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DEVELOPMENT OF A STEAM ACTIVITY-BASED MATHEMATICS TEACHING MODULE TO ENHANCE STUDENTS' ALGEBRAIC REASONING

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ABSTRACT
This study aimed to develop and evaluate the validity, practicality, and effectiveness of a STEAM activity-based mathematics teaching module integrated with Amplify Classroom for developing students' algebraic reasoning in Systems of Linear Equations in Three Variables (SLETV). The study was motivated by students' difficulties in progressing from identifying patterns to recognizing mathematical relationships and formulating generalizations, together with the limited integration of interactive digital technology into mathematics instruction. A Research and Development (R&D) approach was employed using the ADDIE model with 28 Grade X students at SMA Santa Maria Yogyakarta. Data were collected through expert validation sheets, teacher and student practicality questionnaires, observations, and algebraic reasoning pre-tests and post-tests. Quantitative data were analyzed using descriptive statistics, normalized gain, and a pre-test–post-test comparison, while qualitative data were analyzed descriptively. The results showed that the module was developed through the five ADDIE phases and was rated very valid by two experts (95% and 90%) and very practical by students (82.4%) and the teacher (82.5%). Students' mean algebraic reasoning score increased from 44.05 (SD = 21.26) on the pre-test to 64.96 (SD = 21.84) on the post-test, with a normalized gain of 0.4, indicating a moderate level of improvement. All three algebraic reasoning indicators improved, with the largest increase occurring in pattern recognition (from 42.9% to 84.4%), while generalizing remained the lowest post-test indicator (51.1%). These findings provide evidence that the developed module is valid and practical and is associated with improvement in students' algebraic reasoning, while further instructional support is needed to strengthen generalization.

Keywords: algebraic reasoning; amplify classroom; mathematics teaching module; STEAM activity

ABSTRAK
Penelitian ini bertujuan untuk mengembangkan dan mengevaluasi validitas, kepraktisan, dan efektivitas modul ajar matematika berbasis aktivitas STEAM yang terintegrasi dengan Amplify Classroom untuk mengembangkan penalaran aljabar siswa pada materi Sistem Persamaan Linear Tiga Variabel (SPLTV). Penelitian ini dilatarbelakangi oleh kesulitan siswa dalam beralih dari mengidentifikasi pola menuju mengenali hubungan matematis dan merumuskan generalisasi, serta masih terbatasnya integrasi teknologi digital interaktif dalam pembelajaran matematika. Penelitian menggunakan pendekatan Research and Development (R&D) dengan model ADDIE dan melibatkan 28 siswa kelas X SMA Santa Maria Yogyakarta. Data dikumpulkan melalui lembar validasi ahli, angket kepraktisan guru dan siswa, observasi, serta pre-test dan post-test penalaran aljabar. Data kuantitatif dianalisis menggunakan statistik deskriptif, normalized gain (N-gain), dan perbandingan hasil pre-test dan post-test, sedangkan data kualitatif dianalisis secara deskriptif. Hasil penelitian menunjukkan

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bahwa modul dikembangkan melalui lima tahap ADDIE dan dinilai sangat valid oleh dua ahli (95% dan 90%) serta sangat praktis berdasarkan respons siswa (82,4%) dan guru (82,5%). Rata-rata skor penalaran aljabar siswa meningkat dari 44,05 (SD = 21,26) pada pre-test menjadi 64,96 (SD = 21,84) pada post-test, dengan nilai N-gain sebesar 0,4 yang menunjukkan tingkat peningkatan sedang. Ketiga indikator penalaran aljabar mengalami peningkatan, dengan peningkatan terbesar pada pattern recognition (dari 42,9% menjadi 84,4%), sedangkan generalizing tetap menjadi indikator dengan capaian terendah pada post-test (51,1%). Temuan ini memberikan bukti bahwa modul yang dikembangkan memiliki validitas dan kepraktisan yang baik serta berkaitan dengan peningkatan penalaran aljabar siswa, meskipun dukungan pembelajaran lebih lanjut masih diperlukan untuk memperkuat kemampuan generalisasi.

***Kata kunci**: amplify classroom; aktivitas STEAM; modul ajar matematika; penalaran aljabar*

Introduction

STEAM has emerged as a highly relevant pedagogical framework for equipping students with twenty-first-century problem-solving competencies. By integrating multiple disciplines, STEAM enables learning to extend beyond abstract procedures toward authentic real-world applications (Ayuningsih et al., 2022). STEAM-based learning also promotes students' critical, logical, and creative thinking in accordance with the demands of contemporary curricula (Savitri et al., 2025). Through interdisciplinary integration, learners actively construct meaningful understanding from direct experiences. From a mathematics education perspective, STEAM integration should go beyond adding interdisciplinary activities to mathematics lessons by providing meaningful opportunities for students to investigate mathematical relationships, use multiple representations, construct mathematical models, and justify their reasoning (Goos et al., 2023). Recent research on STEAM in mathematics education at secondary and pre-university levels shows that project-based learning, real-life problm solving, and educational technology are frequently used to support STEAM implementation; however, mathematics does not always remain sufficiently central within these interdisciplinary activities, highlighting the need to align STEAM projects explicitly with substantive mathematical learning goals (Diego-Mantecon et al., 2021; Martín-Cudero et al., 2024). The successful implementation of STEAM is further strengthened through the use of interactive and relevant digital technologies, ensuring that the integration of science, technology, engineering, arts, and mathematics becomes an authentic learning experience rather than merely a theoretical concept (Annisa Rahma & Nurlaelah, 2024).

The rapid advancement of digital technology has created substantial opportunities for utilizing interactive platforms to transform abstract mathematical concepts into dynamic visual representations that students can explore (Suyuti et al., 2023). One platform specifically designed to support interactive mathematics learning is Amplify Classroom. Amplify Classroom originated as Desmos Classroom, an interactive teaching and learning platform developed by Desmos. Following Amplify's acquisition of Desmos Classroom in 2022, the platform was subsequently integrated into Amplify's digital learning ecosystem and renamed Amplify Classroom in June 2025. It provides a collaborative learning environment that

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facilitates mathematical visualization through structured learning activities (Chechan et al., 2023). Amplify Classroom enables students to explore mathematical ideas, manipulate variables, and observe graphical representations in real time, all of which are essential processes in developing mathematical reasoning (Hakim et al., 2025). Moreover, the platform supports project-based learning by decomposing complex problems into manageable exploratory stages. Its visual ecosystem has been shown to improve students' representational understanding while narrowing the digital literacy gap (Amarulloh et al., 2025).

The integration of digital technology and the STEAM approach is particularly important in teaching Systems of Linear Equations in Three Variables (SLETV). This topic is often challenging because it requires a strong conceptual understanding of algebraic representations and the relationships among variables (Saputri et al., 2022). Research on SLETV has identified persistent difficulties in prerequisite algebraic knowledge and conceptual understanding, as well as in translating contextual situations into mathematical models and accurately applying procedural methods such as elimination and substitution (Indriyani et al., 2025; Supartinah & Hidayat, 2020; Taqwani et al., 2024; Yusnizar et al., 2024). These difficulties suggest that learning SLETV requires more than procedural practice, as students also need opportunities to connect contextual information with mathematical representations, construct appropriate models, and interpret and verify their solutions (Lubis et al., 2025; Suryati & Maryati, 2025).

Students' ability to transform contextual problems into SLETV mathematical models, analyze variable relationships, and interpret solutions reflects their algebraic reasoning ability (Firnandai & Toni, 2023). Nevertheless, previous studies have consistently reported that students' algebraic reasoning remains relatively low, largely because mathematics instruction is frequently dominated by teacher-centered lectures and procedural memorization with limited conceptual reinforce (Putra et al., 2025). Student-generated representations can also play an important role in this process because representations provide resources for students to investigate relationships and construct mathematical generalizations (Schifter & Russell, 2022). However, visualizing or recognizing a pattern does not automatically lead students to a formal generalized expression. Students may successfully identify relationships in particular cases while still experiencing difficulties in expressing and justifying a general rule (Wilkie, 2022). Therefore, mathematics instruction needs to provide a structured progression from exploring particular situations and recognizing patterns to expressing and justifying generalized relationships.

These findings are consistent with the results of a needs analysis conducted in Grade XA at SMA Santa Maria Yogyakarta. Classroom observations and diagnostic tests indicated that teacher-centered instruction remained dominant and that students' algebraic reasoning ranged from low to moderate, particularly regarding generalization skills. Although most students were familiar with digital applications (51% had previously used interactive applications) and demonstrated positive attitudes toward mathematics, they experienced difficulties in solving abstract algebraic word problems. The diagnostic pre-test provided further evidence of these difficulties. Among the 28 students, the mean algebraic reasoning score was 44.05 (SD = 21.26), with achievement of 64.3% in pattern seeking, 42.9% in pattern recognition, and only 25.0% in generalizing. At the same time, the school possessed

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adequate technological infrastructure and demonstrated a strong commitment to curriculum innovation through its zero-paper policy and STEAM implementation. This discrepancy highlights the urgent need to optimize digital learning media to support authentic, project-based mathematics instruction.

Taken together, these findings suggest that the existing learning conditions do not yet fully connect students' needs, pedagogical practices, and available technological resources. Although the school has adopted Project-Based Learning and STEAM (Ayuningsih et al., 2022) and provides opportunities for students to use digital applications (Zuhriyah et al., 2025) , these elements have not been fully integrated into mathematics learning activities that explicitly develop algebraic reasoning. At the same time, previous studies have demonstrated the potential of STEAM, project-based learning, and digital technologies to support mathematics learning, but these approaches have generally been examined as separate instructional components or in contexts that do not specifically address the development of algebraic reasoning through SLETV. Consequently, there is still a need for an instructional design that brings these elements together and translates them into concrete learning activities that connect authentic interdisciplinary experiences, interactive digital representations, SLETV modelling, and students' progression from identifying patterns to recognizing and generalizing mathematical relationships.

In response to this need, the present study develops a STEAM activity-based mathematics teaching module integrating Project-Based Learning (PjBL) and Amplify Classroom, formerly known as Desmos Classroom, for SLETV learning. The module uses *The St. Mary's Barista Project* as an authentic context in which students explore, represent, and model mathematical relationships through interactive digital activities. The activities are explicitly aligned with three algebraic reasoning processes: pattern seeking, pattern recognition, and generalizing. The novelty of the study lies in integrating STEAM-oriented project activities, interactive digital learning, SLETV modelling, and explicit algebraic reasoning indicators within a coherent instructional framework rather than using any single component in isolation. Through this integration, the module seeks to bridge authentic interdisciplinary experiences and the formalization of mathematical relationships while supporting students' algebraic reasoning in a meaningful real-world context. Accordingly, this study aimed to develop and evaluate the validity, practicality, and effectiveness of a STEAM activity-based mathematics teaching module integrated with Amplify Classroom for enhancing students' algebraic reasoning in Systems of Linear Equations in Three Variables (SLETV).

Research Methods

Containing This study employed a Research and Development (R&D) approach using the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate). The ADDIE model was selected because it is systematic and flexible, making it suitable for developing technology-enhanced teaching modules that require iterative revisions throughout the development process (Rayanto & Sugianti, 2020). Figure 1 shows each step of the ADDIE model. The five phases were implemented sequentially and iteratively to produce a teaching module that satisfied the criteria of validity, practicality, and effectiveness (Nieveen, 1999). Based on Figure 1, the

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teaching module developed during the development stage was validated by experts. Revisions were made based on the results of the expert validation. After the module was revised, it was implemented in the classroom to obtain students' practical responses. The following is presented the development procedure in Figure 1.

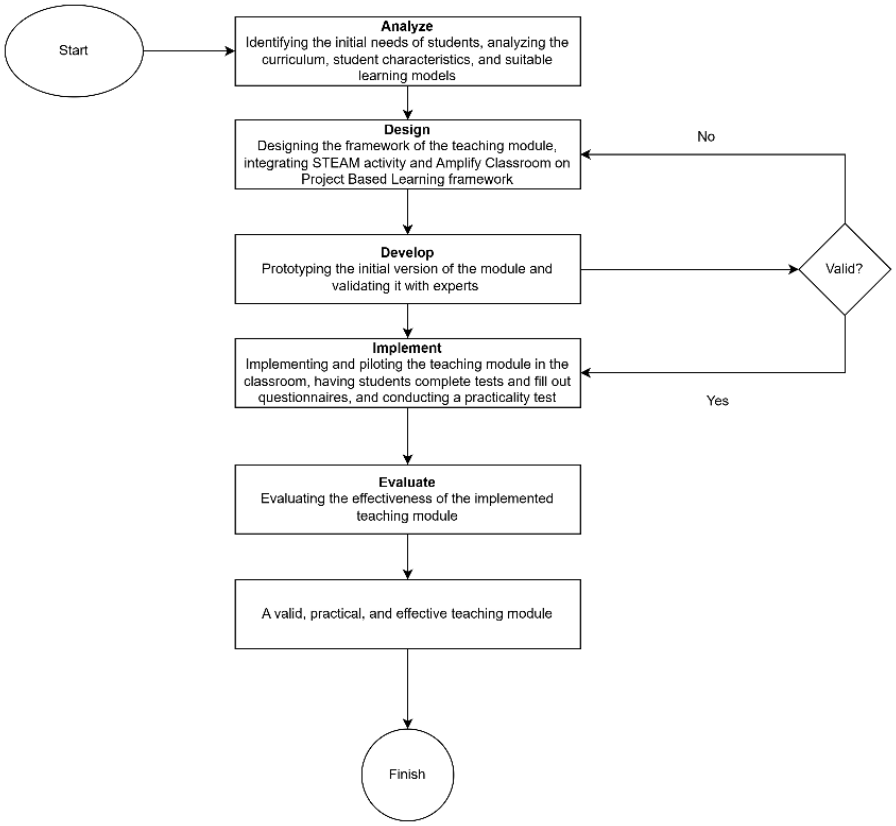

Figure 1. Development Procedure

Participants and Research Context

The study was conducted with 28 Grade X students in class XA at SMA Santa Maria Yogyakarta. All students in class XA participated in the study. Other parallel Grade X classes were not included because the selection of the implementation class followed the school's administrative policy. The permission to conduct the research was documented in research permission letter No. 0268/SMA-SM/AL10/V/2026.

The selection of class XA was also consistent with the findings of the initial needs analysis. The analysis indicated that mathematics instruction was still predominantly teacher-centered, students experienced difficulties in solving abstract algebraic problems, and existing technological resources had not yet been fully integrated into mathematics instructional materials. The school also had technological infrastructure that supported the implementation of digital learning activities.

Data Collection Techniques

Data were collected during the needs analysis, development (expert validation), implementation (observation of implementation fidelity and practicality), and evaluation (assessment of students' algebraic reasoning ability).

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The needs analysis phase involved collecting data on the aspects outlined in Table 1.

Table 1. Aspect of observation in needs analysis

No.	Focus of Observation	Source of Information	Instrument
1	Learning Process	Mathematics Teacher	Class Observation
2	School Management	Curriculum Division	Interview
3	Learning Experiences	Students	Questionnaire
4	Algebraic Reasoning	Students	*Pre-test*

Table 1 presents the aspects examined during the needs analysis, covering the learning process, school management, students' learning experiences, and algebraic reasoning. Data were collected from teachers, the curriculum division, and students using classroom observation, interviews, questionnaires, and a pre-test.

During the development phase, the developed teaching module was evaluated by two expert validators using a validation instrument to determine its feasibility. The first validator was an academic with a Master's degree in Mathematics Education who evaluated the conceptual and substantive aspects of the mathematical content and the construction of the designed media. The second validator was an educational practitioner with a Bachelor's degree in Mathematics Education who evaluated the construction and operationalization of the teaching module and the practical aspects of the media for school implementation. The validation process was designed to ensure that the product evaluation was systematic, objective, and aligned with predetermined assessment criteria. The validation framework employed in this study is presented in Table 2.

Table 2. Validity Assessment Criteria Framework

No.	Assessment Aspect	Indicators
1	Content Validity	Alignment of the learning objectives with the curriculum learning outcomes, integration of STEAM elements, algebraic reasoning indicators, and the students' character profile.
2	Language Appropriateness	Clarity of instructional language, accuracy of terminology, and compliance with standard language conventions.
3	Presentation Quality	Logical organization of the content, coherence among module components, and ease of navigation.
4	Media Quality	Accuracy of graphical visualizations in *Amplify Classroom*, functionality of interactive features, accessibility, and user interface usability.

Table 2 shows the framework used to assess the validity of the developed teaching module across four aspects: content validity, language appropriateness, presentation quality, and media quality. The indicators assess the alignment of learning objectives and STEAM integration, clarity of language, organization and coherence of the module, and the accuracy and usability of visualizations and interactive features in Amplify Classroom.

The algebraic reasoning indicators employed in this study comprised *pattern seeking*, *pattern recognition*, and *generalizing* (Herbert & Brown, 1997) adapted to

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the context SLETV. Table 3 presents the operational descriptions of the algebraic reasoning indicators.

Table 3. Indicators of Algebraic Reasoning

No.	Indicator	Operational Description
1	*Pattern seeking*	The ability to identify patterns and relationships among variables based on information presented in tables, graphs, or contextual problem scenario.
2	*Pattern recognition*	The ability to recognize verbal or visual patterns and translate them into mathematical models of SLETV
3	*Generalizing*	The ability to formulate general rules from identified patterns and derive comprehensive problem-solving strategies.

Table 3 presents three indicators of algebraic reasoning used in the study: pattern seeking, pattern recognition, and generalizing. These indicators describe students' progression from identifying patterns and relationships, to representing them mathematically, and ultimately to formulating general rules and problem-solving strategies. These indicators were used to develop the pre-test and post-test instruments, which consisted of open-ended questions. Students' responses to the open-ended pre-test and post-test items were scored using an analytic scoring rubric with five performance levels ranging from 0 to 4. A score of 0 indicated no response or no evidence of a solution, whereas scores of 1–4 represented progressively higher levels of mathematical understanding, reasoning, and completeness of the response. Both instruments were construct-validated by the two aforementioned validators.

Data Analysis

Data were analyzed using descriptive quantitative and qualitative methods. The validity and practicality of the module were determined using percentage-based feasibility scores. The criteria are presented in Table 4.

Table 4. Criteria of validity and practicality

Score Interval	Validity Criteria	Practicality Criteria
81% – 100%	Highly Valid	Highly Practical
61% – 80%	Valid	Practical
41% – 60%	Quite valid	Quite Practical
21% - 40%	Less Valid	Less Practical
0% – 20%	Invalid	Impractical

(Rahmayani et al., 2022)

Table 4 presents the score intervals used to categorize the validity and practicality of the developed teaching module. Scores of 81%–100% are classified as highly valid and highly practical, while lower score intervals correspond to progressively lower levels of validity and practicality.

The effectiveness of the module was evaluated based on the normalized gain (N-gain) and the percentage of classical learning mastery. The teaching module is considered effective if the N-gain value is greater than 0.3. Students were considered to have achieved mastery if they obtained a minimum score of 70, and the module

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was regarded as effective when at least 70% of the students achieved this criterion (Khoiruddin et al., 2024).

Qualitative analysis was conducted to confirm and elaborate on the empirical findings. Data obtained from interviews, open-ended questionnaires, and curriculum analysis were analyzed qualitatively using the interactive analysis model proposed by Miles and Huberman (Qomaruddin & Sa'diyah, 2024), which consists of three stages: data reduction, data display, and conclusion drawing and verification.

Results and Discussion

Teaching Module Development Process

Contains The teaching module was developed through the five interconnected phases of the ADDIE model.

a. Analyze Phase.

The needs analysis, conducted through interviews, questionnaires, and a pre-test, revealed findings ranging from school-level policies to students' actual learning conditions. SMA Santa Maria Yogyakarta strongly supports educational innovation through adequate technological infrastructure, a zero-paper policy, and the implementation of PjBL and the STEAM approach. Nevertheless, these facilities have not yet been complemented by instructional materials specifically designed to support mathematics learning. Interviews with mathematics teachers indicated that they still experienced difficulties in providing instructional modules capable of visualizing abstract concepts, such as SLETV, through interactive digital media.

The pre-test results demonstrated that students' algebraic reasoning abilities remained at the low-to-moderate level. Students were able to identify patterns at the initial cognitive stage (C2 level), but encountered considerable difficulty in generalizing mathematical relationships (C6 level). Questionnaire responses further indicated that although students exhibited high interest in mathematics (79%) and extensive use of digital media (88%), their confidence in solving algebraic problems remained relatively low (69%). Moreover, only 51% of the students had previous experience using *Amplify Classroom*. This discrepancy between the school's technological readiness and students' algebraic reasoning abilities highlights the urgent need to develop a STEAM-based mathematics teaching module integrated with *Amplify Classroom*.

b. Design Phase

Based on the findings of the needs analysis, the design phase focused on developing a teaching module that integrates the PjBL model with the STEAM approach through the *Amplify Classroom* platform. The module was framed within a coffee-shop business simulation entitled *The St. Mary's Barista* Project, transforming the abstract concepts of SLETV into authentic learning experiences. The instructional sequence consisted of two interconnected learning sessions followed by a post-test session. During the first session (*Mixing Lab*), students simulated beverage preparation by mixing coffee, milk, and syrup, while recording experimental data in *Amplify Classroom* to foster pattern seeking and pattern recognition. During the second session (*From Liquid to Logic*), students transformed these data into formal SLETV models using substitution and elimination methods supported by graphical visualization in *Amplify Classroom*, thereby promoting the

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generalizing aspect of algebraic reasoning. The relationship among the learning syntax, STEAM elements, and algebraic reasoning indicators is presented in Table 5.

Table 5. Design of learning activity

Learning Activity	**Participants and Learning Tasks**	**STEAM Integration**	**Algebraic Reasoning Indicator**
Session 1: *Mixing Lab*	Driving Question and Project Design: Students design a beverage recipe, measure the quantities of raw ingredients (coffee, milk, and syrup), and discuss the initial production cost. Experimental data are entered into *Amplify Classroom*.	S (*Science*): Physical properties of the ingredient mixtures. T (*Technology*): Use of *Amplify Classroom* for real-time data entry. E (*Engineering*): Designing an appropriate beverage formulation by determining the optimal ingredient proportions. A (*Art*): Beverage presentation aesthetics, coffee menu naming, and color composition.	*Pattern Seeking*: Identifying patterns in the quantitative relationships among the raw ingredients and the total production cost.. *Pattern Recognition*: Recognizing patterns in the physical measurements and translating them into a mathematical model using three algebraic variables $(\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z})$.
Session 2: *From Liquid to Logic*	Monitoring Project Progress, Product Testing, and Reflection: Students solve the Systems of Linear Equations in Three Variables (SLETV) model derived from their beverage recipes, examine graphical visualizations of the solution in *Amplify Classroom*, and present the projected profit ratio of their coffee shop.	T (*Technology*): Simulation and graphical validation of the SLETV solution using *Amplify Classroom*.. M (*Mathematics*): Solving the SLETV model using algebraic operations to determine the values of the variables..	*Generalizing*: Formulating general rules from the solution of the system of equations to determine the unit cost of each ingredient and derive an overall profit-maximization strategy.

Table 5 presents the alignment between the learning activities, participant tasks, STEAM components, and algebraic reasoning indicators in the developed module. The learning design integrates contextual project activities with mathematical modelling and interactive digital learning through Amplify Classroom. The activities are systematically aligned with the progression of pattern seeking, pattern recognition, and generalizing, guiding students from exploring quantitative relationships toward constructing and formalizing generalized mathematical relationships.

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c. Development phase

The prototype teaching module was developed in accordance with the components of the National Curriculum, including the module identity, learning outcomes, learning objectives, meaningful understanding, guiding questions, PjBL activities, diagnostic, formative and summative assessments, reflection, as well as student worksheets and *Amplify Classroom* activities provided as appendices. Each Amplify Classroom activity was designed using the Computation Layer feature to provide automated feedback. The module was subsequently evaluated by two expert validators. The expert validation results are summarized in Table 6.

Table 6. Expert Validation Result

Assessment Aspect	**Expert 1**	**Category**	**Expert 2**	**Category**
Content Validity	95%	Highly Valid	90%	Highly Valid
Language Appropriateness	100%	Highly Valid	91%	Highly Valid
Presentation Quality	100%	Highly Valid	100%	Highly Valid
Media Quality	94%	Highly Valid	88%	Highly Valid
Overall Average	95%	Highly Valid	90%	Highly Valid

Table 6 shows that both experts classified the module as highly valid. The first validator recommended strengthening the science and arts components to achieve a more comprehensive STEAM integration and optimizing the *Amplify Classroom* feedback features. The second validator suggested incorporating reflection into each activity, integrating the student worksheets directly into the module, and adding graphical visualizations of SLETV. All recommendations were incorporated during the revision process.

d. Implementation phase

The module was implemented in Class XA of SMA Santa Maria Yogyakarta over three sessions. The first session involved the Mixing Lab activity, the second implemented the From Liquid to Logic activity, and the third was devoted to the post-test. Throughout the implementation, the researcher served as the facilitator, while the mathematics teacher acted as the classroom observer during the two instructional sessions. Students actively participated in hands-on beverage preparation, reflected positively on the authentic learning experience, and subsequently translated their practical experiences into formal mathematical models of SLETV. The implementation concluded with a post-test to evaluate students' algebraic reasoning ability.

e. Evaluation phase

Evaluation was conducted using both formative and summative approaches. Formative evaluation was carried out throughout the development process through expert validation and iterative revisions, whereas summative evaluation was performed after implementation by analyzing the post-test results and the practicality questionnaires.

Feasibility of the Teaching Module

The expert validation results demonstrated that the developed teaching module achieved a highly valid classification. In addition to validity, the module's

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practicality was also evaluated as a key quality criterion. Table 7 presents a summary of the practicality assessment based on students' responses.

Table 7. Practical Result based on Students Responses

Assessment Aspect	**Percentage**	**Category**
Ease of Following the Learning Process	70.3%	Practical
Clarity of Learning Materials and Media	86.9%	Highly Practical
Usefulness of Learning	82.3%	Highly Practical
Ease of Accessing the Media	85.9%	Highly Practical
Student Engagement and Learning Motivation	87.5%	Highly Practical
Overall Average	82.4%	Highly Practical

As shown in Table 7, students rated the teaching module as highly practical, with an overall average score of 82.4%. Student engagement and learning motivation obtained the highest score (87.5%), indicating that the barista project successfully stimulated students' enthusiasm. The clarity of the learning materials and media (86.9%) and the ease of accessing the digital media (85.9%) were also rated as highly practical. Although the ease of following the learning sequence received the lowest score (70.3%), it remained within the practical category.

The teacher practicality questionnaire yielded an average score of 82.5% (Highly Practical). The aspects of teacher instructions, student instructions, and learning media each achieved 87.5%, indicating that the module provided clear guidance supported by the effective use of *Amplify Classroom*. The implementation time and technical feasibility aspects each received 75% (Practical), suggesting that adjustments to the time allocation should be considered in future implementations.

Effectiveness of the Teaching Module in Enhancing Algebraic Reasoning

The effectiveness of the teaching module was evaluated using N-gain and an algebraic reasoning post-test designed according to the three indicators proposed (Herbert & Brown, 1997). The following results of the comparison of pretest and posttest are presented in Table 8.

Table 8. Comparison result of pretest and posttest

	Pretest	**Posttest**
Minimum Score	17	25
Maximum Score	83	97
Average	44	65
Standard Deviation	21.26	21.84

Table 8 presents a comparison of the pre-test and post-test results. The post-test results indicate an improvement in students' performance, with the mean score increasing from 44 to 65. N-gain calculation yielded a value.

$$g = \frac{\bar{X}_{posttest} - \bar{X}_{pretest}}{100 - \bar{X}_{prestest}} = \frac{65 - 44}{100 - 44} = 0.4$$

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Table 9. Algebraic reasoning score of pretest and posttest

Algebraic Reasoning Indicator	Pretest	Posttest
Pattern Seeking	64.3	78.1
Pattern Recognizing	42.9	84.4
Generalization	25.0	51.1
Classical Learning Mastery	17.8	71.4

Based on Table 9, the classical learning mastery rate reached 71.4%, exceeding the minimum criterion of 70%; therefore, the teaching module can be considered effective. All indicators of algebraic reasoning showed improvement, with the most significant increase observed in the pattern recognition indicator.

The development of the mathematics teaching module on topic SLETV integrated with *Amplify Classroom* adopted the ADDIE instructional design model (Rayanto & Sugianti, 2020), which has been recognized as an appropriate framework for the systematic and structured development of interactive digital learning media (Ruswendi et al., 2025). Responding to students' low levels of algebraic reasoning resulting from the predominance of lecture-based instruction (Putra et al., 2025), the module was designed by integrating the STEAM approach with the PjBL model through *The St. Mary's Barista Project*. Previous studies have demonstrated that the integration of PjBL and STEAM effectively bridges students' understanding of abstract mathematical concepts with authentic real-world problem-solving contexts (Aguilera & Ortiz-Revilla, 2021). Based on the product evaluation criteria, the module was judged to be highly valid by expert validators in terms of both content quality and the comprehensive integration of the five STEAM dimensions (Bancong, 2024).

From the perspective of practicality, the observation results and questionnaire responses indicated that the module was highly practical and user-friendly. Teachers reported that the teacher dashboard greatly facilitated real-time classroom monitoring, enabling immediate and targeted feedback and instructional interventions (Martinez-Maldonado et al., 2020). Meanwhile, students expressed high levels of motivation due to the authentic café simulation context embedded in the learning activities (Daryanto, 2013). The integration of technology enhanced the richness of students' learning experiences by providing more interactive and authentic learning opportunities. Technology-integrated STEAM instructional materials exhibit high levels of practicality and user engagement (Iriani et al., 2025).

A central finding of the study was the improvement in students' overall algebraic reasoning performance following implementation of the module. The mean score increased from 44 (SD = 21.26) in the pre-test to 65 (SD = 21.84) in the post-test, representing an increase of 20.91 percentage points and the normalized gain was 0.4. All indicator of algebraic reasoning also increases from pretest to posttest. The improvement can be interpreted in relation to the learning sequence embedded in the module, in which students moved from exploring quantities and relationships in a contextual situation to representing and formalizing them mathematically rather than relying exclusively on symbolic procedures. This progression allowed students to coordinate contextual, numerical, graphical, and symbolic forms of mathematical thinking. Consistent with (Schifter & Russell, 2022), student-generated representations can serve not merely to display mathematical

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ideas but as tools for investigating relationships and developing generalizations. In the present study, students' engagement with contextual data and digital representations may therefore have supported their transition from observing particular cases to recognizing mathematical relationships.

The findings suggest that the contribution of the module is better understood as an integrated instructional design rather than as the independent effect of STEAM, PjBL, or Amplify Classroom. This distinction is important because, although STEAM-PBL has been increasingly adopted, its integration with mathematics requires careful attention to ensure that mathematical objectives remain central (Diego-Mantecon et al., 2021). In the present study, the interdisciplinary and project-based activities were anchored in the development of algebraic reasoning through SLETV, with the project serving as a context for generating and formalizing mathematical relationships. Similarly, Amplify Classroom was embedded within the mathematical activities to support students' interaction with mathematical information and representations rather than merely distributing digital materials, consistent with the potential of digital technology to provide new forms of representation and inter (Engelbrecht & Borba, 2024; Weigand et al., 2024).

Conclusion and Suggestion

The STEAM activity-based teaching module developed in this study was highly relevant to students' learning needs. The module was designed based on a comprehensive needs analysis that reflected the actual conditions of mathematics instruction in schools. STEAM-based learning activities integrated with digital technology were intentionally designed to provide learning experiences that were aligned with students' characteristics and authentic learning contexts. All three algebraic reasoning indicators improved, with the largest increase occurring in pattern recognition, while generalizing remained the most challenging process. These findings suggest that an integrated sequence combining contextual exploration, mathematical representations, modelling, and interactive digital activities can provide favorable conditions for developing algebraic reasoning in SLETV learning.

Several aspects may be further improved to strengthen the implementation of mathematics instruction. First, students' mastery of prerequisite algebraic concepts should be reinforced before introducing SLETV, accompanied by additional practice to improve procedural accuracy. Second, technological infrastructure, particularly the stability of internet connectivity, should be enhanced to ensure the smooth implementation of technology-supported learning activities. Third, more responsive feedback features should be incorporated into *Amplify Classroom* to assist students in independently identifying and correcting procedural calculation errors.

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