



Development of Formative Tests Based on Self-Directed Learning-Oriented Assessment for Mathematics in Junior High School

Ihsanul Amin^{1*}, Chairil Faif Pasani¹, Kamaliyah¹, and Zainudin Hassan²

¹Mathematics Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia

²Educational Foundation and Social Education, Universiti Teknologi Malaysia, Skudai, Malaysia

*aminihsanul13@gmail.com

Article Info	Abstract
Article history: Received: March 5, 2026 Accepted: April 7, 2026 Published: May 25, 2026	Formative assessment practices in schools often focus on Assessment for Learning (AfL) but insufficiently facilitate Assessment as Learning (AaL), limiting students’ reflection and self-assessment. To address this, Self-directed Learning Oriented Assessment (SLOA) is employed as an approach integrating self-assessment to foster self-directed learning capacities by aligning the functions of assessment of, for, and as learning. This study aimed to develop valid, practical, and effective SLOA-based formative tests for junior high school mathematics. The study employed a research and development (R&D) approach using the ADDIE model. The research was conducted in a single seventh-grade class at a junior high school in Barito Kuala under the <i>Kurikulum Merdeka</i> , involving 25 students and one mathematics teacher. Data were collected through expert validation sheets, a teacher practicality questionnaire, and students’ mastery of learning outcomes. The results indicated that the developed formative tests and self-assessment sheets were very valid, with mean scores of 3.47 and 3.36, respectively. The product was categorized as very practical, obtaining a practicality percentage of 98%. In terms of effectiveness, the product was categorized as effective, with an average classical mastery reached of 61.3%, derived from three test packages showing a consistent upward trend in student performance. The progressive increase in students’ mastery and metacognitive accuracy suggests that integrating structured self-assessment into formative testing supports learning achievement and reflective awareness. This study implies that SLOA-based formative tests can serve as a strategic framework to foster student independence, provided that they are implemented with adequate instructional time and systematic feedback cycles.
Keywords: Formative test Mathematics Self-directed learning oriented assessment (SLOA)	
This article is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.	
© 2026 Journal of Mathematics, Science, and Computer Education	
To cite this article: Amin, I., Pasani, C. F., Kamaliyah, K., & Hassan, Z. (2026). Development of formative tests based on self-directed learning oriented assessment (SLOA) for mathematics in junior high school. <i>Journal of Mathematics, Science, and Computer Education</i> , 6(1), 158-172.	

INTRODUCTION

Assessment in education serves not only to measure students' learning outcomes at the end of instruction, i.e., assessment of learning, but also to support the learning process through assessment for learning (AfL) and assessment as learning (AaL) (Kemendikdasmen, 2025). While AfL focuses on using assessment information to guide instructional decisions, AaL emphasizes students' active engagement in self-reflection and self-assessment, enabling

them to develop independence and responsibility in learning. In mathematics classrooms, where conceptual understanding and procedural fluency are expected to develop in an integrated manner, assessment practices that actively engage students in reflective processes are essential to support meaningful learning processes (Maskos et al., 2025).

Formative assessment is widely recognized as a key strategy for enhancing classroom learning and promoting students' active engagement (Nhor et al., 2022; Panadero et al., 2018). It involves the systematic collection and interpretation of evidence to inform ongoing instruction (Kemendikbud & Abduh, 2019). Unlike summative assessment, formative assessment aims to support learning processes by providing meaningful feedback that helps students identify their strengths and weaknesses and determine appropriate follow-up actions (Al Kamli & Almalki, 2024; Carless & Winstone, 2017). As one of its forms, formative tests are commonly administered during the learning process, for instance after completing a particular unit or topic, to monitor students' achievement and provide feedback for further instruction (Mujahidittauhid et al., 2024). For teachers, formative tests offer insight into students' learning progress and help identify those who require additional support. For students, these tests can foster active involvement in evaluating their own understanding, thereby making subsequent learning more effective.

However, in practice, formative test implementation in mathematics classrooms often remains teacher-centered, as students frequently lack the strategies to initiate work or manage difficulties independently (Granberg et al., 2021). Although administered during the learning process, these tests frequently function primarily as only grading and diagnostic tools for teachers to identify student status (Maskos et al., 2025; Zaini et al., 2025). Consequently, students are typically limited to completing tests and receiving corrective feedback, with limited opportunities for students to engage in structured self-assessment. As a result, the Assessment as Learning function is not optimally facilitated because students are not involved in structured self-assessment, causing them to lose the opportunity to develop metacognitive awareness.

This condition was also identified in the specific context of this study at State Junior High School 4 Alalak (SMP Negeri 4 Alalak), where formative tests were regularly conducted, yet students' active involvement in evaluating their own understanding and planning improvement strategies remains limited. These conditions indicate an urgent need for formative assessment instruments that explicitly integrate structured self-assessment components, where students follow a guided framework to reflect on their cognitive progress.

To address this issue, a framework that systematically integrates self-assessment into assessment practices is required. One framework that addresses this need is Self-directed Learning Oriented Assessment (SLOA). SLOA is designed to align assessment practices with the development of students' self-directed learning capacities (Mok, 2013). Unlike other formative assessment approaches, SLOA is characterized by the deliberate alignment of assessment of, for, and as learning within a single coherent framework. Its core principles focus on making learning the central goal, engaging students as active assessors of their own progress, and using feedback as a feedforward mechanism to inform future actions. It emphasizes structured self-assessment activities that encourage learners to reflect on their learning processes, identify areas for improvement, and formulate follow-up actions (Mok, 2013; Yan & Brown, 2016). By integrating assessment with metacognitive regulation, SLOA has the potential to strengthen the AaL dimension in mathematics learning.

Previous studies have developed SLOA-based formative assessment instruments in mathematics at the elementary school level, such as on data representation topics and fractions, and reported that these instruments are valid, practical, and effective (Hidayah et al., 2025; Marvelia et al., 2025). However, existing studies have not specifically developed

structured SLOA-based formative test instruments for junior high school mathematics that explicitly integrate self-assessment within the testing process, particularly for the topic of ratios. Considering that junior high school students are in a critical transition toward more formal and abstract mathematical thinking, they require more sophisticated tools to manage their independent learning.

The novelty of this study lies in the development of structured SLOA-based formative test packages for junior high school mathematics that embed self-assessment sheets directly within each test package. Unlike generic self-reflection, this structured approach provides students with specific criteria and prompts to facilitate assessment as learning systematically. Accordingly, this study aimed to develop formative tests based on SLOA for mathematics in junior high school that are valid, practical, and effective. Specifically, this research sought to address the following questions: (1) What is the validity level of the developed SLOA-based formative tests? (2) How is the practicality of the instruments as perceived by the teacher? and (3) how effective are the test packages in supporting student learning outcomes?

METHODS

This study employed a research and development (R&D) approach to develop formative tests based on self-directed learning-oriented assessment (SLOA) for mathematics in junior high school. The development process followed the ADDIE model, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation (Fajrin et al., 2023). The research procedure based on the ADDIE model is illustrated in Figure 1.

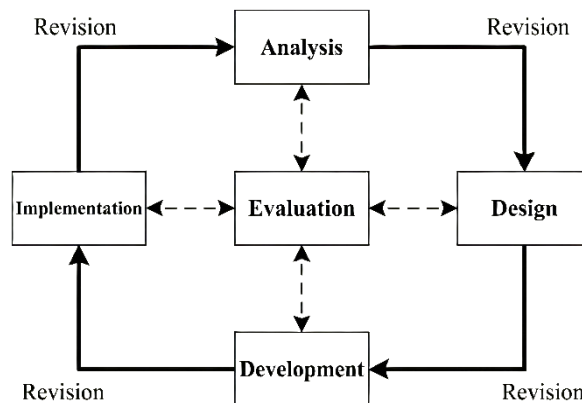


Figure 1 ADDIE development cycle

During the analysis stage, classroom assessment practices and curriculum learning outcomes were examined. The design stage involved constructing test blueprints aligned with mathematics learning objectives, drafting self-assessment rubrics, and preparing validation and practicality instruments. In the development stage, three formative test packages were produced, each consisting of two reasoned multiple-choice questions and two essay questions. These packages were integrated with structured self-assessment sheets consisting of two main sections. The first section includes three reflective statements to evaluate students' conceptual understanding and procedural confidence using a three-point scale (Not Understand, Understand, and Fully Understand). The second section features three open-ended questions designed to identify learning difficulties, recognize strengths, and formulate future learning plans. These products were subsequently reviewed and revised based on expert validation. The implementation stage involved piloting the revised formative test packages in Grade VII mathematics learning. Evaluation was conducted

continuously across all stages to refine the product based on expert feedback, teacher responses, and students' learning outcomes.

The implementation was conducted in November 2025 with a single class consisting of 25 seventh-grade students at State Junior High School 4 Alalak. This intact group was selected to evaluate the functional feasibility of the SLOA-based formative test packages in a real classroom setting. Prior to classroom implementation, the formative test packages were validated by three experts consisting of two mathematics education lecturers and one Grade VII mathematics teacher. Permission for conducting the research was obtained from the school.

The research instruments consisted of three types: expert validation sheets, a teacher practicality questionnaire, and SLOA-based formative test packages. The expert validation sheet was administered to validators to evaluate the developed formative test packages in terms of material aspect (alignment with learning objectives and conceptual accuracy of ratio content), construction aspect (clarity of instructions and item structure), and language aspect (clarity and appropriateness of language use) using a four-point rating scale ranging from 0 (not appropriate) to 4 (highly appropriate). The practicality instrument was a questionnaire distributed to a Grade VII mathematics teacher to obtain responses regarding goal attainment, ease of use, time efficiency, and the provision of feedback. Meanwhile, the SLOA-based formative test instrument consisted of three test packages, which, for this study, were contextualized on ratio topics. These packages comprised multiple-choice and essay questions accompanied by self-assessment sheets, which were used to determine the effectiveness of the developed product based on students' mastery of learning outcomes.

Data analysis employed both quantitative and qualitative approaches. Quantitative analysis was used to determine the feasibility of the developed SLOA-based formative tests in terms of validity, practicality, and effectiveness. Qualitative analysis was used to describe expert suggestions and teacher feedback as the basis for product revision. Product validity was determined based on expert judgment using the mean validity score (VR) formula adapted from Sudjana (1995), as cited in Riyani et al. (2017). The validation process involved two steps: first, calculating the mean score from each validator ($\bar{V}_l$), and second, determining the overall average validity score using the following formula:

$$VR = \frac{\sum_{l=1}^n \bar{V}_l}{n} \quad (1)$$

Where VR is the average validity, $\bar{V}_l$ is the mean score from each validator, and n is the number of validators. The final VR scores were then interpreted according to the categories in Table 1, where a score of at least 2.00 indicates that the instrument is valid (Riyani et al., 2017).

Table 1 Validity category	
Score Interval (VR)	Validity Category
$0 \leq VR < 1$	Invalid
$1 \leq VR < 2$	Less Valid
$2 \leq VR < 3$	Valid
$3 \leq VR \leq 4$	Very Valid

The practicality was calculated as the percentage of the obtained score relative to the maximum score ($P = \frac{\sum x}{x_{\max}} \times 100\%$). The percentage was then interpreted according to the categories in Table 2, where a percentage of at least 61% indicates that the product is practical (Eliza & Myori, 2017).

Table 2 Practicality category

Practicality Percentage (P)	Practicality Category
$80\% < P \leq 100\%$	Very Practical
$60\% < P \leq 80\%$	Practical
$40\% < P \leq 60\%$	Fairly Practical
$20\% < P \leq 40\%$	Less Practical
$0\% \leq P \leq 20\%$	Not Practical

The effectiveness was determined based on students' mastery of learning outcomes. Students were categorized as achieving mastery if they obtained a score of at least 70, in accordance with the established school standard (KKTP). The mastery percentage was calculated as the proportion of students achieving mastery relative to the total number of students. Since three formative test packages were administered, overall effectiveness was determined by averaging the mastery percentages of the three tests. The results were then interpreted according to the categories in Table 3, where a percentage exceeding 60% indicates that the product is effective (Hodiyanto et al., 2020). The effectiveness criterion was set at exceeding 60% based on the effectiveness threshold often used in educational development research.

Table 3 Effectiveness category

Percentage Interval (P)	Practicality Category
$80\% < P \leq 100\%$	Very Effective
$60\% < P \leq 80\%$	Effective
$40\% < P \leq 60\%$	Moderately Effective
$20\% < P \leq 40\%$	Less Effective
$0\% < P \leq 20\%$	Not Effective

As supplementary analysis, metacognitive accuracy was examined by comparing students' perceived understanding in the self-assessment rubric with their actual test performance, adopting the comparison approach used by Kulcsár (2023). Based on the alignment between perception and achievement, students were then categorized into three distinct groups. Students were classified as calibrated when their perceived understanding aligned with their actual test performance, such as reporting high understanding and achieving high scores. Conversely, students were categorized as overconfident if they exhibited an "illusion of competence" by reporting high perceived understanding despite demonstrating low actual performance. Finally, the underconfident category included students who reported low perceived understanding or a lack of mastery despite achieving high actual performance.

RESULTS AND DISCUSSION

This section presents the findings of the study on the development of SLOA-based formative tests for ratio topics in Grade VII. The development outcomes are organized according to the ADDIE instructional design model: Analysis, Design, Development, Implementation, and Evaluation.

Analysis

This study developed formative tests based on SLOA for ratio topics among Grade VII students at State Junior High School 4 Alalak using the ADDIE development model. The process began with the analysis stage, which identified a key gap in classroom assessment practice. Initial findings from interviews with the mathematics teacher indicated that

formative assessment primarily fulfilled the function of Assessment for Learning (AfL), where students mainly received scores and corrections. However, Assessment as Learning (AaL), which emphasizes students' active involvement in evaluating their own understanding, had not been optimally implemented. This condition potentially limits the development of students' metacognitive awareness and learning independence.

Furthermore, curriculum analysis confirmed that the product should align with the *Kurikulum Merdeka* learning outcomes (CP) for Phase D, particularly within the Number element. Based on this framework and consultations with the partner teacher, the development focused on the topic of ratios, subdivided into three specific sub-topics: (1) basic concepts of ratios; (2) advanced ratio concepts, including equivalent ratios and proportions; and (3) scales. This analysis led to the formulation of specific learning objectives (LO). These objectives served as the blueprint for creating three distinct formative test packages, ensuring that each item directly addressed identified student needs in mastering formal and abstract mathematical thinking.

Design

Building upon the analysis phase, the design stage formulated an initial prototype consisting of three formative test packages, each accompanied by a self-assessment sheet as a central component of SLOA implementation. The specific topics for each formative test package are detailed in Table 4.

Table 4 Distribution of formative test packages and topics

Formative Test Packages	Topic Focus	Description
Package 1	Basic ratio concepts	Focuses on distinguishing between ratio and difference, interpreting ratio meanings in contexts, and simplifying ratios.
Package 2	Advanced ratio concepts	Covers the application of ratios in finding unknown quantities, identifying equivalent ratios, and solving proportion-related problems.
Package 3	Scale	Addresses the application of scale concepts, including finding actual sizes, model sizes, and using scale factors in dilation.

The test items were constructed in the form of reasoned multiple-choice (two-tier) questions and essay tasks. The implementation of the two-tier format is a strategic design choice to strengthen diagnostic depth. It requires students to not only select a final answer but also provide a written justification for their reasoning. This approach effectively uncovers underlying student misconceptions or "lucky guesses" that frequently remain undetected in conventional multiple-choice tests. Meanwhile, the self-assessment component included structured statements of understanding and open-ended reflective prompts designed to stimulate students' metacognitive engagement.

To provide a clearer illustration of the developed product, selected excerpts of the SLOA-based formative test are presented in Figure 2 and Figure 3. These excerpts represent the structural design consistently implemented across the three formative test packages.

Perhatikan soal berikut!

A. Pilihlah satu jawaban yang paling tepat dengan memberikan tanda silang (X) pada huruf A, B, C, atau D, kemudian berikan alasan singkat jawabanmu!

1. Tinggi badan Adi adalah 150 cm, sedangkan tinggi badan adiknya yang bernama Putra adalah 125 cm. Pernyataan yang benar terkait perbandingan tinggi badan mereka adalah...

A. Selisih tinggi badan Adi dan Putra adalah 5:6
 B. Selisih tinggi badan Adi dan Putra adalah 6:5
 C. Rasio tinggi badan Adi terhadap Putra adalah 25 cm
 D. Rasio tinggi badan Adi terhadap Putra adalah 6:5

Alasan jawaban saya:

B. Jawablah pertanyaan-pertanyaan berikut dengan jelas dan tuliskan langkah-langkah pengerjaanmu!

1. Perhatikan resep dan takaran bahan untuk membuat kue pais pisang pada tabel berikut.



Bahan	Jumlah
Tepung beras	500 gr
Pisang	10 buah
Gula pasir	300 gr

Berdasarkan resep di atas, tuliskan bentuk rasio paling sederhana dari banyak tepung beras terhadap banyak gula pasir yang diperlukan. Kemudian jelaskan makna dari rasio yang kamu tuliskan sesuai konteks resep tersebut!

Penyelesaian:

2.




IKAN GUPPY IKAN NEON TETRA

Di dalam sebuah akuarium, rasio antara banyak ikan guppy dan banyak ikan neon tetra adalah 4:6. Manakah pernyataan di bawah ini yang paling tepat untuk menjelaskan makna dari rasio tersebut?

A. Selisih antara banyak ikan guppy dan ikan neon tetra adalah 2 ekor.
 B. Jumlah seluruh ikan di akuarium adalah 10 ekor.
 C. Untuk setiap 4 ekor ikan guppy, terdapat 6 ekor ikan neon tetra.
 D. Di dalam akuarium pasti hanya ada 4 ekor ikan guppy dan 6 ekor ikan neon tetra.

Alasan jawaban saya:

2. Di sebuah tempat parkir terdapat 18 buah mobil dan 12 buah sepeda motor.

a. Hitung selisih antara jumlah mobil dan sepeda motor!
 b. Tuliskan rasio jumlah sepeda motor terhadap jumlah mobil dalam bentuk yang paling sederhana!
 c. Jelaskan perbedaan makna selisih dan rasio yang kamu tuliskan sesuai konteks situasi di tempat parkir tersebut!

Penyelesaian:

Figure 3 Reasoned multiple-choice items and essay tasks in the first formative test package

Figure 2 displays an example of a reasoned multiple-choice item and an essay task taken from the first formative test package. The two-tier item consists of a content tier for selecting the answer and a reason tier for providing the underlying mathematical justification. Meanwhile, the essay task presents a contextual problem that requires students to provide a complete step-by-step solution.

Lembar Self-Assessment (Penilaian Diri)
Tes Formatif 1 – Konsep Dasar Rasio

Nama: _____ **Kelas:** _____ **Hari, tanggal:** _____

Petunjuk:
 Yuk, kita lihat sejauh mana pemahamanmu! Isilah lembar ini dengan **jujur** sesuai dengan apa yang kamu pahami dan rasakan setelah mengerjakan tes formatif yang telah diberikan.

Bagian 1: Pemahaman Terhadap Materi
 Berilah tanda centang (✓) pada kolom yang paling sesuai dengan tingkat pemahamanmu.

No.	Pertanyaan	Belum Pahami	Pahami	Sangat Pahami
1	Saya dapat menyatakan rasio dalam bentuk paling sederhana.			
2	Saya dapat menjelaskan makna dari sebuah rasio sesuai konteks masalah.			
3	Saya dapat membedakan penggunaan konsep selisih dan rasio dalam membandingkan dua besaran.			

Bagian 2: Refleksi dan Rencana Belajar
 Jawablah pertanyaan berikut dengan singkat dan jujur.

1. Nomor soal atau bagian mana yang menurutmu **paling sulit**? Jelaskan mengapa?
 Jawab: _____

2. Nomor soal atau bagian mana yang menurutmu **paling mudah** dan kamu paling yakin dengan jawabanmu?
 Jawab: _____

3. Setelah mengerjakan tes formatif, apa yang akan kamu lakukan agar lebih paham tentang materi konsep dasar rasio?

☐ Bertanya kepada guru bagian yang belum dipahami.

☐ Belajar bersama teman

☐ Mencari soal latihan tambahan

☐ Lainnya: _____

Figure 2 Self-assessment accompanying the first formative test package

Figure 3 presents the self-assessment sheet accompanying the formative test. The sheet consists of structured statements measuring perceived understanding and reflective prompts guiding students to identify difficulties and determine follow-up learning strategies.

Development

During the development stage, the prototype was refined, and its validity was examined through expert judgment. The formative tests and self-assessment sheets were evaluated in terms of content relevance, item construction, and language clarity by three highly competent expert validators, consisting of two mathematics education lecturers with expertise in assessment development and one experienced Grade VII mathematics teacher from State Junior High School 4 Alalak.

The summary of expert validation results for the formative tests is presented in Table 5.

Table 5 Validity results of formative tests

Validator	Aspect			Total Score	Number of Indicators	Mean Score
	A	B	C			
Math Education Lecturer	12	14	14	40	12	3.33
Math Education Lecturer	16	14	12	42	12	3.50
Teacher	15	14	14	43	12	3.58
Average Validity						3.47
Category						Very Valid

Note: Aspect A = Content, Aspect B = Construction, C = Language

As shown in Table 5, the formative tests achieved an overall mean validity score of 3.47, categorized as very valid. Minor revisions were recommended, particularly concerning distractor effectiveness in reasoned multiple-choice items and the placement of visual illustrations. These revisions were incorporated during the development stage to strengthen the final version of the instrument.

Similarly, the validation results of the self-assessment sheets are summarized in Table 6.

Table 6 Validity results of self-assessment sheets

Validator	Aspect			Total Score	Number of Indicators	Mean Score
	A	B	C			
Math Education Lecturer	15	17	13	45	14	3.21
Math Education Lecturer	15	19	13	47	14	3.36
Teacher	17	18	14	49	14	3.50
Average Validity						3.36
Category						Very Valid

Note: Aspect A = Content, Aspect B = Construction, C = Language

The self-assessment sheets obtained an overall mean validity score of 3.36, also categorized as very valid. Unlike the test component, the self-assessment sheets required no substantive revision.

Implementation

The validated formative tests were subsequently implemented in a field trial involving 25 seventh-grade students across four instructional meetings. The practicality of the SLOA-based formative tests was evaluated after this implementation using a teacher practicality questionnaire. The questionnaire focused on the feasibility of administering the formative tests, clarity of structure, and usefulness in supporting instructional decision-making. The

results indicated a total score of 49 out of 50, corresponding to a practicality percentage of 98%, categorized as very practical. The teacher emphasized that the inclusion of the self-assessment provided clearer information regarding students' learning needs and enabled more targeted feedback.

At the initial stage of implementation, specifically during the first meeting, observations indicated that students required additional time to adapt to writing reasoned explanations and completing reflective responses for the first formative test package. Subsequent feedback sessions in the second meeting clarified misconceptions and guided students toward more accurate self-assessment. By the third and fourth meetings, students demonstrated greater independence and familiarity with the assessment process, completing both the formative tests and self-assessment tasks with reduced reliance on teacher direction.

Evaluation

Evaluation was conducted formatively throughout the ADDIE cycle to ensure product quality and summatively to measure the product's effectiveness. Observations during implementation indicated that the initial 30-minute allocation per package was insufficient for students to complete both reasoning tasks and reflective components. Consequently, the final version extended the working time to 40 minutes.

The effectiveness of the SLOA-based formative tests was determined based on the percentage of students achieving the minimum mastery criterion across the three test packages. The minimum mastery criterion was set at 70. A summary of students' mastery levels is provided in Table 7.

Table 7 Effectiveness results of the SLOA-based formative tests

Test Package	Mean Score	Student Achieving Mastery	Mastery Percentage (%)
Package 1 (Basic Ratio Concepts)	52.64	11	44
Package 2 (Advanced Ratio Concepts)	69.96	17	68
Package 3 (Scale)	81.32	18	72
Average Mastery			61.3
Effectiveness Criterion			Effective

As shown in Table 7, students' mastery levels increased progressively across the three packages, from 44% in Package 1 to 72% in Package 3. The overall average mastery percentage of 61.3% meets the effectiveness criterion. To further evaluate the effectiveness of the SLOA-based formative tests, an N-gain analysis was conducted by comparing the mean scores of Package 1 and Package 3. The analysis yielded an N-gain score of 0.61, categorized as moderate. This result confirms that the implementation of the developed formative tests effectively supported the improvement of student learning outcomes.

Supplementary Findings: Development of Metacognitive Accuracy

In addition to the primary criteria of validity, practicality, and effectiveness, students' metacognitive accuracy was analyzed as supplementary evidence. Metacognitive accuracy refers to the alignment between students' perceived understanding, as expressed in the self-assessment rubric, and their actual performance.

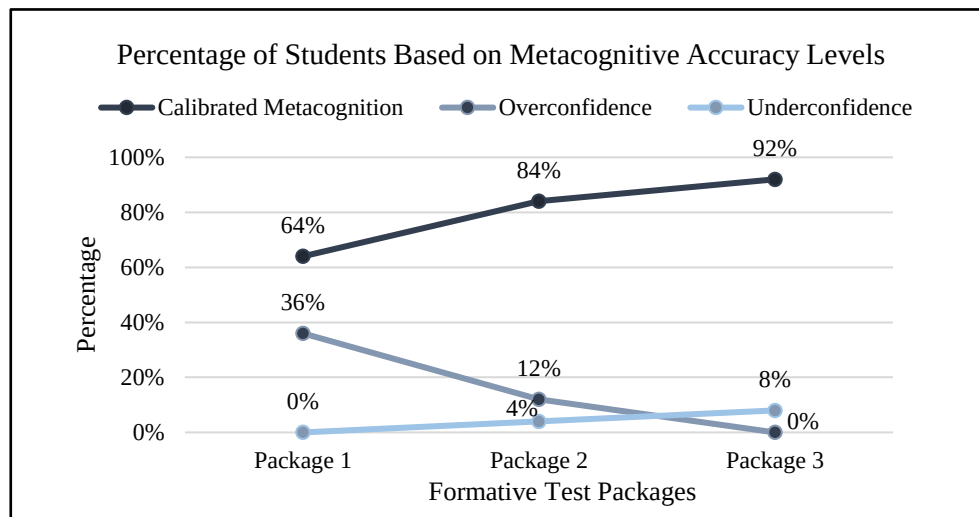


Figure 4 Distribution of students' metacognitive accuracy across the three formative test packages

As presented in Figure 4, the proportion of students demonstrating calibrated metacognition increased substantially across the three packages. Conversely, the proportion of overconfident students decreased and was no longer observed in the final package. Interestingly, a small proportion of underconfidence emerged in the final package. This controlled underconfidence can be interpreted as a sign of developing metacognitive awareness. It suggests that as students become more familiar with the SLOA framework, they develop a more cautious and critical stance in evaluating their own understanding.

The primary quality criteria of the developed product, validity, practicality, and effectiveness, were systematically addressed throughout the ADDIE stages, alongside supplementary findings related to students' metacognitive accuracy. Accordingly, this section explains how SLOA-based formative tests support both mastery achievement and students' engagement in assessment as learning. From the AaL perspective, students are expected to participate actively in assessment activities and develop the ability to assess themselves in order to understand the steps needed to achieve optimal learning (Setiawati et al., 2019). Therefore, the development of SLOA-based formative tests was intended not only to measure achievement but also to strengthen self-directed learning through structured self-assessment (Rikayanti, 2015).

The design of this product reflects the SLOA framework, in which assessment functions not only as an evaluative tool but also as a diagnostic and developmental process. Reasoned multiple-choice items are particularly valuable because they assess both answer accuracy and the conceptual reasoning underlying students' responses, thereby providing richer diagnostic information (Mok, 2013). The essay task further requires students to distinguish between additive comparison (difference) and multiplicative comparison (ratio), encouraging deeper conceptual understanding and systematic mathematical explanation. Integrating self-assessment positions students not only as test-takers but also as active evaluators of their own learning, promoting autonomy and responsibility (Hidayat, 2018; Maskos et al., 2025). This design directly operationalizes the principles of assessment as learning within the SLOA framework.

Expert validation confirms that the components met the established quality standards and support the feasibility of implementing SLOA-based formative assessment in junior high school mathematics, aligning with validity expectations in educational product development research (Riyani et al., 2017). The practicality results are consistent with

practicality criteria in development research, which state that an instrument is considered practical if it can be implemented without major obstacles (Eliza & Myori, 2017). This finding suggests that the SLOA-based formative tests were easy to administer and integrate into classroom activities. Regarding implementation, the initial adaptation phase is expected, as self-assessment practices are generally not applied commonly in many traditional classrooms, making them unfamiliar to students initially (Karaman, 2021). Subsequent feedback sessions in the second meeting clarified misconceptions and guided students toward more accurate self-assessment, consistent with the SLOA cycle in which external feedback supports internal regulation (Mok, 2013).

Regarding the effectiveness results, the lower mastery in Package 1 (44%) was expected, as students were encountering two-tier reasoning tasks and structured self-assessment for the first time. This initial phase functioned as a period of adaptation to the SLOA framework. However, the subsequent increase to 72% in Package 3 indicates that repeated engagement with self-assessment acted as a form of metacognitive training. By reflecting on their mistakes and formulating learning plans after each test, students became more adept at monitoring their own understanding and correcting misconceptions. This progressive mastery suggests that repeated engagement with SLOA-based formative tests, combined with systematic feedback, supported students' learning progress over time. The overall average mastery percentage of 61.3% meets the effectiveness threshold established by Hodiyanto et al. (2020), which is a widely accepted threshold in educational development research to indicate that a product is functionally effective in a classroom setting. The N-gain score of 0.61, which is categorized as moderate, supports this finding. This classification is consistent with educational development research that defines the moderate category for N-gain scores between 0.3 and 0.7 (Soesilo & Munthe, 2020). This result confirms that the implementation of the developed formative tests effectively supported the improvement of student learning outcomes. The initial presence of overconfidence reflects a common bias among learners newly introduced to self-assessment, as they may overestimate their competence in the absence of clear performance standards (Beck, 2025; Kulcsár, 2023). Through successive cycles of structured self-assessment and feedback, students became better able to align perceived understanding with actual performance. This finding supports the role of feedback in reducing the gap between current performance and intended learning goals (Lubbe & Mentz, 2021).

Overall, the findings demonstrate that the developed SLOA-based formative tests meet the criteria of validity, practicality, and effectiveness in supporting both mastery achievement and the development of self-directed learning behaviors. This study extends previous research on SLOA by providing empirical evidence of its applicability in junior high school mathematics, particularly in ratio learning. Nevertheless, several considerations should be noted. The two-tier reasoning format requires adequate written communication skills, and some students experienced difficulty articulating explanations despite understanding the computational procedures. In addition, the reflective self-assessment component introduces additional cognitive demands, indicating that gradual familiarization and appropriate time allocation are essential for sustainable classroom implementation.

CONCLUSION

The development of formative tests based on SLOA for mathematics in junior high school demonstrates that the product meets the criteria of validity, practicality, and effectiveness. Expert validation and field testing indicate that the developed product is very valid and very practical for classroom implementation. Furthermore, the effectiveness results reveal

a consistent positive trend in students' mastery of learning outcomes across the implementation cycles, successfully meeting the established effectiveness criterion.

Although metacognitive accuracy was a supplementary focus, the findings provide compelling evidence that students' alignment between perceived and actual understanding improved through repeated engagement with the SLOA framework. This suggests that integrating structured self-assessment into formative testing enhances learners' awareness and supports self-directed learning behaviors. Consequently, SLOA-based formative tests are feasible strategic tools for promoting both mastery achievement and student independence. The primary contribution of this study lies in operationalizing a coherent framework where assessment for learning and assessment as learning are integrated simultaneously.

However, this study was limited by a relatively short implementation period and a single-class sample. To address these limitations, future research is recommended to (1) conduct large-scale implementation across diverse mathematical topics, such as geometry or algebra, to obtain broader evidence of generalizability; (2) extend the implementation period to observe how students' ability to improve their own learning develops over a longer time; and (3) employ quasi-experimental designs with control groups to rigorously test the effectiveness of SLOA-based instruments compared to conventional formative assessment. This study implies that mathematics teachers can utilize structured self-assessment to foster learner autonomy, provided that adequate instructional time and systematic feedback cycles are ensured.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

IA is responsible for the study's design, data collection, and data analysis. ZH contributed to reviewing the manuscript and providing suggestions for improving the quality and clarity of the article. CFP and K contributed to supervising the research process, reviewing the manuscript, and providing suggestions and constructive feedback to improve the quality of the study.

AI DISCLOSURE STATEMENT

The author used ChatGPT, Gemini, and Grammarly during the preparation of this work for language polishing and translation. Additionally, Publish or Perish, Google Scholar, and Mendeley were utilized for literature searching and reference management. After using the tool/service, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of the publication. The author declare that the core research, data analysis, and interpretations were conducted without the aid of artificial intelligence.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, for the academic support and facilities provided. The authors also extend their appreciation to State Junior High School 4 Alalak for facilitating the implementation of this research. In addition, the authors would like to thank all parties who contributed support and assistance in the completion of this research study.

REFERENCES

- Al Kamli, H. M., & Almalki, M. S. (2024). Learning-oriented assessment (LOA) implementation in EFL tertiary contexts: Towards a more task-based learning (TBL) environment. *World Journal of English Language*, 14(1), 1–8. <https://doi.org/10.5430/wjel.v14n1p1>
- Beck, A. P. (2025). Assessment of first-year medical student perceptions in the development of self-directed learning skills in a single medical school course. *BMC Medical Education*, 25(1), 340–353. <https://doi.org/10.1186/s12909-025-06890-9>
- Carless, D., & Winstone, N. (2017). Teacher feedback literacy and its interplay with student feedback literacy. *Teaching in Higher Education*, 28(1), 150–163. <https://doi.org/10.1080/13562517.2020.1782372>
- Eliza, F., & Myori, D. E. (2017). Trainer pada pembelajaran dasar dan pengukuran listrik. *Jurnal Teknologi Informasi Dan Pendidikan*, 10(1), 12–22. <https://tip.ppj.unp.ac.id/index.php/tip/article/view/40>
- Fajrin, C. E., Ningsih, S. W. W., Kartini, Saputra, A., Khoiriyah, U., & Duma, M. (2023). Student and teacher collaboration in developing STEM-based learning modules and pancasila student profiles. *JPI (Jurnal Pendidikan Indonesia)*, 12(1), 39–49. <https://doi.org/10.23887/jpiundiksha.v12i1.52704>
- Granberg, C., Palm, T., & Palmberg, B. (2021). A case study of a formative assessment practice and the effects on students' self-regulated learning. *Studies in Educational Evaluation*, 68(3), 1–10. <https://doi.org/10.1016/j.stueduc.2020.100955>
- Hidayah, N., Pasani, C. F., & Amalia, R. (2025). Pengembangan tes formatif piktogram dan diagram batang berbasis self-directed learning oriented assessment (SLOA) di kelas IV sekolah dasar. *Jurmadikta (Jurnal Mahasiswa Pendidikan Matematika)*, 5(2), 83–95. <https://doi.org/10.20527/jurmadikta.v5i2.3181>
- Hidayat, A. (2018). Meta analisis: Pentingnya self dan peer assessment dalam pembelajaran. *Jurnal Basicedu*, (1), 95–101. <https://doi.org/10.31004/basicedu.v2i1.127>
- Hodiyanto, Darma, Y., & Putra, S. R. S. (2020). Pengembangan media pembelajaran berbasis macromedia flash bermuatan problem posing terhadap kemampuan pemecahan masalah matematis. *Mosharafa: Jurnal Pendidikan Matematika*, 9(2), 323–334. <https://doi.org/10.31980/mosharafa.v9i2.652>
- Karaman, P. (2021). The impact of self-assessment on academic performance: a meta-analysis study. *International Journal of Research in Education and Science*, 7(4), 1151–1166. <https://doi.org/10.46328/ijres.2344>
- Kemendikbud, P. P. P., & Abduh, M. (2019). *Model penilaian formatif pada pembelajaran abad ke-21 untuk sekolah dasar*. Pusat Penilaian Pendidikan.
- Kemendikdasmen. (2025). *Panduan pembelajaran dan asesmen: Pendidikan anak usia dini, jenjang pendidikan dasar, dan jenjang pendidikan menengah*. Badan Standar, Kurikulum, dan Asesmen Pendidikan (BSKAP).
- Kulcsár, N. (2023). Self-assessment or peer assessment? Which is better predictor of test results. In *Proceedings of the 51st Annual Conference of the European Society for Engineering Education (SEFI)* (pp.703–709). <https://doi.org/10.21427/HTNS-KS58>
- Lubbe, A., & Mentz, E. (2021). Self-directed learning-oriented assessment and assessment literacy: Essential for 21st century learning. In E. Mentz & A. Lubbe (Eds.), *Learning through assessment: An approach towards Self-Directed Learning* (Vol. 7, pp. 1–25). AOSIS. <https://doi.org/10.4102/aosis.2021.BK280.01>
- Marvelia, R. T., Pasani, C. F., & Juhairiah. (2025). Pengembangan asesmen formatif materi pecahan berbasis self-directed learning oriented assessment (SLOA) di kelas IV

- SD/MI. *Jurmadikta (Jurnal Mahasiswa Pendidikan Matematika)*, 5(2), 12–24. <https://doi.org/10.20527/jurmadikta.v5i2.3152>
- Maskos, K., Schulz, A., Oeksuez, S. S., & Rakoczy, K. (2025). Formative assessment in mathematics education: a systematic review. *ZDM - Mathematics Education*, 57(4), 679–693. <https://doi.org/10.1007/s11858-025-01696-x>
- Mok, M. M. C. (2013). *Self-directed learning oriented assessments in the asia-pacific* (Vol. 18). Springer. <https://doi.org/10.1007/978-94-007-4507-0>
- Mujahidittauhid, A., Hidayah, N., Handayani, L., Anjani, A. R., & Herianto, E. (2024). Tes formatif dan dampaknya pada hasil belajar siswa pada mata pelajaran PPKn. *IJEDR: Indonesian Journal of Education and Development Research*, 2(1), 559–569. <https://doi.org/10.57235/ijedr.v2i1.1877>
- Nhor, R., Pang, S., & Em, S. (2022). Teachers' and learners' perceptions of formative assessment practice in enhancing learning in EFL courses. *Jurnal As-Salam*, 6(2), 181–201. <https://doi.org/10.37249/assalam.v6i2.434>
- Panadero, E., Andrade, H., & Brookhart, S. (2018). Fusing self-regulated learning and formative assessment: a roadmap of where we are, how we got here, and where we are going. *The Australian Educational Researcher*, 45(1), 13–31. <https://doi.org/10.1007/s13384-018-0258-y>
- Rikayanti, R. (2015). Peran self-directed oriented assessment SLOA dalam pembelajaran matematika. *Jurnal Pendidikan Unsika*, 3, 200–208. <https://doi.org/10.35706/judika.v3i2.212>
- Riyani, R., Maizora, S., & Hanifah. (2017). Uji validitas pengembangan tes untuk mengukur kemampuan pemahaman relasional pada materi persamaan kuadrat siswa kelas VIII SMP. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, 1(1), 60–65. <https://doi.org/10.33369/jp2ms.1.1.60-65>
- Setiawati, W., Asmira, O., Ariyana, Y., Bestary, R., & Pudjiastuti, A. (2019). *Buku penilaian berorientasi higher order thinking skills*. Direktorat Jenderal Guru dan Tenaga Kependidikan.
- Soesilo, A., & Munthe, A. P. (2020). Pengembangan buku teks matematika kelas 8 dengan model ADDIE. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, 10(3), 231–243. <https://doi.org/https://doi.org/10.24246/j.js.2020.v10.i3.p231-243>
- Yan, Z., & Brown, G. T. L. (2016). A cyclical self-assessment process: Towards a model of how students engage in self-assessment. *Assessment & Evaluation in Higher Education*, 42(8), 1247–1262. <https://doi.org/10.1080/02602938.2016.1260091>
- Zaini, N. F. M. M., Mohamed, N. A., Idalisa, N., Mohamed, N. H., & Mohamed, N. F. (2025). Formative feedback in mathematics education: a systematic review of research instruments and learning outcomes. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, 9(3), 365–380. <https://doi.org/10.33369/jp2ms.9.3.365-380>

AUTHOR PROFILES



Full name: Ihsanul Amin
Email: aminihsanul13@gmail.com
Expertise: Mathematical Education
Affiliation: Universitas Lambung Mangkurat



Full name: Chairil Faif Pasani
Email: chfaifp@ulm.ac.id
Expertise: Mathematics Values and Character Education
Affiliation: Universitas Lambung Mangkurat
Bio: [Google Scholar](#), Sinta ID: [6101608](#)
Orchid ID: [0000-0001-7846-3302](#), Scopus ID: [57203687819](#)



Full name: Kamaliyah
Email: kamaliy4h@ulm.ac.id
Expertise: Mathematics Education
Affiliation: Universitas Lambung Mangkurat
Bio: [Google Scholar](#), Sinta ID: [6101033](#)
Orchid ID: [0000-0003-4720-1865](#), Scopus ID: [57208748763](#)



Full name: Zainudin Hassan
Email: p-zainudin@utm.my
Expertise: Social Change, Sociology in Education Service Learning, Higher Education
Affiliation: Universiti Teknologi Malaysia
Bio: [Google Scholar](#), Orchid ID: [0000-0002-8606-2899](#)
Scopus ID: [55796732500](#)