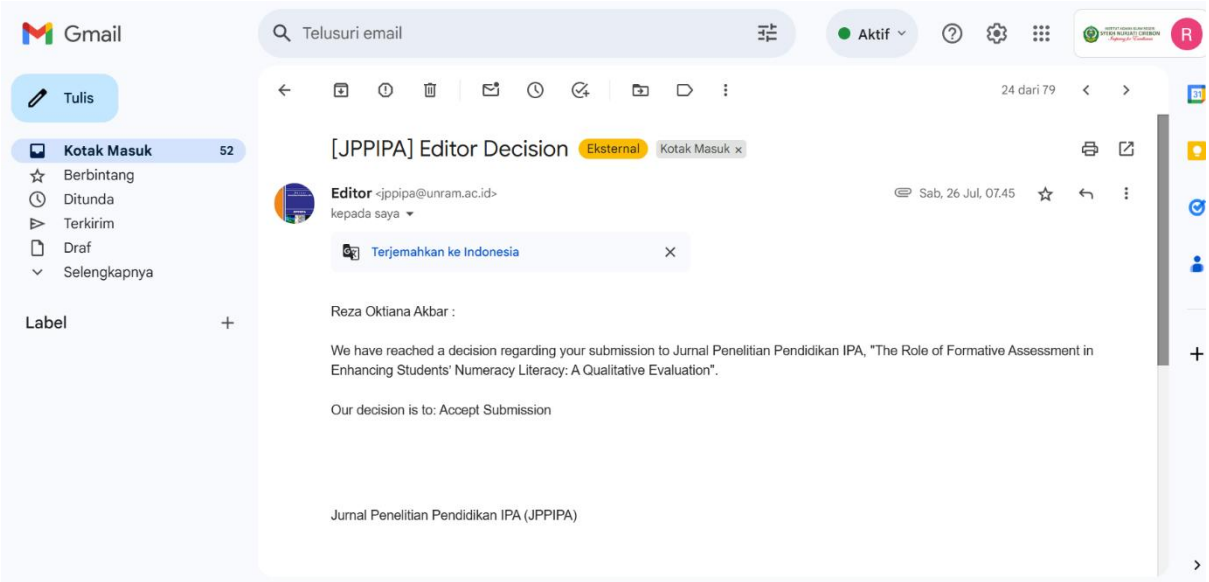

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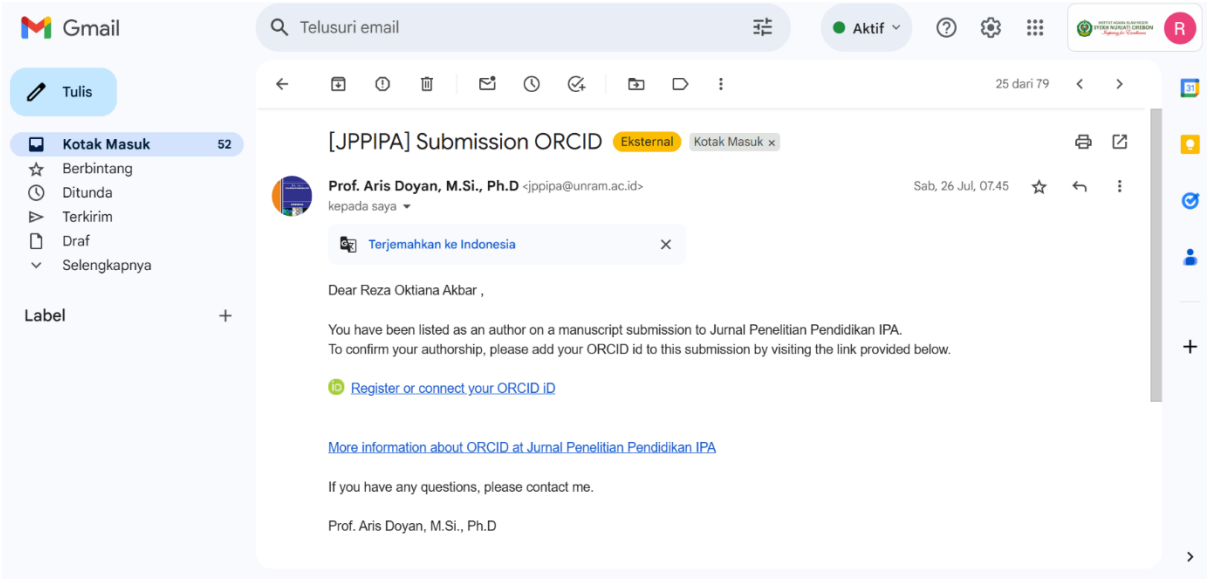

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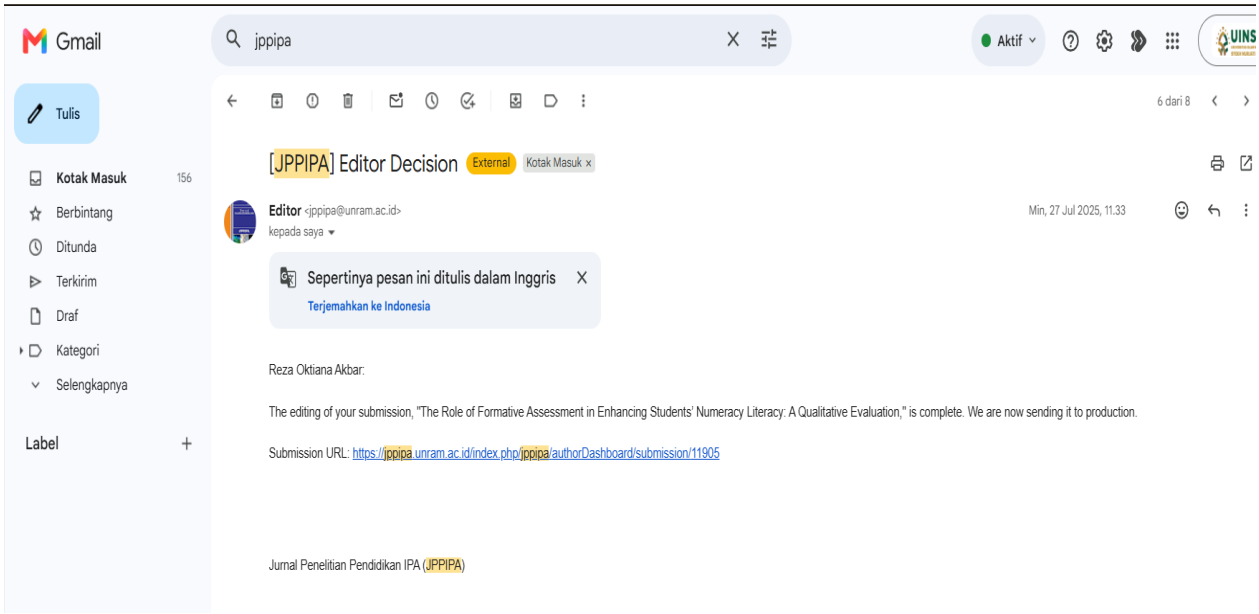

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The Role of Formative Assessment in Enhancing Students' Numeracy Literacy: A Qualitative Evaluation

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Abstract: In the context of 21st-century education, numeracy literacy is a crucial competency that supports students' critical thinking and problemsolving abilities across various disciplines. However, many students continue to struggle with applying mathematical concepts in real life situations. This study aims to explore the role of formative assessment in enhancing students' numeracy literacy in secondary school settings. Utilizing a qualitative approach, data were collected through classroom observations, semi-structured interviews with teachers and students, and documentation analysis. The participants consisted of three mathematics teachers and twelve students from different grade levels in a public secondary school. Thematic analysis was employed to identify key patterns in the data. The findings reveal that formative assessment strategies such as real-time feedback, reflective questioning, and peer assessment significantly contributed to the development of students' numeracy skills. Teachers reported improved student engagement and better diagnostic understanding of learning gaps, while students demonstrated increased confidence and ability to apply mathematical reasoning. The study concludes that formative assessment is an effective pedagogical tool for supporting numeracy literacy and recommends its integration into daily classroom practices to foster a deeper understanding of mathematical concepts.

Keywords: formative assessment, numeracy literacy, qualitative research, student learning, mathematics education

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Introduction

In the current global education discourse, numeracy literacy has gained increasing attention as a core competence essential for navigating both academic and real-world challenges. Defined broadly as the ability to apply mathematical knowledge effectively in daily life, numeracy is no longer confined to solving textbook equations but extends to interpreting data, making financial decisions, and understanding statistics in media and policy contexts (Geiger et al., 2015). Yet, various studies highlight that many students especially in secondary education continue to underperform in basic numeracy tasks.

This growing concern is evident in international assessments such as PISA, where Indonesian students have consistently ranked below the OECD average in mathematical literacy. One of the core reasons behind this performance gap is not solely the students' lack of knowledge, but rather their inability to meaningfully apply mathematical understanding in unfamiliar contexts (Fenanlampir et al., 2019). These challenges are compounded by traditional classroom assessments that emphasize summative judgments over formative guidance, failing to capture the learning process that supports numeracy growth.

Against this backdrop, formative assessment emerges as a promising strategy. Rather than merely judging student outcomes at the end of instruction, formative assessment focuses on continuous feedback and adaptive teaching to improve student understanding during the learning process (Lamberg et al., 2020). It empowers both teachers and learners to recognize learning gaps early and adjust their strategies

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The educational benefits of formative assessment have been substantiated in various contexts. For example, a study by (Palm et al., 2020) in Sweden demonstrated that when mathematics teachers received targeted professional development in formative assessment, their students showed measurable improvement in mathematical understanding and engagement. Similar findings were echoed by (Waluyo, 2020), where formative techniques led to greater student autonomy and problem-solving skills.

In addition to cognitive benefits, formative assessment also has affective impacts. Research (Wafubwa, 2022) found that students exposed to formative feedback displayed higher motivation and confidence in mathematics, which in turn contributed to deeper engagement with numeracy tasks. These psychological factors are crucial in addressing math anxiety and negative attitudes that frequently hinder student performance.

Despite these positive findings, gaps remain in understanding how formative assessment functions in real classroom settings, especially in non-Western contexts. Much of the existing literature is based on large-scale quantitative studies or theoretical propositions. What is lacking are qualitative insights into how teachers actually implement formative practices, how students interpret them, and how these interactions shape numeracy development (Roach, 2024).

In Indonesia, few studies have critically examined the pedagogical realities of formative assessment in secondary mathematics classrooms. This is surprising given that the Ministry of Education has promoted assessment reform as part of its "Merdeka Belajar" curriculum initiative. However, the uptake and practical execution of formative practices remain inconsistent across regions, schools, and teacher backgrounds (Tairi & Khouan, 2022).

This inconsistency raises a fundamental research problem: how exactly is formative assessment being used in Indonesian classrooms, and what is its actual impact on students' numeracy literacy? Moreover, do students perceive formative assessment as supportive of their mathematical learning, or merely as another form of evaluation? These questions demand deeper exploration grounded in empirical classroom data.

This study is driven by the assumption that formative assessment when implemented effectively can serve as a bridge between procedural knowledge and conceptual understanding in numeracy. It can help students not just calculate, but also interpret and communicate mathematical reasoning in contextually meaningful ways (Brown et al., 2024). Yet, realizing this potential depends heavily on how formative assessment is practiced, not just prescribed.

Thus, the main problem addressed in this research is: *How does formative assessment enhance students' numeracy literacy in secondary school mathematics classrooms?* This broad question is refined into three guiding sub-questions: (1) What formative assessment strategies are employed by teachers? (2) How do students perceive and respond to these strategies? (3) What specific aspects of numeracy literacy appear to improve through these formative practices?

The study's objectives are closely aligned with these questions. First, it seeks to identify and describe the formative assessment approaches used by mathematics teachers in actual classroom interactions. Second, it aims to explore student experiences, particularly their perceptions of feedback, self-assessment, and peer collaboration. Third, the study examines how these formative encounters influence students' ability to interpret, apply, and communicate mathematical ideas key dimensions of numeracy literacy.

To achieve these objectives, this research adopts a qualitative case study design. Data collection involves three main techniques: classroom observation, semi-structured interviews with both teachers and students, and analysis of instructional materials and student work. The case study setting is a public secondary school in West Java, Indonesia, selected for its active implementation of formative strategies under the new curriculum policy.

Thematic analysis will be used to interpret the data, focusing on recurring patterns in teacher strategies, student responses, and observable learning outcomes. This method allows for a nuanced understanding of the complex dynamics at play during mathematics instruction, particularly how assessment is embedded within the learning process rather than imposed externally (Blampied, 2024).

Findings from this study are expected to contribute both to theory and practice. Theoretically, they can enrich the discourse on formative assessment by offering insights from a Southeast Asian context often underrepresented in global literature. Practically, the results may inform teacher training programs, curriculum design, and school-based assessment policies aimed at improving numeracy outcomes.

Importantly, this research aligns with the global call for inclusive, equitable, and quality education as outlined in Sustainable Development Goal 4. By focusing on formative assessment as a tool for equity and learning, the study highlights how assessment can be reimagined as a process of dialogue and

development, rather than mere judgment and ranking. Ultimately, enhancing numeracy literacy is not just a matter of curriculum content or teaching technique. It requires a shift in how learning is understood, supported, and assessed. This study offers a modest yet meaningful step in that direction by listening to the voices of students and teachers as they engage with the mathematics classroom in real time.

Method

This qualitative research employed a case study design to explore how formative assessment practices influence students' numeracy literacy in secondary mathematics classrooms. The study was conducted at a public school in West Java, Indonesia, involving three mathematics teachers and fifteen ninth-grade students selected through purposive sampling. Data were collected over six weeks using classroom observations, semi-structured interviews, and document analysis of lesson plans and student work. Thematic analysis, following Braun and Clarke's (2006) six-step model, was used to identify patterns and themes from transcribed interviews and observation notes. NVivo 12 software supported data organization and coding. To ensure trustworthiness, triangulation across methods, member checking with participants, and peer debriefing were applied. Ethical clearance was obtained from the research ethics committee, and all participants provided informed consent with confidentiality maintained throughout the study.

Result and Discussion

Results

The analysis of classroom observations, interviews, and instructional documents revealed three major findings regarding the role of formative assessment in enhancing students' numeracy literacy. First, mathematics teachers employed a range of formative assessment strategies such as oral questioning, exit tickets, peer feedback, and descriptive comments focused on learning processes rather than correctness. These strategies were used regularly and adapted in real-time, especially when students appeared disengaged or confused. Teachers often encouraged students to verbalize their mathematical reasoning, promoting metacognitive awareness and conceptual understanding. This finding is consistent with previous studies that advocate for formative assessment as a tool for fostering deeper learning and engagement.

Second, student responses to formative assessment were largely positive. Most students reported that they felt more comfortable engaging with mathematics when feedback was constructive and non-threatening. The practice of peer feedback and self-assessment was particularly appreciated, as it allowed them to track their own progress and correct errors without fear of grades. Some students expressed that being allowed to explain their thinking and receive tailored feedback made them more confident and motivated to solve numerical problems. These observations echo prior findings on the motivational effects of formative assessment on student autonomy and engagement.

Third, there was clear evidence that formative assessment contributed to improved numeracy literacy. Students demonstrated better understanding of number operations, contextual problem-solving, and the ability to justify their answers using appropriate language. An analysis of their written work before and after feedback showed improvements in clarity, structure, and logic. This reinforces the notion that formative assessment not only identifies learning gaps but also supports students in bridging those gaps through targeted instructional guidance.

The following table summarizes the three key themes, their descriptions, and supporting evidence drawn from multiple data sources:

Table 1. Summary of Key Findings

Theme	Description	Supporting Evidence
Formative Assessment Strategies	Use of questioning, peer feedback, exit tickets, and process-oriented feedback	Observed in all 3 classrooms, confirmed by teacher interviews
Student Response & Motivation	Increased engagement, reduced fear of mistakes, improved self-regulation	Students highlighted appreciation for non-graded assessments
Impact on Numeracy Literacy	Improved problem interpretation, justification, and mathematical expression	Document analysis showed clear progress in structure and clarity

Despite these positive outcomes, some challenges were noted. For example, a few students struggled with interpreting open-ended feedback and relied heavily on teacher guidance. Additionally, the level of implementation varied among teachers, often influenced by their experience, workload, and familiarity with recent curricular reforms such as *Merdeka Belajar*. These factors align with previous research indicating that the success of formative assessment is contingent upon both individual teacher capacity and systemic support. In summary, the study confirms that formative assessment when practiced consistently and purposefully enhances students'

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numeracy literacy by cultivating critical thinking, reflection, and a growth mindset. It underscores the importance of viewing assessment not merely as a tool for evaluation but as an integral part of the learning process.

DISCUSSION

The study provides compelling evidence supporting the significant role of formative assessment in enhancing students' numeracy literacy, particularly in secondary mathematics classrooms. The findings underscore the effectiveness of various formative assessment strategies such as real-time feedback, oral questioning, exit tickets, peer feedback, and process-oriented feedback that focus on the learning process rather than solely on correctness. These strategies were consistently used by teachers to engage students and adapt to their needs, especially when students appeared disengaged or confused. The teachers in the study regularly encouraged students to verbalize their mathematical reasoning, promoting metacognitive awareness and deeper conceptual understanding. This approach is in line with previous research, which highlights formative assessment as an essential tool for fostering active learning, engagement, and critical thinking in students.

Moreover, the study reveals that student responses to formative assessment were overwhelmingly positive. Students expressed that they felt more comfortable and motivated to engage with mathematical tasks when feedback was constructive and non-threatening. The practice of peer feedback and self-assessment, in particular, was highly appreciated by students as it allowed them to track their progress and correct mistakes without fear of grading. Students reported that being able to explain their thought process and receive tailored feedback boosted their confidence and encouraged a greater willingness to solve numerical problems. These findings support prior research on the motivational effects of formative assessment, which enhances student autonomy, engagement, and self-regulation in learning. The study highlights that formative assessment not only provides diagnostic feedback to address learning gaps but also empowers students by allowing them to take ownership of their learning process.

A significant outcome of this research is the clear evidence that formative assessment contributed directly to improvements in numeracy literacy. Through targeted formative practices, students demonstrated better understanding of numerical operations, improved contextual problem-solving skills, and the ability to justify their answers using appropriate mathematical language. An analysis of students' written work before and after receiving feedback showed notable improvements in clarity, structure, and logical progression, which indicates that formative assessment is effective in helping students bridge learning gaps. The results reaffirm the notion that formative assessment is not merely a tool for evaluating learning outcomes, but an integral part of the instructional process that actively supports students' conceptual understanding and mathematical reasoning.

Despite these positive findings, the study also identified several challenges in the implementation of formative assessment practices. Although all teachers employed formative assessment strategies, the depth and consistency of their implementation varied. This variation was often influenced by factors such as teachers' level of experience, workload, and their familiarity with recent curricular reforms, particularly Indonesia's Merdeka Belajar curriculum. These challenges align with previous research, which has shown that the success of formative assessment depends not only on individual teachers' capacity but also on systemic support and institutional constraints. The study highlights the importance of ongoing professional development for teachers to enhance their capacity to design and implement formative assessment strategies effectively. Without adequate training and resources, the full potential of formative assessment may not be realized.

The findings of this study also resonate with the goals of Indonesia's Merdeka Belajar curriculum, which emphasizes student-centered learning and diagnostic assessment. However, for these educational reforms to be effective, schools need to ensure that teachers are equipped with the necessary skills and resources to design and interpret formative assessment tasks properly. The positive impact on students' numeracy skills documented in this study underscores the need to align assessment reforms with classroom practices. To achieve this, schools must foster a culture of continuous professional growth and support for teachers, ensuring that formative assessment is fully integrated into the learning process.

In conclusion, this study affirms that formative assessment, when consistently and purposefully implemented, can significantly enhance students' numeracy literacy. It emphasizes the importance of formative assessment as a pedagogical approach that bridges the gap between assessment and instruction, fostering deeper learning, critical thinking, and a growth mindset among students. By focusing on the learning process and providing timely feedback, formative assessment helps students not only grasp mathematical concepts but also apply them in meaningful ways. The study advocates for the continued integration of formative assessment into daily classroom practices to

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promote a more holistic approach to mathematics education. Furthermore, the study calls for future research, particularly longitudinal studies, to track the long-term impact of formative assessment on numeracy outcomes. Expanding the research sample to include diverse school contexts would allow for a broader generalization of these findings and further enhance the understanding of how formative assessment can support numeracy literacy in different educational settings.

Conclusion

This study confirms that formative assessment plays a significant role in enhancing students' numeracy literacy, especially in secondary school mathematics classrooms. The findings highlight that strategies such as real-time feedback, reflective questioning, and peer assessment contribute effectively to students' understanding of mathematical concepts. Teachers reported improvements in student engagement and a better diagnostic understanding of learning gaps, while students demonstrated increased confidence and the ability to apply mathematical reasoning in various contexts. The study emphasizes the importance of quality feedback, focusing on process rather than just correctness, and fostering a safe, collaborative environment that encourages student participation. Although challenges in implementation were noted, particularly due to varying teacher experiences and institutional constraints, the research underscores the effectiveness of formative assessment when consistently applied and supported by professional development. This research suggests that formative assessment should be integrated into daily teaching practices to foster deeper learning and critical thinking skills.

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Conflicts of Interest
All authors have no conflict of interest in the publication of this article.

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Deeper Analysis:
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Link to Theory:
Relate the research results to relevant theories.

Practical Implications:
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Practical Implications:
Explain the practical implications of your research findin

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Conceptualization, C. H. S. A, P. M. Z, T. R, R. A. E, M. S.; methodology, C. H. S. A.; validation, P. M. Z. and T. formal analysis, R. A. E.; investigation, M. N. S., and C. A.; resources, P. M. Z. and T. R.; data curation, R. A. E.: writing—original draft preparation, M. N. S and C. H. S. writing—review and editing, P. M. Z.: visualization, and R. and R. A. E. All authors have read and agreed to the published version of the manuscript.

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development, rather than mere judgment and ranking. Ultimately, enhancing numeracy literacy is not just a matter of curriculum content or teaching technique. It requires a shift in how learning is understood, supported, and assessed. This study offers a modest yet meaningful step in that direction by listening to the voices of students and teachers as they engage with the mathematics classroom in real time.

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Third, there was clear evidence that formative assessment contributed to improved numeracy literacy. Students demonstrated better understanding of number operations, contextual problem-solving, and the ability to justify their answers using appropriate language. An analysis of their written work before and after feedback showed improvements in clarity, structure, and logic. This reinforces the notion that formative assessment not only identifies learning gaps but also supports students in bridging those gaps through targeted instructional guidance.

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Despite these positive outcomes, some challenges were noted. For example, a few students struggled with interpreting open-ended feedback and relied heavily on teacher guidance. Additionally, the level of implementation varied among teachers, often influenced by their experience, workload, and familiarity with recent curricular reforms such as *Merdeka Belajar*. These factors align with previous research indicating that the success of formative assessment is contingent upon both individual teacher capacity and systemic support. In summary, the study confirms that formative assessment when practiced consistently and purposefully enhances students'

numeracy literacy by cultivating critical thinking, reflection, and a growth mindset. It underscores the importance of viewing assessment not merely as a tool for evaluation but as an integral part of the learning process.

DISCUSSION

The study provides compelling evidence supporting the significant role of formative assessment in enhancing students' numeracy literacy, particularly in secondary mathematics classrooms. The findings underscore the effectiveness of various formative assessment strategies such as real-time feedback, oral questioning, exit tickets, peer feedback, and process-oriented feedback that focus on the learning process rather than solely on correctness. These strategies were consistently used by teachers to engage students and adapt to their needs, especially when students appeared disengaged or confused. The teachers in the study regularly encouraged students to verbalize their mathematical reasoning, promoting metacognitive awareness and deeper conceptual understanding. This approach is in line with previous research, which highlights formative assessment as an essential tool for fostering active learning, engagement, and critical thinking in students.

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A significant outcome of this research is the clear evidence that formative assessment contributed directly to improvements in numeracy literacy. Through targeted formative practices, students demonstrated better understanding of numerical operations, improved contextual problem-solving skills, and the ability to justify their answers using appropriate mathematical language. An analysis of students' written work before and after receiving feedback showed notable improvements in clarity, structure, and logical progression, which indicates that formative assessment is effective in helping students bridge learning gaps. The results reaffirm the notion that formative assessment is not merely a tool for evaluating learning outcomes, but an integral part of the instructional process that actively supports students' conceptual understanding and mathematical reasoning.

Despite these positive findings, the study also identified several challenges in the implementation of formative assessment practices. Although all teachers employed formative assessment strategies, the depth and consistency of their implementation varied. This variation was often influenced by factors such as teachers' level of experience, workload, and their familiarity with recent curricular reforms, particularly Indonesia's Merdeka Belajar curriculum. These challenges align with previous research, which has shown that the success of formative assessment depends not only on individual teachers' capacity but also on systemic support and institutional constraints. The study highlights the importance of ongoing professional development for teachers to enhance their capacity to design and implement formative assessment strategies effectively. Without adequate training and resources, the full potential of formative assessment may not be realized.

The findings of this study also resonate with the goals of Indonesia's Merdeka Belajar curriculum, which emphasizes student-centered learning and diagnostic assessment. However, for these educational reforms to be effective, schools need to ensure that teachers are equipped with the necessary skills and resources to design and interpret formative assessment tasks properly. The positive impact on students' numeracy skills documented in this study underscores the need to align assessment reforms with classroom practices. To achieve this, schools must foster a culture of continuous professional growth and support for teachers, ensuring that formative assessment is fully integrated into the learning process.

In conclusion, this study affirms that formative assessment, when consistently and purposefully implemented, can significantly enhance students' numeracy literacy. It emphasizes the importance of formative assessment as a pedagogical approach that bridges the gap between assessment and instruction, fostering deeper learning, critical thinking, and a growth mindset among students. By focusing on the learning process and providing timely feedback, formative assessment helps students not only grasp mathematical concepts but also apply them in meaningful ways. The study advocates for the continued integration of formative assessment into daily classroom practices to

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promote a more holistic approach to mathematics education. Furthermore, the study calls for future research, particularly longitudinal studies, to track the long-term impact of formative assessment on numeracy outcomes. Expanding the research sample to include diverse school contexts would allow for a broader generalization of these findings and further enhance the understanding of how formative assessment can support numeracy literacy in different educational settings.

Conclusion

This study confirms that formative assessment plays a significant role in enhancing students' numeracy literacy, especially in secondary school mathematics classrooms. The findings highlight that strategies such as real-time feedback, reflective questioning, and peer assessment contribute effectively to students' understanding of mathematical concepts. Teachers reported improvements in student engagement and a better diagnostic understanding of learning gaps, while students demonstrated increased confidence and the ability to apply mathematical reasoning in various contexts. The study emphasizes the importance of quality feedback, focusing on process rather than just correctness, and fostering a safe, collaborative environment that encourages student participation. Although challenges in implementation were noted, particularly due to varying teacher experiences and institutional constraints, the research underscores the effectiveness of formative assessment when consistently applied and supported by professional development. This research suggests that formative assessment should be integrated into daily teaching practices to foster deeper learning and critical thinking skills.

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The Role of Formative Assessment in Enhancing Students' Numeracy Literacy: A Qualitative Evaluation

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Abstract: In the context of 21st-century education, numeracy literacy is a crucial competency that supports students' critical thinking and problemsolving abilities across various disciplines. However, many students continue to struggle with applying mathematical concepts in real life situations. This study aims to explore the role of formative assessment in enhancing students' numeracy literacy in secondary school settings. Utilizing a qualitative approach, data were collected through classroom observations, semi-structured interviews with teachers and students, and documentation analysis. The participants consisted of three mathematics teachers and twelve students from different grade levels in a public secondary school. Thematic analysis was employed to identify key patterns in the data. The findings reveal that formative assessment strategies such as real-time feedback, reflective questioning, and peer assessment significantly contributed to the development of students' numeracy skills. Teachers reported improved student engagement and better diagnostic understanding of learning gaps, while students demonstrated increased confidence and ability to apply mathematical reasoning. The study concludes that formative assessment is an effective pedagogical tool for supporting numeracy literacy and recommends its integration into daily classroom practices to foster a deeper understanding of mathematical concepts.

Keywords: Formative assessment; Numeracy literacy; Qualitative research

Introduction

In the current global education discourse, numeracy literacy has gained increasing attention as a core competence essential for navigating both academic and real-world challenges (Díez-Palomar et al., 2023). Defined broadly as the ability to apply mathematical knowledge effectively in daily life, numeracy is no longer confined to solving textbook equations but extends to interpreting data, making financial decisions, and understanding statistics in media and policy contexts (Geiger et al., 2015). Yet, various studies highlight that many students especially in secondary education continue to underperform in basic numeracy tasks.

This growing concern is evident in international assessments such as PISA, where Indonesian students have consistently ranked below the OECD average in mathematical literacy. One of the core reasons behind this performance gap is not solely the students' lack of knowledge, but rather their inability to meaningfully apply mathematical understanding in unfamiliar contexts (Fenanlampir et al., 2019). These challenges are compounded by traditional classroom assessments that emphasize summative judgments over formative guidance, failing to capture the learning process that supports numeracy growth.

Against this backdrop, formative assessment emerges as a promising strategy. Rather than merely judging student outcomes at the end of instruction,

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formative assessment focuses on continuous feedback and adaptive teaching to improve student understanding during the learning process (Lamberg et al., 2020). It empowers both teachers and learners to recognize learning gaps early and adjust their strategies accordingly, fostering a culture of reflection and improvement.

The educational benefits of formative assessment have been substantiated in various contexts. For example, a study by Palm et al. (2020) in Sweden demonstrated that when mathematics teachers received targeted professional development in formative assessment, their students showed measurable improvement in mathematical understanding and engagement. Similar findings were echoed by (Waluyo, 2020), where formative techniques led to greater student autonomy and problem-solving skills.

In addition to cognitive benefits, formative assessment also has affective impacts. Research (Wafubwa, 2022) found that students exposed to formative feedback displayed higher motivation and confidence in mathematics, which in turn contributed to deeper engagement with numeracy tasks. These psychological factors are crucial in addressing math anxiety and negative attitudes that frequently hinder student performance (Beilock & Maloney, 2015).

Despite these positive findings, gaps remain in understanding how formative assessment functions in real classroom settings, especially in non-Western contexts. Much of the existing literature is based on large-scale quantitative studies or theoretical propositions. What is lacking are qualitative insights into how teachers actually implement formative practices, how students interpret them, and how these interactions shape numeracy development (Belbase et al., 2008; Roach, 2024).

In Indonesia, few studies have critically examined the pedagogical realities of formative assessment in secondary mathematics classrooms. This is surprising given that the Ministry of Education has promoted assessment reform as part of its "*Merdeka Belajar*" curriculum initiative. However, the uptake and practical execution of formative practices remain inconsistent across regions, schools, and teacher backgrounds (Tairi & Khouan, 2022).

This inconsistency raises a fundamental research problem: how exactly is formative assessment being used in Indonesian classrooms, and what is its actual impact on students' numeracy literacy? Moreover, do students perceive formative assessment as supportive of their mathematical learning, or merely as another form of evaluation? These questions demand deeper exploration grounded in empirical classroom data (Rakoczy et al., 2017).

This study is driven by the assumption that formative assessment when implemented effectively can serve as a bridge between procedural knowledge and conceptual understanding in numeracy. It can help students not just calculate, but also interpret and communicate mathematical reasoning in contextually meaningful ways (Brown et al., 2024). Yet, realizing this potential depends heavily on how formative assessment is practiced, not just prescribed.

Thus, the main problem addressed in this research is: *How does formative assessment enhance students' numeracy literacy in secondary school mathematics classrooms?* This broad question is refined into three guiding sub-questions: (1) What formative assessment strategies are employed by teachers? (2) How do students perceive and respond to these strategies? (3) What specific aspects of numeracy literacy appear to improve through these formative practices?

The study's objectives are closely aligned with these questions. First, it seeks to identify and describe the formative assessment approaches used by mathematics teachers in actual classroom interactions. Second, it aims to explore student experiences, particularly their perceptions of feedback, self-assessment, and peer collaboration. Third, the study examines how these formative encounters influence students' ability to interpret, apply, and communicate mathematical ideas key dimensions of numeracy literacy.

To achieve these objectives, this research adopts a qualitative case study design. Data collection involves three main techniques: classroom observation, semi-structured interviews with both teachers and students, and analysis of instructional materials and student work. The case study setting is a public secondary school in West Java, Indonesia, selected for its active implementation of formative strategies under the new curriculum policy.

Thematic analysis will be used to interpret the data, focusing on recurring patterns in teacher strategies, student responses, and observable learning outcomes. This method allows for a nuanced understanding of the complex dynamics at play during mathematics instruction, particularly how assessment is embedded within the learning process rather than imposed externally (Blampied, 2024).

Findings from this study are expected to contribute both to theory and practice. Theoretically, they can enrich the discourse on formative assessment by offering insights from a Southeast Asian context often underrepresented in global literature. Practically, the results may inform teacher training programs, curriculum design, and school-based assessment policies aimed at improving numeracy outcomes.

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implementation varied among teachers, often influenced by their experience, workload, and familiarity with recent curricular reforms such as *Merdeka Belajar* (Kumayas et al., 2025; Sutinah et al., 2024). These factors align with previous research indicating that the success of formative assessment is contingent upon both individual teacher capacity and systemic support. In summary, the study confirms that formative assessment when practiced consistently and purposefully enhances students' numeracy literacy by cultivating critical thinking, reflection, and a growth mindset. It underscores the importance of viewing assessment not merely as a tool for evaluation but as an integral part of the learning process.

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The study provides compelling evidence supporting the significant role of formative assessment in enhancing students' numeracy literacy, particularly in secondary mathematics classrooms. The findings underscore the effectiveness of various formative assessment strategies such as real-time feedback, oral questioning, exit tickets, peer feedback, and process-oriented feedback that focus on the learning process rather than solely on correctness. These strategies were consistently used by teachers to engage students and adapt to their needs, especially when students appeared disengaged or confused. The teachers in the study regularly encouraged students to verbalize their mathematical reasoning, promoting metacognitive awareness and deeper conceptual understanding. This approach is in line with previous research, which highlights formative assessment as an essential tool for fostering active learning, engagement, and critical thinking in students (Fitrah et al., 2025; Haq & others, 2024).

Moreover, the study reveals that student responses to formative assessment were overwhelmingly positive. Students expressed that they felt more comfortable and motivated to engage with mathematical tasks when feedback was constructive and non-threatening (Kurniawan, 2023). The practice of peer feedback and self-assessment, in particular, was highly appreciated by students as it allowed them to track their progress and correct mistakes without fear of grading. Students reported that being able to explain their thought process and receive tailored feedback boosted their confidence and encouraged a greater willingness to solve numerical problems. These findings support prior research on the motivational effects of formative assessment, which enhances student autonomy, engagement, and self-regulation in learning. The study highlights that formative assessment not only provides diagnostic feedback to address learning gaps but also empowers students by allowing them to take ownership of their learning process (Mizela et al., 2023).

A significant outcome of this research is the clear evidence that formative assessment contributed directly to improvements in numeracy literacy. Through targeted formative practices, students demonstrated better understanding of numerical operations, improved contextual problem-solving skills, and the ability to justify their answers using appropriate mathematical language (Wibowo et al., 2025). An analysis of students' written work before and after receiving feedback showed notable improvements in clarity, structure, and logical progression, which indicates that formative assessment is effective in helping students bridge learning gaps (Morris et al., 2021). The results reaffirm the notion that formative assessment is not merely a tool for evaluating learning outcomes, but an integral part of the instructional process that actively supports students' conceptual understanding and mathematical reasoning.

Despite these positive findings, the study also identified several challenges in the implementation of formative assessment practices. Although all teachers employed formative assessment strategies, the depth and consistency of their implementation varied (Wylie & Lyon, 2015). This variation was often influenced by factors such as teachers' level of experience, workload, and their familiarity with recent curricular reforms, particularly Indonesia's *Merdeka Belajar* curriculum. These challenges align with previous research, which has shown that the success of formative assessment depends not only on individual teachers' capacity but also on systemic support and institutional constraints (Meidawati & Kusdarini, 2025). The study highlights the importance of ongoing professional development for teachers to enhance their capacity to design and implement formative assessment strategies effectively. Without adequate training and resources, the full potential of formative assessment may not be realized.

The findings of this study also resonate with the goals of Indonesia's *Merdeka Belajar* curriculum, which emphasizes student-centered learning and diagnostic assessment (Marthawati & Setyo, 2024). However, for these educational reforms to be effective, schools need to ensure that teachers are equipped with the necessary skills and resources to design and interpret formative assessment tasks properly. The positive impact on students' numeracy skills documented in this study underscores the need to align assessment reforms with classroom practices. To achieve this, schools must foster a culture of continuous professional growth and support for teachers, ensuring that formative assessment is fully integrated into the learning process.

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