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Advancing mathematical representation abilities through scientifically-oriented contextual learning modules in junior secondary education

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Abstract

Background: Many students face difficulties in expressing mathematical ideas due to the absence of instructional materials that connect lessons with real-world contexts. Applying a contextual approach aligned with scientific inquiry may improve students' conceptual understanding and engagement.
Aims: This research seeks to develop and assess the effectiveness of contextual teaching modules designed using a scientific framework to strengthen the mathematical representation skills of junior secondary learners.
Methods: Adopting the ADDIE instructional design model, this study utilized a Research and Development (R&D) methodology involving 87 seventh-grade students from two Indonesian schools. Data collection included expert validation instruments, learner feedback surveys, and pretest-posttest measurements, with analysis based on validity, practicality, and effect size metrics.
Results: Expert evaluations confirmed high validity, with average ratings of 3.71 for content and 3.73 for media. Student feedback indicated high engagement across both trial groups (mean scores above 3.3). Effect size analysis showed substantial learning gains, with Cohen's d values of 0.82 and 0.96, indicating strong impact on students' mathematical representation ability.
Conclusion: The contextual modules developed through this study, when implemented with a scientific approach, were validated as effective tools for improving students' ability to represent mathematical concepts. These outcomes underscore the value of integrating contextual and inquiry-driven strategies into teaching practices to make abstract content more accessible and meaningful in mathematics education.

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INTRODUCTION

Mathematics contributes significantly to the growth of students' logical and analytical reasoning abilities. It supports learners in understanding complex patterns, solving problems, and making informed decisions in various contexts. However, many students encounter difficulties in internalizing mathematical concepts, especially when those concepts are presented abstractly. One of the major challenges lies in the students' inability to represent mathematical ideas through appropriate formats such as diagrams, graphs, or symbolic expressions. This lack of representational ability affects their overall comprehension and performance in mathematics. The disconnect between mathematical instruction and students' real-life experiences often contributes to this issue. When concepts are presented without meaningful context, students struggle to relate them to practical applications. This situation underscores the need for instructional strategies that bridge abstract theory with everyday reality (Alam & and Mohanty, 2023; Fantinelli et al., 2024).

Contextual learning has emerged as a promising educational strategy to address these challenges. It emphasizes the relevance of content by linking mathematical ideas to familiar, real-world scenarios. Through this approach, students are encouraged to draw connections between what they learn in the classroom and their lived experiences. Contextual learning does not only improve

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comprehension, but also promotes motivation and engagement (Hwang & and Chang, 2023; Li et al., 2021). When students see the usefulness of mathematical knowledge in real life, they are more likely to participate actively and retain information longer. Moreover, it supports critical and reflective thinking as students apply knowledge in different settings. Contextual instruction aligns well with constructivist theories, which emphasize learning through active construction of meaning (Kritt & Budwig, 2022; Le & Nguyen, 2024). In this regard, contextual strategies are well suited to improve mathematical understanding among junior secondary learners.

Nevertheless, contextual learning alone may not fully cultivate the depth of understanding needed for mastering mathematical representation. Integrating it with a scientific approach further strengthens the learning experience by engaging students in systematic inquiry. A scientific approach in education involves stages such as observing phenomena, asking questions, collecting and analyzing data, drawing conclusions, and communicating findings. This process mirrors how knowledge is constructed in real-life scientific practice and encourages students to become independent thinkers. When applied in mathematics education, it allows students to explore problems in depth and develop their reasoning skills. As they progress through this inquiry cycle, students build stronger conceptual foundations. The synergy between contextual content and scientific processes makes the learning environment richer and more authentic. Thus, combining both approaches is key to addressing the representation gap in mathematics (Bakker et al., 2021; Ziatdinov & Valles, 2022).

However, implementing such instructional innovations faces several barriers, especially at the classroom level. A significant number of teachers lack adequate training or resources to design and deliver lessons that embody contextual and scientific principles (Akuma & Gaigher, 2021; Darling-Hammond et al., 2024). As a result, traditional lecture-based methods remain dominant, often relying on memorization and procedural practice. Additionally, many existing teaching materials are not designed to facilitate deep understanding or active student engagement. These resources tend to focus on presenting rules and formulas, without encouraging exploration or conceptual thinking. The absence of suitable learning modules contributes to students' passive learning attitudes and weak representational skills (Al Mamun & Lawrie, 2023; Tong et al., 2021). Teachers need structured, practical, and pedagogically sound materials to support meaningful instruction. Addressing this issue requires deliberate efforts in instructional material development using evidence-based design frameworks.

One such framework is the ADDIE model, which offers a structured and iterative process for creating educational resources. The model includes five phases: Analysis, Design, Development, Implementation, and Evaluation, each ensuring alignment with learning objectives and student needs (Barthakur et al., 2022; Youhasan et al., 2021) In the analysis phase, the designer identifies the learning problems, target audience, and curriculum standards. The design phase focuses on selecting appropriate strategies and organizing content. Development involves creating and refining materials based on the design plan. Implementation allows for the actual use of materials in real classroom settings to observe student interactions. Finally, the evaluation phase measures effectiveness, identifies areas for improvement, and ensures quality control. This systematic approach ensures that learning modules are purposeful, relevant, and capable of addressing instructional gaps.

In this study, particular attention is given to the skill of mathematical representation, which is often underdeveloped yet crucial in mathematics education. Representation involves expressing mathematical ideas in multiple forms, including symbols, visual models, and written explanations (Munfaridah et al., 2021; Ünal et al., 2023). Students with strong representational skills can interpret and solve problems more effectively by switching between different modes of thinking. Unfortunately, most classrooms do not emphasize this skill explicitly, and few teaching materials are designed to develop it systematically (Moon et al., 2024; Stieff & DeSutter, 2021). By using contextual and inquiry-based approaches, educators can provide more opportunities for students to practice and refine their representational abilities. Through carefully structured modules, students are guided to visualize and articulate abstract ideas clearly. This targeted intervention is particularly needed at the junior secondary level. Therefore, the development of materials that focus on this skill is timely and significant.

Junior secondary students represent a key group in the development of mathematical literacy. At this stage, learners begin transitioning from concrete operational thinking to more abstract reasoning, making it a critical period for reinforcing conceptual understanding (Hurrell, 2021; Saracho, 2023). If foundational skills like representation are not properly developed during this phase, students may face greater challenges in higher-level mathematics. Research has shown that students benefit from instructional tools that are both interactive and contextually relevant. Well-designed learning modules that incorporate real-life examples and encourage scientific thinking can address these needs effectively. Moreover, using visual aids and hands-on activities helps reinforce abstract ideas. Such materials not only support comprehension but also foster a more positive attitude towards mathematics. This highlights the importance of designing instructional interventions suited to the developmental stage of learners.

In conclusion, the persistent challenges in mathematics education—particularly those related to students' difficulty in representing abstract concepts—demand innovative solutions. Contextual learning combined with a scientific approach has shown great potential in addressing these challenges by promoting active engagement and meaningful learning. However, the lack of suitable, research-based teaching materials continues to hinder effective implementation (Ahmed et al., 2024; Petraki & and Khat, 2022). By employing a structured model like ADDIE, educators can systematically develop and evaluate instructional modules that are aligned with both curriculum goals and student needs. Focusing on mathematical representation as a core outcome addresses a specific yet critical aspect of mathematics learning. This study aims to fill that gap by producing and validating contextual-scientific modules designed for junior secondary students. The insights from this research may contribute to improving instructional practices and enhancing mathematics education at broader levels.

Contextual and scientific approaches have been widely shown to enhance mathematics learning. Mahmuti et al. (2025) confirmed that real-world contexts improve student achievement, while Firmansyah et al. (2025) found digital contextual modules effective for boosting confidence and problem-solving. Abd Rahman et al. (2024) reported that GeoGebra-assisted learning raised higher-order thinking, supported by Rachmadina et al. (2021) through Powtoon-based videos. Ethnomathematical contexts were used by Pramulia et al. (2025) and Pathuddin et al. (2023) to build numeracy skills, while Otis et al., (2025) applied cultural heritage in geometry. Disaster-linked math was studied by Johar et al., (2025) and Ismail et al., (2024) focused on context-based HOTS assessment. Spooner, (2024) used modeling to link differential equations to real situations. Vinogradova et al., (2024) emphasized contextual learning in agriculture and Ernesto et al., (2022) connected physiology with civic themes. de Andrade et al., (2022) used engineering contexts to develop critical thinking. Validation of contextual modules was done by Hasanah et al., (2025) and Indrapangastuti et al., (2021). Perspectives on contextual STEM were explored by Pathoni et al., (2022), Nariman (2021), and Haigler (2021), while Dilla & Turpin (2021) reviewed contextual problem-solving in STEM.

While prior research has demonstrated the benefits of contextual and scientific learning strategies in mathematics, much of it emphasizes general outcomes such as academic performance, motivation, or problem-solving. There is limited focus on enhancing students' mathematical representation skills, which are vital for expressing mathematical ideas through visual, symbolic, or diagrammatic formats. Additionally, although models like ADDIE have been used in instructional design, few studies apply this model specifically to develop modules targeting representational ability. Existing studies also tend to concentrate on primary or higher education levels, leaving a gap at the junior secondary stage, where foundational mathematical reasoning is still forming. This study aims to bridge that gap by designing and validating a contextual-scientific module tailored to improving mathematical representation among seventh-grade students using a structured development framework.

This study is intended to create and assess a contextual mathematics module that incorporates a scientific approach and follows the ADDIE development model. The focus is to strengthen students' ability to represent mathematical ideas in varied forms, such as equations, graphs, and diagrams. The study evaluates the module based on its validity (expert judgment), practicality (student response), and effectiveness (learning outcomes through pretest and posttest).

METHOD

Research Design

This study employed a Research and Development (R&D) approach aimed at designing, developing, and evaluating an educational product that meets the criteria of validity, practicality, and effectiveness (Sugiyono, 2020). The development model used was the ADDIE model, a structured and interactive framework introduced by Dick and Carey, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase provides systematic guidelines to ensure the production of high-quality instructional materials. The procedural steps of the ADDIE model are illustrated in Figure 1.

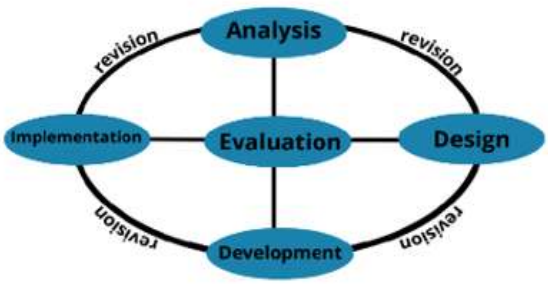

Figure 1. Stages in ADDIE

The first stage is the Analysis phase, which involves needs analysis, curriculum analysis, and learner characteristics analysis as the foundation for developing contextual learning materials. The second stage is Design, where the results of the analysis phase serve as the basis for constructing the instructional design. Activities in this phase include organizing the content framework, designing the presentation of materials, and developing the necessary instruments.

The Development stage is focused on producing the actual learning materials based on the prior design (Slamet, 2022). This stage aligns with the design phase, involving the creation of the instructional product followed by expert evaluation for revision and refinement. The expert validation process is assessed using four different evaluation criteria. These validation criteria are presented in Table 1.

Table 1. Expert Validation Answer Categories

Answer Categories	Score Criteria
Not Good	1
Less Good	2
Good	3
Very Good	4

Next, it is changed into a statement to determine the module's eligibility. The eligibility criteria can be seen in the table below:

Table 2. Expert Validation Eligibilty Criteria

Answer Categories	Score Criteria
3,26 < x̄ ≤ 4,00	Valid
2,51 < x̄ ≤ 3,26	Fairly Valid
1,76 < x̄ ≤ 2,51	Less Valid
1,00 < x̄ ≤ 1,76	Invalid

After the validation process and once the product was deemed feasible/valid by the experts, the next step was to conduct a trial involving students to gather their responses regarding the attractiveness of the product. The Implementation stage refers to the trial phase in real classroom conditions, where the validated product was tested during mathematics instruction. This trial aimed to evaluate students' responses to the product's appeal and its effectiveness in enhancing their mathematical representation skills. The scoring rubric for student response questionnaires is presented in the table below:

Table 3. Interesting Answer Categories

Answer Categories	Score Criteria
Not Attractive	1
Less Interesting	2
Interesting	3
Very Interesting	4

Next, convert it into a statement to determine the attractiveness of the module. The criteria can be seen in table 4 below:

Table 4. Attractiveness Response Criteria

Answer Categories	Score Criteria
3,26 < x̄ ≤ 4,00	Very Interesting
2,51 < x̄ ≤ 3,26	Interesting
1,76 < x̄ ≤ 2,51	Less Interesting
1,00 < x̄ ≤ 1,76	Not Attractive

To determine the effectiveness of the contextual teaching materials using a scientific approach in improving students' mathematical representation skills, the researcher employed Cohen's standard as outlined by Hake, using the effect size formula. The formula used is as follows:

$$d = \frac{(M_2 - M_1)}{SD_{polled}} \qquad SD_{polled} = \sqrt{\frac{SD_1^2 + SD_2^2}{2}}$$

Explanation:
D : Effect Size
M1 : Mean of the pretest
M2 : Mean of the posttest
SD_{pooled} : Pooled standard deviation
SD1 : Standard deviation of the pretest
SD2 : Standard deviation of the posttest

Find the standard deviation of the pretest and posttest, you can use the following formula:

$$SD = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}}$$

Explanation:
SD : Standard deviation
n : Number of students / data points
$\bar{x}$ *: Mean score of the students' test results*
x_i *: The i-th data point*

The criteria for the size of the Effect Size can be seen in the following table:

Tabel 5. Effect Size

Big d	Interpretation
0,8 ≤ d < 2,0	Big/tall
0,5 ≤ d < 0,8	Average (medium)

The evaluation stage is carried out at each stage where the evaluation stage will stop after the final assessment results have valid/feasible, interesting criteria so that they can be used in learning.

Participant

This research was conducted at one of the public junior high schools in Lampung and one of the public junior high schools in South Sumatra. The population of the study was 87 students in grade VII. Of that number, 29 students were included in the small group trial category and 58 students were included in the large group trial category.

Instruments

The instruments used in this study were expert validation assessment, student attractiveness response and effectiveness. Expert validation assessment was given to material experts and media experts to evaluate the suitability of design materials and media alignment. Attractiveness response was given to students using a questionnaire to assess the attractiveness of the product. Furthermore, effectiveness was used to see the improvement in mathematical representation ability through pretest and posttest.

Data Analysis

The analysis in this study was carried out to evaluate the contextual learning module in terms of its validity, practicality, and effectiveness, following the ADDIE development framework. To determine validity, assessments were conducted by content and media experts using a four-point Likert scale, and the average scores were interpreted to decide whether the module was appropriate for educational use. Practicality was measured through student feedback collected after the module's implementation, where the level of attractiveness was classified into several categories based on their average questionnaire responses. Effectiveness was assessed by comparing students' mathematical representation scores before and after the learning intervention, with calculations based on Cohen's effect size to quantify learning improvement. Interpretation of effect size followed standard thresholds: below 0.5 for low, between 0.5 and 0.8 for moderate, and above 0.8 for high effectiveness. Through this multi-faceted analysis, the study provided a clear picture of the module's quality and its relevance for supporting mathematics learning at the junior secondary level.

RESULTS AND DISCUSSION

Results

The results of this research and development study conclude that the contextual learning materials designed using a scientific approach and developed through the ADDIE model effectively enhance the mathematical representation abilities of junior secondary school students. This study is in line with previous research indicating that the improvement in students' mathematical representation ability through Contextual Teaching and Learning (CTL) and Discovery Learning was classified as moderate, with students' attitudes toward these approaches generally considered adequate. The study indicated that both CTL and Discovery Learning models can be effectively used to improve students' mathematical representation skills. This research is also relevant to a study conducted by Rahmadanis Shafira et al., which concluded that all developed teaching instruments were declared valid, and the student worksheets (LKPD) were considered readable based on individual trial results. Both studies share the use of contextual approaches and the ADDIE model in developing educational products. However, the key difference lies in the focus: Shafira's team developed a syllabus, four lesson plans (RPP), and four LKPDs to assess mathematical communication skills, whereas the present study produced a learning module specifically aimed at improving mathematical representation skills.

- **Analysis Phase**
  In the analysis stage, the researchers examined the needs of students, the curriculum in use, and the learner characteristics at a public junior high school in Lampung and another in South Sumatra. The needs analysis, based on student interviews and questionnaires, revealed that neither teachers nor students had previously used contextual modules to support the learning process. Moreover, mathematics instruction had not been connected to students' daily experiences. Curriculum analysis was conducted to identify learning objectives and competencies, with both schools implementing the revised 2013 curriculum (K-13). The analysis of student characteristics was used to ensure the content of the contextual module matched the scientific approach and learner profile.
- **Design Phase**
  In the design phase, insights from the analysis stage were used to create the framework for the instructional module. Activities in this phase included structuring the module outline, designing the presentation of materials, and developing assessment instruments aligned with the learning objectives.
- **Development Phase**
  During the development stage, the contextual module was created using tools such as Canva and Microsoft Word. Once the module was completed, it underwent expert validation to identify areas for improvement. Feedback and suggestions from validators were then used to revise and refine the module until it met the required standards of quality. The results of expert validation from content specialists are presented as follows:

Table 6. results of assessment by material and media experts

No.	Assessment Indicators	Analysis	Validator		
			Expert 1	Expert 2	Expert 3
1.	Content Quality	$\sum score$	22	21	24
		Max Score	24	24	24
		x_i	3.6	3.5	4
		$\bar{x}$	3.7		
		Criteria	Valid		
2.	Accuracy of Coverage	$\sum skor$	15	13	16
		Max Score	16	16	16
		x_i	3.75	3.25	4
		$\bar{x}$	3.66		
		Criteria	Valid		
3.	Language	$\sum skor$	11	11	12
		Max Score	12	12	12
		x_i	3.66	3.66	4
		$\bar{x}$	3.77		
		Criteria	Valid		
Average			**3,71**		
Criteria			**Valid**		

No.	Assessment Indicators	Analysis	Validator		
			Expert 1	Expert 2	Expert 3
1.	Module Size	$\sum skor$	8	7	8
		Max Score	8	8	8
		x_i	4	3.5	4
		$\bar{x}$	3.85		
		Criteria	Valid		
2.	Module Cover Design	$\sum skor$	26	23	27
		Max Score	28	28	28
		x_i	3.71	3.28	3.85
		$\bar{x}$	3.61		
		Criteria	Valid		
3.	Language	$\sum skor$	72	58	72
		Max Score	72	72	72
		x_i	4	3.22	4
		$\bar{x}$	3.74		
		Criteria	Valid		
Average			**3,73**		
Criteria			**Valid**		

- **Implementation Stage**

After the product is validated through expert assessments of material, media, and religion so that suggestions and input are obtained. Then, researchers make revisions and improvements to the developed product to make it better. The results of the students' interest responses are as follows:

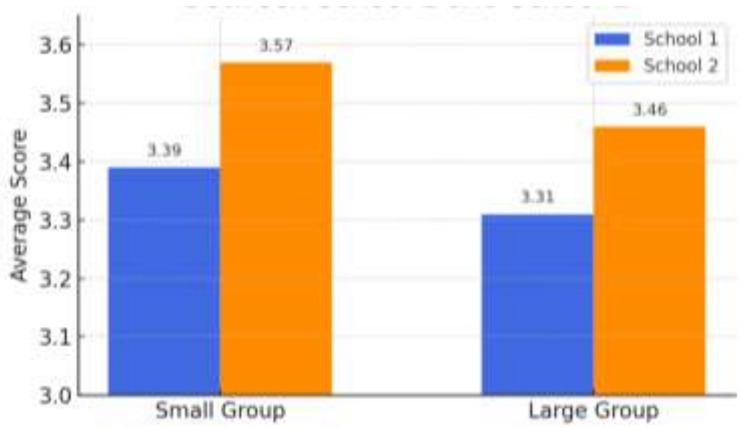

Figure 1. Comparison of Product Attractiveness Test Between School 1 and School 2

Figure 1 presents a comparison of the trial results between School 1 (a public junior high school in Lampung) and School 2 (a public junior high school in South Sumatra). The results show that the small-group trial in School 1 yielded a score of 3.39, while School 2 achieved a score of 3.57, both of which fall under the "very attractive" category. However, the small-group score was higher in School 2. In the large-group trial, School 1 scored 3.31 and School 2 scored 3.46, with both also categorized as "very attractive." Again, the large-group results were higher in School 2. Based on the attractiveness trials conducted in both schools—covering small- and large-group evaluations—the developed product was consistently rated as "very attractive." These findings indicate that the contextual learning module is engaging and suitable for classroom use. The following section presents the analysis of the product's effectiveness.

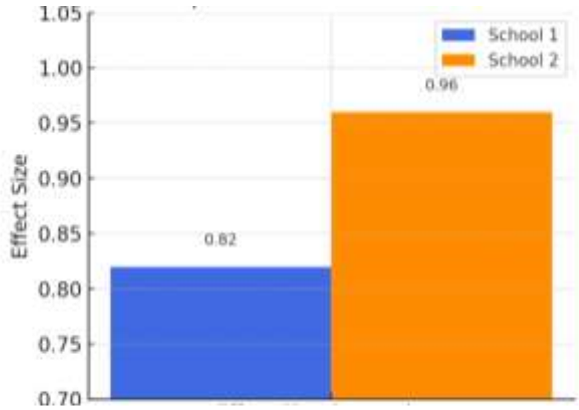

Figure 2. Comparison of Effect Size Test

Based on Figure 7, the calculated effect size was 0.82, categorized as "high," in the public junior high school in Lampung, and 0.96, also categorized as "high," in the public junior high school in South Sumatra. These results indicate that the contextual module developed using a scientific approach is effective for use in mathematics instruction.

- **Evaluation Stage**

The final phase of the ADDIE model is Evaluation. This stage is carried out continuously at each phase of development to identify and minimize errors or deficiencies, ensuring the quality of the product before final implementation.

Discussion

The development of contextual learning modules based on a scientific approach is a timely response to the ongoing challenges in mathematics education, particularly regarding students' ability to represent mathematical concepts. This study confirms that integrating real-life contexts with structured inquiry stages enables students to internalize abstract mathematical ideas more meaningfully. As observed in both research sites—SMP Negeri in Lampung and South Sumatra—students were previously unfamiliar with modules that encourage them to relate mathematics to their everyday lives. These findings echo the concerns raised by Hasanah and Retnawati (2022), who argued that the disconnect between students' real-world experiences and mathematical content contributes to low levels of motivation and performance.

In designing the module, the ADDIE framework proved highly effective in guiding the systematic development and evaluation process. From needs analysis to final evaluation, the model provided a clear structure that ensured the product was both relevant and pedagogically sound. The structured flow also supported ongoing revisions based on expert feedback. This aligns with the perspective of Pathoni et al., (2022), who emphasized that a rigorous instructional design model increases the validity and usability of educational resources. In this study, the module underwent validation by three experts, all of whom rated it as valid in terms of content accuracy, language clarity, visual design, and appropriateness for the target learners.

One of the most compelling aspects of this study is the significant positive response from students during the trial phase. In both small- and large-group trials, the module received ratings above 3.3 on a 4-point scale, categorized as "very attractive." This level of engagement is vital for fostering deeper cognitive processing and sustaining interest in learning. The findings are consistent with those of Rachmadina et al., (2021), who demonstrated that using Powtoon-based videos in mathematics classes increased student participation. Visual design, relevance to daily life, and student-centered language were crucial factors in attracting students' interest, further validating the design decisions made in this study.

The effectiveness of the developed module was further confirmed through statistical analysis using Cohen's d, which showed high effect sizes (0.82 in Lampung and 0.96 in South Sumatra). These values indicate a substantial improvement in students' mathematical representation skills. Such results are in line with the findings of Mahmuti et al., (2025), who reported moderate to high improvements in mathematical achievement when using contextual learning and discovery models. The added value of this study is the focus on representation skills—a competency often overlooked yet essential for mathematical reasoning and communication. Contextual learning, when implemented thoughtfully, does more than make math relatable—it builds a cognitive bridge between experience and abstraction.

This is exemplified in studies by Pramulia et al., (2025) and Pathuddi et al., (2023), who developed ethnomathematical materials that helped students understand cultural systems through a mathematical lens. Although this study did not specifically adopt an ethnomathematical theme, its focus on real-life contexts such as daily routines, household budgeting, and measurement in students' environments served a similar function—creating a meaningful framework for understanding abstract concepts. The scientific approach embedded in the module also played a critical role in shaping the learning experience. By encouraging students to observe, question, investigate, and conclude, the module activated deeper levels of inquiry and critical thinking. This mirrors the approach adopted by Johar et al., (2025), who applied contextual inquiry within the framework of disaster education. Their findings revealed that students became more engaged and retained concepts longer when learning was connected to significant and meaningful issues. This supports the dual role of context and inquiry in promoting not just understanding, but lasting impact.

While many contextual learning initiatives target motivation or general achievement, this study addresses the underrepresented area of mathematical representation. As Spooner (2024) illustrated in his study on differential equations, modeling and contextualization significantly improved students' conceptual grasp. Likewise, Dilla and Turpin (2021) highlighted the importance of problem representation in STEM learning but noted that many curricula still lack targeted instruction in this area. The current study contributes directly to this gap by designing, implementing, and evaluating a module focused solely on representational skills.

In addition, this research underscores the importance of tailoring instructional materials to the developmental stage of learners. The transition from concrete to abstract thinking in junior secondary students requires thoughtful scaffolding. As noted by Vinogradova et al., (2024), when materials are aligned with students' cognitive and contextual realities, they become more motivated and engaged. The present study achieved this by embedding relatable problems and activities that students could visualize and discuss, thereby supporting both cognitive and emotional engagement.

The findings also have implications for broader educational design, especially in STEM fields. Nariman (2021) emphasized that industry-aligned, problem-based learning increased career interest among underrepresented students. Similarly, Haigler (2021) advocated for aligning educational assessments with real workplace expectations. This study, while focused on school-level mathematics, contributes to that trajectory by demonstrating how real-life relevance and inquiry can serve as foundational strategies for preparing students not just academically, but for lifelong problem-solving. In conclusion, this research confirms that a scientifically grounded, contextually rich instructional module developed through the ADDIE model can significantly enhance mathematical representation skills. The study not only supports but also expands upon prior findings by researchers such as de Andrade et al., (2022) and Ernesto et al., (2022), who showed the value of real-world relevance in learning. By focusing on a specific cognitive skill within a structured development model, this research contributes to both theoretical understanding and practical advancement in mathematics education.

Implication

This study offers meaningful insights into how contextual learning, when integrated with a scientific approach, can significantly support students' ability to represent mathematical concepts in diverse forms. The structured use of the ADDIE model not only ensured that the module met the standards of validity and practicality, but also helped foster an engaging learning experience. The encouraging results from student trials suggest that learning materials grounded in everyday experiences and inquiry-based thinking are more likely to capture students' interest and deepen their understanding. These findings can inform teachers, curriculum designers, and education stakeholders seeking to transform mathematics instruction into a more relevant and student-centered process. In particular, the emphasis on representation skills adds value, as these abilities are often underdeveloped despite being critical for mathematical reasoning and communication. The success of this module also presents a framework that can be adapted for other topics and subjects to promote meaningful and active learning.

Limitations

While the outcomes of this research are promising, several limitations should be noted. The study was limited to two schools, which may affect how broadly the results can be applied to other educational settings. The number of students involved, although sufficient for a pilot test, may not reflect the full diversity of learners in different regions or academic contexts. Furthermore, the module was applied to one particular mathematical topic; its adaptability and effectiveness for other topics or across different grade levels were not assessed. The influence of additional factors—such as teacher delivery style, students' initial ability levels, and classroom dynamics—was not examined in depth, even though such variables could impact the outcomes. Also, the study did not include a long-term follow-up to observe the durability of the learning gains. Future research could expand the sample size, cover a broader range of content, and explore these external factors to gain a more comprehensive understanding of how such modules function over time and in various learning environments.

Suggestions

Based on the results and conclusions of this study, several suggestions are proposed for further development and application of contextual learning modules in mathematics education. First, teachers are encouraged to adopt and adapt context-based and inquiry-driven materials in their classrooms to enhance students' understanding and engagement, particularly in topics that involve abstract or complex representations. Providing training or workshops on the design and implementation of such modules may help educators integrate them more effectively into existing curricula. Second, future researchers are advised to extend this study by applying the developed module across different mathematical topics and educational levels to assess its adaptability and impact. It would also be valuable to explore how factors such as students' learning styles, prior knowledge, and teacher facilitation influence the success of contextual-scientific modules. Additionally, longitudinal studies should be conducted to determine whether improvements in representation skills are sustained over time. Finally, curriculum developers and policymakers should consider incorporating contextual and scientific approaches into national mathematics education standards. Emphasizing representation skills explicitly within curriculum objectives may guide the development of more effective learning tools and ensure that students are equipped with the competencies necessary for higher-order thinking and real-world problem-solving.

CONCLUSION

The results of this research and development indicate that the contextual teaching material, designed using a scientific approach and developed through the ADDIE model, which includes the five stages of Analysis, Design, Development, Implementation, and Evaluation. Fulfills the criteria of validity, practicality, and effectiveness for use in mathematics instruction. Based on expert evaluations, the contextual material achieved an average score of 3.71 from content experts and 3.73 from media experts, both falling under the "valid" category. Practicality tests showed that the module was easy to use and well-received by students, with a small-group trial score of 3.39 in the public junior high school in Lampung and 3.57 in the school in South Sumatra, both categorized as “very attractive.” In the large-group trials, the module received a score of 3.31 in Lampung and 3.46 in South Sumatra, again classified as “very attractive.” These findings are further supported by effectiveness data, with Cohen’s effect size scores of 0.82 in Lampung and 0.96 in South Sumatra, both indicating a high level of effectiveness.

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