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Development of an Interactive Google Sites-Based E-Module for Mathematical Literacy in Social Arithmetic

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Abstract: *This study aimed to develop an interactive Google Sites-based e-module on social arithmetic and examine its validity, practicality, and effectiveness in supporting junior high school students' mathematical literacy. This research employed a Research and Development (R&D) approach using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages. The study was conducted at SMP/MTs in Pemalang Regency during the 2025 academic year, involving 32 eighth-grade students in a limited trial. Data were collected through needs analysis questionnaires, expert validation sheets, student response questionnaires, and mathematical literacy tests. The validity of the product was assessed by material and media experts, while practicality was measured through student responses. Effectiveness was analyzed using pretest–posttest results, paired sample t-test, effect size, and N-Gain. The validation results showed that the e-module was highly valid, with a feasibility score of 92.5% from material experts and 90.3% from media experts. The practicality test showed a positive student response score of 89.6%, indicating that the e-module was easy to use, attractive, and helpful in understanding social arithmetic concepts. The effectiveness test showed an increase in students' mean score from 56.40 in the pretest to 78.25 in the posttest, with an N-Gain score of 0.52 in the moderate category. These findings indicate that the Google Sites-based interactive e-module is valid, practical, and effective in supporting students' mathematical literacy, particularly in interpreting contextual problems, formulating mathematical models, applying concepts, and communicating mathematical solutions.*

Keywords: *interactive e-module, google sites, mathematical literacy, social arithmetic, ADDIE.*

INTRODUCTION

Mathematical literacy is recognized as one of the essential competencies needed by students to face real-life challenges in the 21st century. In mathematics learning, students are expected not only to perform procedural calculations but also to interpret contextual situations, formulate mathematical models, apply concepts appropriately, and communicate solutions effectively. This competence is emphasized in the Programme for International Student Assessment (PISA), which defines mathematical literacy as an individual's ability to reason mathematically and apply mathematical concepts in various real-world contexts. Recent PISA findings indicate that Indonesian students' mathematical literacy achievement remains relatively low compared to the international average, particularly in solving contextual and real-life problem-solving tasks (OECD, 2023). One of the mathematics topics closely associated with contextual problem solving is social arithmetic, which includes concepts such as profit and loss, discounts, taxes, and simple interest.

Preliminary observations conducted in several SMP/MTs in Pemalang Regency revealed that many students still experienced difficulties in understanding and solving contextual social arithmetic problems. Based on interviews with mathematics teachers and classroom observations, students tended to focus on memorizing formulas without fully understanding the meaning of the problems presented. In addition, students often encountered difficulties in interpreting story problems, determining mathematical models, and connecting arithmetic concepts with real-life situations. Teachers also reported that learning activities were still dominated by conventional teaching methods and printed worksheets, while the use of interactive digital learning media remained limited. As a result, students' participation and motivation during mathematics learning activities were relatively low, especially when dealing with literacy-oriented questions.

The integration of digital technology into mathematics learning is increasingly important in supporting meaningful and student-centered instruction. Interactive learning media can facilitate independent learning, increase student engagement, and provide contextual learning experiences. One digital platform that has recently attracted attention in educational practice is Google Sites, which allows teachers to organize learning materials, videos, quizzes, and interactive activities into a flexible web-based environment. Google Sites is a web-based platform developed by Google that enables users to create simple websites and digital learning spaces without requiring coding skills. In educational contexts, Google Sites can be used as a class portal, a digital portfolio, a project page, or a structured space for organizing learning materials that can be easily accessed by teachers and students (Barros et al., 2024; Inga & Inga, 2022; Olivares & Sotomayor, 2022; Vivanco et al., 2023). As part of Google Workspace for Education, Google Sites can also be integrated with other Google tools, such as Google Drive, Google Classroom, Google Forms, and Google Meet, making it useful for managing resources, presenting content, and supporting collaboration in learning activities (Albós et al., 2023; Jaramillo-Benítez et al., 2020).

In mathematics learning, Google Sites can function as a digital learning platform that provides structured materials, examples, exercises, videos, interactive links, and formative assessments in one accessible learning environment. Teachers can embed dynamic mathematics tools such as GeoGebra, digital worksheets, PDF materials, and problem-solving activities to enrich students' mathematical representations and conceptual understanding (Olivares & Sotomayor, 2022; Sousa et al., 2022). Its application also supports both synchronous and asynchronous learning, improves access to learning resources, and encourages student engagement through reflection, discussion, and digital feedback activities (García et al., 2022; Vivanco et al., 2023).

Previous studies have demonstrated that Google Sites can support learning effectiveness and improve students' engagement. Research by Rahmawati et al. (2023) showed that Google Sites-based learning media improved students' learning motivation and accessibility in digital classrooms. Likewise, Prasetyo and Nugraheni (2022) reported that web-based interactive learning media contributed positively to students' conceptual understanding and participation during classroom activities. Other studies also revealed that Google Sites provides an accessible and attractive learning environment that supports flexible learning implementation in secondary education contexts. However, previous studies mostly examined Google Sites as a general instructional platform and were not specifically designed to improve mathematical literacy in social arithmetic learning. Research focusing on the development of interactive e-modules integrated with contextual literacy tasks for junior high school mathematics remains limited, particularly in the context of SMP/MTs students in Pemalang Regency. Therefore, this study

offers novelty by developing an interactive Google Sites-based e-module specifically designed to strengthen students' mathematical literacy through contextual social arithmetic activities aligned with literacy indicators such as interpreting problems, formulating mathematical models, applying arithmetic concepts, and communicating solutions. In addition, this study integrates interactive digital learning features with literacy-oriented exercises to support more meaningful mathematics learning experiences.

Based on the background above, this study aims to develop an interactive Google Sites-based e-module on social arithmetic and examine its feasibility and potential contribution to improving junior high school students' mathematical literacy. Specifically, this study seeks to design a digital learning module that integrates contextual social arithmetic problems, interactive learning activities, and accessible web-based features to help students interpret, apply, and communicate mathematical ideas in real-life situations.

The expected implication of this study is that the developed e-module can provide an alternative digital teaching material for mathematics teachers in creating more contextual, interactive, and student-centered learning experiences. In practical terms, the module is expected to support teachers in organizing learning materials, presenting contextual problems, providing guided exercises, and encouraging students' independent learning. In theoretical terms, this study is expected to enrich the discussion on the use of web-based learning platforms, particularly Google Sites, in strengthening mathematical literacy. Furthermore, the findings may serve as a reference for future researchers who intend to develop similar digital learning resources for other mathematical topics or broader educational contexts.

METODE

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a structured framework for developing educational products and evaluating their feasibility and effectiveness in classroom learning. This model has been widely applied in digital learning media development research due to its flexibility and systematic procedures in integrating instructional design, validation, implementation, and evaluation processes (Branch, 2009; Aldoobie, 2015).

The research was conducted at several SMP/MTs in Pemalang Regency involving eighth-grade students during the 2025 academic year. The participants consisted of 32 students selected using purposive sampling techniques based on recommendations from mathematics teachers and school considerations related to students' learning characteristics and accessibility to digital learning facilities. The study also involved two material experts and two media experts as validators. The material experts were lecturers and mathematics education practitioners with expertise in mathematical literacy and junior high school mathematics content, while the media experts specialized in educational technology and digital learning media development.

The ADDIE development procedure was carried out systematically through five stages: analysis, design, development, implementation, and evaluation. the research procedure can be seen in Figure 1.

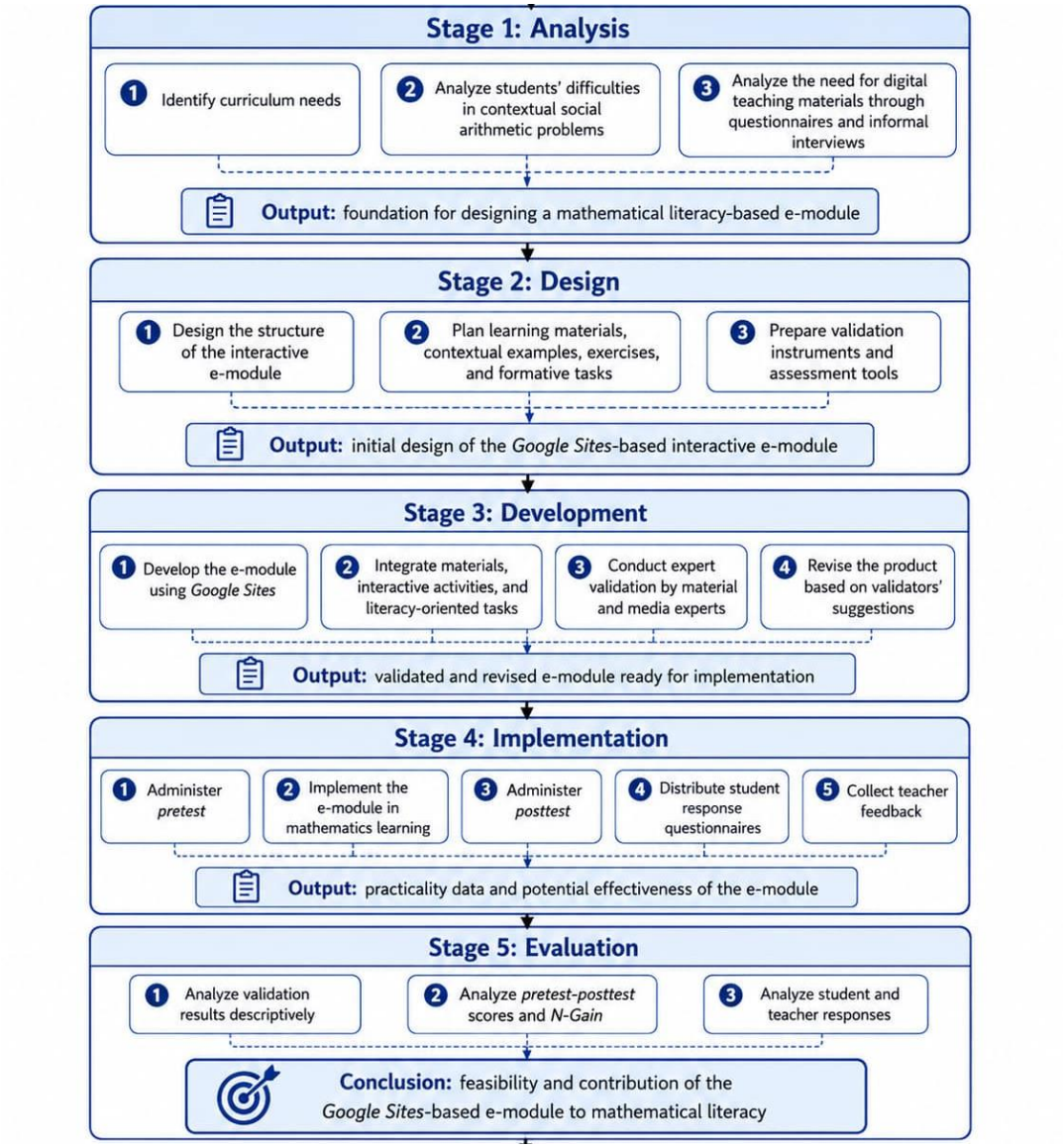


Figure 1. Research Procedure Flowchart

The first stage was analysis. At this stage, a preliminary study was conducted to identify students' learning difficulties, curriculum demands, and the need for digital learning media in mathematics learning. Data were collected through classroom observations, interviews with mathematics teachers, and student needs analysis questionnaires. The preliminary findings showed that many students experienced difficulties in interpreting contextual social arithmetic problems, determining mathematical models, and applying arithmetic concepts to real-life situations. Teachers also reported that existing learning resources were still dominated by printed worksheets and conventional explanations, while interactive digital learning media were rarely used in mathematics instruction. Similar findings have been reported in previous studies indicating that students' mathematical literacy skills in contextual mathematics problems remain relatively low and that digital learning innovation is needed to support more meaningful mathematics learning processes (OECD, 2023; Sari & Wijaya, 2023; Rahmawati et al., 2024).

The second stage was design. Based on the needs analysis results, the researcher designed the structure and learning components of the interactive e-module. The module framework included learning objectives, literacy-oriented materials, contextual problem-solving activities,

interactive examples, formative exercises, videos, quizzes, and evaluation tasks integrated into Google Sites. The mathematical literacy indicators used in the module referred to students' abilities to interpret problems, formulate mathematical models, apply concepts, and communicate solutions.

The third stage was development. During this stage, the interactive e-module was developed using Google Sites and validated by experts before implementation. The validation process involved material experts and media experts who assessed the module in terms of content suitability, language clarity, literacy orientation, instructional presentation, visual appearance, navigation, usability, and technical quality. The validation instruments used Likert-scale assessment sheets with five rating categories ranging from very poor to very good. The validation results indicated that the e-module achieved a feasibility score of 92.5% from material experts and 90.3% from media experts, both categorized as very feasible. Revisions were then carried out based on suggestions from validators before field implementation.

The fourth stage was implementation. The validated e-module was implemented in mathematics learning activities involving 32 eighth-grade students. Students completed a pretest before using the e-module and a posttest after the learning process to measure improvements in mathematical literacy skills. The implementation process was conducted during social arithmetic lessons using literacy-oriented contextual tasks integrated into the Google Sites platform.

The fifth stage was evaluation. Evaluation was conducted to analyze the feasibility, practicality, and instructional contribution of the developed e-module. Quantitative data were obtained from validation sheets, pretest–posttest scores, and student response questionnaires, while qualitative data were obtained from interviews and student reflections. Student responses toward the e-module reached an average score of 89.6%, indicating positive perceptions regarding usability, attractiveness, accessibility, and conceptual understanding.

Several research instruments were used in this study, including needs analysis questionnaires, interview guidelines, expert validation sheets, student response questionnaires, and mathematical literacy tests. The needs analysis questionnaire contained indicators related to learning difficulties, learning motivation, digital learning experiences, and students' needs for interactive media. The expert validation sheets assessed aspects of content quality, instructional design, visual communication, and technical usability. The student response questionnaire evaluated ease of use, visual attractiveness, learning motivation, and concept understanding. Meanwhile, the mathematical literacy test consisted of contextual social arithmetic problems designed according to literacy indicators.

The validity of the research instruments was examined through expert judgment conducted by mathematics education lecturers and educational technology experts. Instrument reliability was analyzed using Cronbach's Alpha coefficient. The student response questionnaire obtained a reliability coefficient of 0.87, indicating high reliability. The mathematical literacy test instrument was also analyzed for item validity, reliability, difficulty index, and discrimination index before implementation.

Data analysis was conducted using both qualitative and quantitative techniques. Qualitative data from interviews and observations were analyzed descriptively to identify students' learning needs and classroom conditions. Quantitative data from validation sheets and questionnaires were analyzed using percentage techniques and category interpretation criteria. The improvement of students' mathematical literacy skills was analyzed using normalized gain (N-Gain) scores with the following formula:

$$N\text{-}Gain = \frac{Posttest - Pretest}{Maximum\ Score - Pretest}$$

The N-Gain criteria used in this study were categorized as high (N-Gain > 0.70), medium (0.30 ≤ N-Gain ≤ 0.70), and low (N-Gain < 0.30). The analysis results showed an increase in the mean pretest score from 56.40 to the posttest score of 78.25 with an average N-Gain value of 0.52, indicating a moderate improvement in students' mathematical literacy skills after using the interactive e-module based on Google Sites.

RESULTS AND DISCUSSION

This study was conducted at several SMP/MTs in Pemalang Regency during the 2025 academic year, involving eighth-grade students as the subjects of limited implementation. The main purpose of this study was to develop an interactive Google Sites-based e-module on social arithmetic and to examine its feasibility, practicality, and potential contribution to improving students' mathematical literacy skills. the results of this research are presented as follows.

1. Result of Analysis Stage

The analysis stage was conducted to identify students' learning needs, learning difficulties, curriculum demands, and the availability of digital learning resources in mathematics classrooms. Data were collected through classroom observations, interviews with mathematics teachers, and student needs analysis questionnaires involving eighth-grade students from SMP/MTs in Pemalang Regency.

The findings showed that students experienced several difficulties in learning social arithmetic, especially in solving contextual problems related to daily life situations. Students often had difficulty interpreting information in word problems, determining appropriate mathematical models, selecting relevant formulas, and applying arithmetic concepts to real-life contexts such as profit and loss, discounts, taxes, and interest rates. Teachers also reported that students tended to memorize formulas without fully understanding the meaning of the problem situations.

In terms of learning resources, classroom instruction was still dominated by printed worksheets, textbooks, and conventional explanations. Interactive digital learning media were rarely used in mathematics learning. However, students showed greater interest in visual, interactive, and technology-based learning activities. Teachers also expressed the need for accessible digital teaching materials that could present contextual problems and guide students in developing mathematical literacy skills.

Table 1. Results of Needs Analysis

Aspect	Findings
Student difficulties	Students had difficulty interpreting contextual social arithmetic problems and formulating mathematical models.
Learning resources	Learning was still dominated by printed worksheets, textbooks, and conventional explanations.
Digital learning media	Interactive digital learning media were rarely used in mathematics learning.
Student learning motivation	Students showed higher interest in visual and technology-based learning activities.
Teacher needs	Teachers needed accessible and contextual digital teaching materials.

These findings indicate that students need learning resources that are not only digital and attractive, but also able to guide them in understanding contextual problems. Therefore, the development of an interactive Google Sites-based e-module was considered relevant to support mathematical literacy-oriented learning in social arithmetic.

2. Result of Design Stage

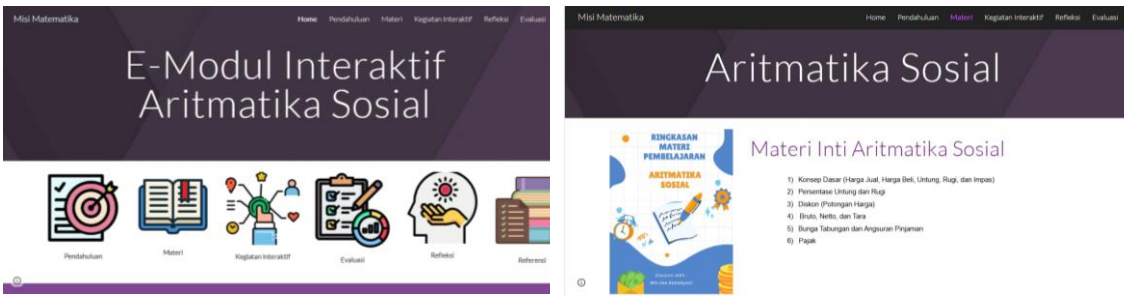
The design stage was carried out based on the findings of the needs analysis. At this stage, the researcher designed the structure, learning flow, content organization, and interactive components of the e-module. The e-module was designed to align with the social arithmetic topic and mathematical literacy indicators, including interpreting contextual problems, formulating mathematical models, applying mathematical concepts, and communicating mathematical solutions.

The Google Sites platform was selected because it is accessible, flexible, easy to operate, and allows the integration of various learning resources such as text, images, videos, Google Forms quizzes, guided exercises, and reflection activities. The design of the e-module emphasized contextual learning activities related to students' daily lives, such as shopping discounts, profit and loss in trading activities, taxes, and simple interest.

Table 2. Structure of the Google Sites-Based E-Module

Menu	Description
Homepage	Introduction and navigation instructions
Learning Instructions	Guidelines for using the e-module
Learning Objectives	Competencies and mathematical literacy indicators
Learning Materials	Social arithmetic concepts and explanations
Contextual Examples	Daily-life problem illustrations
Interactive Exercises	Guided literacy-oriented exercises
Formative Quiz	Online quiz integrated with Google Forms
Evaluation	Post-learning assessment
Reflection	Student self-reflection activities
References	Learning resources and references

The design of the e-module was intended to help students move gradually from understanding contextual situations to solving problems mathematically. Each learning activity was arranged to support students' active involvement, independent learning, and meaningful understanding of social arithmetic concepts. As for the product snippet produced, it can be seen in the following Image 2



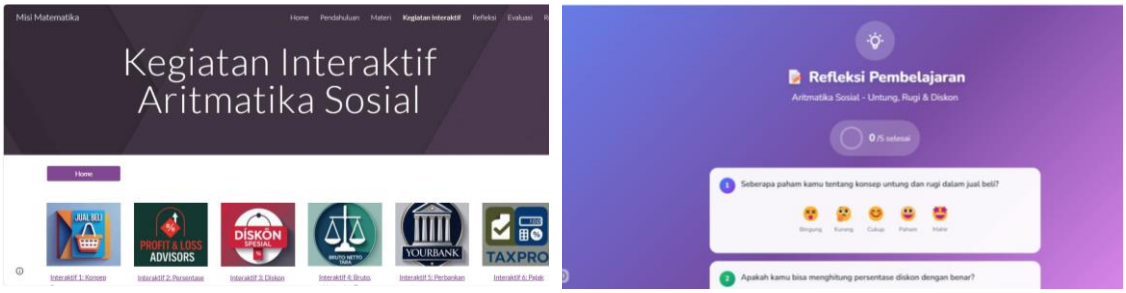


Figure 2. Display of Several Parts of The Google Sites-Based E-Module

3. Result of Development Stage

The development stage involved producing the Google Sites-based interactive e-module based on the previously prepared design. The e-module was developed by integrating social arithmetic materials, contextual examples, interactive exercises, formative quizzes, videos, and student reflection activities into the Google Sites platform.

After the initial product was completed, the e-module was validated by two material experts and two media experts. The material experts assessed content suitability, literacy orientation, language clarity, and instructional presentation. Meanwhile, the media experts assessed visual appearance, navigation, usability, and technical quality. The validation results by the material experts and media experts are presented sequentially in Tables 3 and 4.

Table 3. Material Expert Validation Results

Aspect Assessed	Mean Score	Percentage	Category
Content suitability	4.70	94%	Very Feasible
Literacy orientation	4.60	92%	Very Feasible
Language clarity	4.50	90%	Very Feasible
Instructional presentation	4.70	94%	Very Feasible
Average	**4.63**	**92.5%**	**Very Feasible**

Table 4. Media Expert Validation Results

Aspect Assessed	Mean Score	Percentage	Category
Visual appearance	4.55	91%	Very Feasible
Navigation	4.45	89%	Very Feasible
Usability	4.60	92%	Very Feasible
Technical quality	4.45	89%	Very Feasible
Average	**4.51**	**90.3%**	**Very Feasible**

The validation results showed that the e-module was categorized as very feasible by both material and media experts. The material expert validation score of 92.5% indicates that the content, language, learning presentation, and literacy orientation were appropriate for junior high school students. The media expert validation score of 90.3% indicates that the visual design, navigation, usability, and technical quality of the Google Sites-based e-module were suitable for classroom implementation.

Several revisions were made based on expert suggestions. These revisions included improving visual consistency, simplifying navigation, clarifying learning instructions, adding

contextual literacy problems, and adjusting the language to match students' cognitive level. After revision, the e-module was considered ready for limited classroom implementation.

4. Result of Implementation Stage

The implementation stage was conducted through a limited trial involving 32 eighth-grade students. The e-module was used during social arithmetic learning activities over four meetings. Students accessed the e-module using smartphones and available school computer facilities. The teacher acted as a facilitator, while students explored materials, completed contextual exercises, answered formative quizzes, and reflected on their learning.

The implementation procedure consisted of administering a pretest, introducing the Google Sites-based e-module, conducting contextual learning activities, facilitating guided discussions, administering a posttest, and collecting student response questionnaires. During the learning process, students were encouraged to interpret contextual problems, formulate mathematical models, apply arithmetic procedures, and communicate their solutions.

Students' mathematical literacy was measured using pretest and posttest assessments. The results are presented in Table 5.

Table 5. Pretest and Posttest Results of Mathematical Literacy

Test Type	N	Mean	SD	Minimum	Maximum
Pretest	32	56.40	8.21	40	72
Posttest	32	78.25	6.54	65	92

The results showed an increase in the mean score from 56.40 in the pretest to 78.25 in the posttest. This increase indicates that students demonstrated better mathematical literacy performance after learning with the Google Sites-based interactive e-module. The lower standard deviation in the posttest also suggests that students' scores became more consistent after the learning intervention.

To determine whether the improvement was statistically significant, a paired sample t-test was conducted after the data were found to be normally distributed based on the Shapiro–Wilk test.

Table 6. Paired Sample t-Test Results

Variable	t-value	Sig. (2-tailed)	Effect Size
Pretest–Posttest	12.47	0.000	1.21

The paired sample t-test result showed a significance value of 0.000, indicating a statistically significant difference between students' pretest and posttest scores. The effect size value of 1.21 indicates a strong instructional effect. These results suggest that the use of the Google Sites-based interactive e-module had a positive contribution to students' mathematical literacy achievement in social arithmetic.

5. Result of Evaluation Stage

The evaluation stage was conducted to examine the feasibility, practicality, and instructional contribution of the developed e-module. Evaluation data were obtained from expert validation results, student response questionnaires, pretest–posttest scores, N-Gain analysis, and student reflections.

The improvement in students' mathematical literacy was further analyzed using normalized gain. The N-Gain result is presented in Table 7.

Table 7. N-Gain Analysis Result

Indicator	Mean N-Gain	Category
Mathematical Literacy Improvement	0.52	Moderate

The N-Gain score of 0.52 indicates a moderate improvement in students' mathematical literacy. This means that the e-module provided a meaningful contribution to students' learning progress, although the improvement was not yet in the high category. This result is reasonable because mathematical literacy requires students to develop several complex abilities, including understanding contextual situations, translating problems into mathematical models, applying concepts, and explaining solutions logically.

Student responses were also analyzed to evaluate the practicality and attractiveness of the e-module.

Table 8. Student Response Questionnaire Results

Aspect Evaluated	Mean Score	Category
Ease of Use	3.58	Very Good
Learning Motivation	3.62	Very Good
Concept Understanding	3.55	Very Good
Visual Attractiveness	3.70	Very Good

The student response results indicate that the e-module was perceived positively by students. The highest score was obtained in the aspect of visual attractiveness, indicating that students found the e-module visually appealing. The aspects of ease of use, learning motivation, and concept understanding were also categorized as very good. These findings show that the e-module was practical, accessible, and helpful for students in understanding social arithmetic concepts.

The evaluation results also showed that the e-module supported the development of mathematical literacy indicators. First, the contextual examples helped students interpret information from real-life problem situations. Second, the guided exercises encouraged students to formulate mathematical models from word problems. Third, the interactive activities and quizzes supported students in applying social arithmetic concepts such as discounts, profit and loss, taxes, and interest. Fourth, the reflection and discussion activities encouraged students to communicate their reasoning and conclusions more clearly.

Overall, the evaluation stage confirmed that the Google Sites-based interactive e-module was feasible, practical, and had positive potential to support students' mathematical literacy in social arithmetic learning. However, the findings should be interpreted carefully because the implementation was conducted in a limited trial with a relatively small sample and without a control group. Therefore, further research involving larger samples, longer implementation periods, and experimental designs is needed to examine the effectiveness of the e-module more comprehensively.

The findings of this study indicate that the Google Sites-based interactive e-module has positive potential to support students' mathematical literacy in social arithmetic. This contribution can be explained through four main indicators of mathematical literacy: interpreting contextual problems, formulating mathematical models, applying mathematical concepts, and communicating mathematical solutions. These indicators are consistent with the mathematical literacy framework that emphasizes students' ability to formulate, employ, and interpret

mathematics in various real-life contexts. In the context of social arithmetic, mathematical literacy is not limited to calculating discounts, profit and loss, taxes, or simple interest, but also involves understanding the situation, identifying relevant information, selecting appropriate mathematical strategies, and explaining the solution logically.

First, the e-module supports students' ability to interpret contextual problems by presenting social arithmetic tasks in familiar daily-life situations. Problems related to shopping discounts, business profit and loss, taxes, and savings interest allow students to connect mathematical ideas with social and economic activities they may encounter in real life. This contextual orientation is in line with the concept of mathematical literacy and letramento matemático, which emphasizes the use of mathematics to understand and respond to social situations (Arruda et al., 2020; Costa et al., 2022; Gomes & Bernardi, 2022; Olgin, 2022). Through contextual examples, students are guided to identify known information, determine what is being asked, and understand the meaning of the problem before applying procedures.

Second, the e-module supports the ability to formulate mathematical models. One of the main difficulties found in the analysis stage was students' tendency to memorize formulas without being able to translate word problems into mathematical representations. The guided exercises in the Google Sites-based e-module help students gradually transform verbal information into mathematical models, such as equations, percentage relationships, tables, or calculation procedures. This is relevant to D'Ambrósio's idea of mathemacia, which highlights the importance of using mathematics as a tool to interpret signs, construct models, and make decisions in everyday life (Arruda et al., 2020; Gomes & Bernardi, 2022). Thus, modeling activities in the e-module help students move from informal understanding toward more structured mathematical reasoning.

Third, the e-module facilitates students' ability to apply mathematical concepts through interactive exercises, formative quizzes, and immediate feedback. These features encourage students to use social arithmetic concepts in varied contexts rather than merely repeat routine procedures. The integration of tables, visual illustrations, calculation steps, and digital quiz features enables students to check their understanding and revise errors during the learning process. Such iterative problem-solving activities are important because mathematical literacy requires students not only to know formulas but also to employ mathematical concepts appropriately in contextual situations. Previous studies also emphasize that contextual tasks, problem formulation, and modeling activities can strengthen students' conceptual understanding and mathematical literacy (Santos, 2020; Costa et al., 2022; Samá & Silva, 2020).

Fourth, the e-module encourages students to communicate mathematical solutions. Communication is an important component of mathematical literacy because students need to explain their reasoning, justify their strategy, and present conclusions in understandable forms. Through reflection activities, guided questions, discussion, and written responses, students are encouraged to express their mathematical thinking using words, symbols, tables, and visual representations. The ability to communicate solutions in multiple forms is emphasized in mathematics education literature, particularly in problem formulation, modeling, and exposition-oriented learning (Costa et al., 2022; Samá & Silva, 2020; Santos et al., 2024). Therefore, the increase in students' mathematical literacy scores after using the e-module can be interpreted as the result of learning activities that systematically trained students to interpret, model, apply, and communicate mathematics in social arithmetic contexts.

The findings of this study are strongly supported by social constructivist learning theory. Social constructivism views learning as an active process in which students construct knowledge

through interaction with meaningful contexts, peers, teachers, and learning tools. In this study, the Google Sites-based e-module provided a digital learning environment that enabled students to engage with contextual problems, receive guidance, discuss strategies, complete interactive exercises, and reflect on their understanding. This learning process is consistent with the social constructivist emphasis on context, collaboration, guided participation, and scaffolded problem-solving.

The role of scaffolding is particularly relevant in explaining how the e-module supports students' mathematical literacy. Students were not directly asked to solve complex social arithmetic problems independently. Instead, they were gradually guided through learning instructions, contextual examples, modeling prompts, interactive exercises, and formative quizzes. These elements function as scaffolds that help students move from initial difficulty toward more independent problem-solving. This is consistent with the idea of the Zone of Proximal Development, where students can achieve higher levels of understanding when appropriate support is provided by teachers, peers, or learning media. In this context, the e-module serves as a digital scaffold that supports students in interpreting problems, formulating models, applying concepts, and communicating solutions.

Furthermore, the interactive and asynchronous features of Google Sites support collaboration and peer discourse. Students can access learning materials repeatedly, complete tasks at their own pace, and engage in discussion or reflection activities. These features are aligned with active and investigative learning approaches, which emphasize student participation, exploration, justification, and problem-solving (Littig et al., 2020; Beltrán-Pellicer & Alsina, 2022; Freitas & Hartmann, 2022). Contextualized and feedback-rich digital environments also help students construct mathematical understanding through discourse, representation, and reflection (Arruda et al., 2020; Costa et al., 2022; Xavier et al., 2021; Santos et al., 2024).

In addition to social constructivism, cognitive load considerations also support the design of the e-module. A clear visual structure, simple navigation, concise instructions, and organized learning sequences help reduce unnecessary cognitive load so that students can focus on understanding mathematical ideas. However, the main theoretical foundation remains social constructivism because the e-module emphasizes meaningful contexts, guided learning, interaction, and communication. Some recent studies on technology-enhanced mathematics learning also show that digital tools do not automatically improve achievement unless they are supported by well-designed scaffolds, feedback, and meaningful learning activities (Cheng et al., 2024; Arruda et al., 2020). Therefore, the positive results of this study can be understood as the effect of combining digital media with contextual, guided, and socially meaningful learning processes.

The findings of this study are generally consistent with previous research showing that Google Sites-based learning media, interactive e-modules, and web-based mathematics learning resources can support students' engagement, conceptual understanding, and mathematical literacy. Previous studies have reported that contextual problems and interactive digital media can help students interpret mathematical situations, construct models, and apply concepts more meaningfully (Parameswari et al., 2023; Palanas & Palanas, 2022; Ke & Zhang, 2021; Lidiana & Sukestiyarno, 2023). The present study supports these findings because students showed improvement from pretest to posttest and gave positive responses to the e-module in terms of ease of use, motivation, conceptual understanding, and visual attractiveness.

This study is also in line with research on interactive e-modules and learning activity sheets that emphasize formative feedback, multimodal representation, and reflective communication.

Studies by Hiloma and Briones (2022), Espinas et al. (2022), Hafizah et al. (2024), and Wulandari et al. (2024) indicate that digital and interactive learning materials can improve students' conceptual understanding and communication when they are designed with structured tasks and feedback. Similarly, this study found that the integration of contextual examples, guided exercises, formative quizzes, and reflection activities helped students engage more actively with social arithmetic problems. The use of Google Sites as a web-based platform also aligns with blended and hybrid learning studies showing that digital tools can improve student engagement and learning outcomes when used to organize materials, activities, and communication (Kumar et al., 2021; Denton, 2023).

However, this study also differs from previous studies in several ways. Many earlier studies positioned Google Sites mainly as a platform for presenting learning materials, assignments, or digital resources. In contrast, the present study developed Google Sites as an interactive e-module specifically oriented toward mathematical literacy indicators. The product was not only designed to deliver content but also to guide students through the processes of interpreting contextual problems, formulating mathematical models, applying social arithmetic concepts, and communicating solutions. This distinction strengthens the contribution of the study because the e-module was developed with a specific pedagogical orientation rather than merely as a digital repository.

The findings also need to be interpreted with attention to several nuances found in previous literature. Some studies have shown that the effectiveness of web-based modules may be influenced by access to devices, internet quality, students' digital skills, and the quality of instructional scaffolding (Pahriah et al., 2024; Parameswari et al., 2023). In addition, the impact of technology-enhanced learning may vary depending on the learning domain, feedback design, and level of student support (Cheng et al., 2024; Arruda et al., 2020). Therefore, although the findings of this study are consistent with previous research, the moderate N-Gain result suggests that the e-module still needs broader testing and further refinement to produce stronger and more generalizable evidence.

The results of this study have practical implications for mathematics teachers, schools, and digital learning media developers. For mathematics teachers, the Google Sites-based e-module can be used as a structured tool for contextual problem-solving and mathematical modeling. The e-module helps teachers present social arithmetic not merely as formula-based calculation but as a set of real-life problems requiring interpretation, representation, justification, and communication. Teachers can use the e-module to provide differentiated guidance according to students' needs, especially by using examples, guided exercises, and feedback as scaffolds within students' Zone of Proximal Development (Faisyal et al., 2023; Marsitin & Sesanti, 2023; Romafilani et al., 2024).

For schools, this study shows that Google Sites can be developed as a practical and accessible platform for strengthening literacy-based mathematics learning. Schools can use similar e-modules as part of digital learning innovation, especially because Google Sites allows the integration of text, video, quizzes, links, and student reflection in one learning space. The platform can also support asynchronous learning, collaboration, and formative assessment across different student groups. However, school support is needed in the form of internet access, device availability, teacher training, and policies that encourage the development of digital learning resources (Parameswari et al., 2023; Denton, 2023; Yaniawati et al., 2022; Maharani et al., 2023).

For media developers, the study provides an example of how ADDIE-guided development can be used to design digital mathematics learning products systematically. Developers should

not only focus on visual appearance or technological features but also on pedagogical alignment, contextual relevance, problem-posing prompts, modeling activities, multimodal communication, and evaluation mechanisms. Validation results, student responses, pretest–posttest scores, and N-Gain analysis are important evidence to demonstrate the feasibility and instructional potential of digital learning products (Faisyal et al., 2023; Marsitin & Sesanti, 2023; Arthamevia et al., 2022; Nopriana et al., 2023). Thus, the e-module developed in this study can serve as a reference for designing other literacy-oriented mathematics learning media.

Theoretically, this study strengthens the view that mathematical literacy can be supported through the integration of digital technology, contextual learning, guided modeling, and reflective communication. The findings suggest that digital media are more meaningful when they are designed not only to deliver content but also to structure students' thinking processes. Therefore, Google Sites-based e-modules can contribute to mathematics education by providing an accessible digital environment for developing students' reasoning, modeling, and communication skills.

Although the findings show that the Google Sites-based interactive e-module is feasible, practical, and has positive potential to support students' mathematical literacy, this study has several limitations. First, the implementation involved only 32 eighth-grade students in a limited trial. This relatively small sample size limits the generalizability of the findings to broader student populations. Second, the study did not use a control group. Therefore, although the pretest–posttest results showed improvement, the increase cannot be fully attributed to the e-module alone. Other factors, such as teacher guidance, students' prior knowledge, classroom interaction, and repeated exposure to similar tasks, may also have influenced the results.

Third, the implementation duration was limited to four meetings. Mathematical literacy is a complex competence that requires continuous practice in interpreting problems, modeling situations, applying concepts, and communicating reasoning. Therefore, a short intervention period may not be sufficient to capture the long-term impact of the e-module on students' mathematical literacy development. Fourth, differences in students' digital skills, internet access, and device availability may have affected their learning experience. Previous studies have noted that access and equity issues can moderate the effectiveness of web-based modules and digital learning interventions (Pahriah et al., 2024; Parameswari et al., 2023).

Fifth, the developed e-module focused only on social arithmetic. Although social arithmetic is highly relevant to contextual problem-solving, the findings cannot automatically be generalized to other mathematics topics such as geometry, algebra, statistics, or probability. Future studies should test similar e-module designs across different topics and educational levels. In addition, further research should involve larger samples, control groups, longer implementation periods, and more diverse school contexts to examine the effectiveness of Google Sites-based interactive e-modules more comprehensively.

Overall, the results of this study indicate that the Google Sites-based interactive e-module developed through the ADDIE model is feasible, practical, and has positive potential to support students' mathematical literacy in social arithmetic. The feasibility of the product was supported by expert validation results, while its practicality was reflected in students' positive responses regarding ease of use, motivation, conceptual understanding, and visual attractiveness. The improvement from pretest to posttest, supported by the N-Gain result, also suggests that the e-module contributed positively to students' learning progress.

The contribution of the e-module can be understood through its design, which integrates contextual problems, modeling prompts, interactive exercises, formative quizzes, feedback, and

reflection activities. These components support the core processes of mathematical literacy: interpreting contextual situations, formulating mathematical models, applying mathematical concepts, and communicating solutions. This finding is consistent with literature emphasizing that mathematical literacy develops more effectively when students are engaged in meaningful, contextual, interactive, and reflective learning activities (Domínguez, 2023; Xavier et al., 2021; Santos et al., 2024).

Nevertheless, the findings should be interpreted proportionally because the study was conducted in a limited trial without a control group. Therefore, the e-module can be stated as feasible and promising for supporting literacy-based mathematics learning, but broader effectiveness claims require further empirical testing. Future research involving larger samples, experimental designs, longer implementation periods, and various mathematics topics is necessary to strengthen the evidence regarding the effectiveness of Google Sites-based interactive e-modules in improving students' mathematical literacy.

CONCLUSION AND SUGGESTIONS

This study developed an interactive Google Sites-based e-module on social arithmetic using the ADDIE development model. The results show that the developed e-module is valid, practical, and effective for supporting students' mathematical literacy. The validity of the e-module was indicated by the material expert validation score of 92.5% and the media expert validation score of 90.3%, both categorized as very feasible. The practicality of the e-module was reflected in students' positive responses, with an average score of 89.6%, indicating that the e-module was easy to use, visually attractive, and helpful in understanding social arithmetic concepts. The effectiveness of the e-module was shown by the increase in students' mean score from 56.40 in the pretest to 78.25 in the posttest, supported by an N-Gain score of 0.52 in the moderate category. These findings indicate that the Google Sites-based interactive e-module is valid, practical, and effective in a limited trial context for improving students' mathematical literacy, particularly in interpreting contextual problems, formulating mathematical models, applying mathematical concepts, and communicating solutions

Suggestions, based on the findings and limitations of this study, several suggestions are proposed for relevant educational stakeholders.First, mathematics teachers are encouraged to utilize interactive digital learning resources such as Google Sites-based e-modules to support contextual mathematics learning and improve students' mathematical literacy skills. The integration of literacy-oriented activities, contextual problem-solving tasks, and interactive exercises may help students engage more actively in mathematics learning and strengthen independent learning processes. Second, future researchers are recommended to conduct broader effectiveness testing involving larger sample sizes, control groups, and longer implementation durations in order to obtain more comprehensive evidence regarding the effectiveness of Google Sites-based interactive e-modules in improving mathematical literacy skills. Future studies may also explore the integration of adaptive learning systems, collaborative learning features, gamification elements, or the development of similar literacy-oriented e-modules for other mathematics topics and educational levels.

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