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Development of contextual learning-based mathematics teaching modules on rational number materials

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Abstract

This research aims to develop a mathematics teaching module on rational number material for grade VII junior high school students that is valid, practical, and effective. This research is motivated by students' limited understanding of rational numbers and by the limitations of teaching materials that fail to connect the material to real-life contexts systematically. The research gap lies in the limited development of contextual modules that not only focus on validity and practicality but also comprehensively test effectiveness through statistical analysis. The novelty of this research lies in the development of a teaching module that integrates real-life contexts into each learning component in a structured manner and is equipped with an effectiveness analysis using statistical tests and N-Gain. The method used is research and development (R&D) with a 4D model, which includes the define, design, develop, and disseminate stages. The research subjects consisted of expert validators, teachers, and 23 grade VII junior high school students. The results of the study showed that the teaching module had an eligibility level of 76% (material experts) and 80% (media experts) with the feasible category, a practicality level of 90% (teachers) and 77.78% (students) with the very practical and practical category, and effectively improved student learning outcomes with an N-Gain value of 0.47 (medium category). Thus, this context-based teaching module is suitable as an alternative teaching material to improve students' understanding of rational numbers.

Keywords: rational numbers; contextual; teaching modules; math learning; 4D development.

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INTRODUCTION

Education plays a strategic role in shaping high-quality human resources capable of facing the challenges of the 21st century. One subject that significantly contributes to the development of logical, critical, and systematic thinking skills is mathematics. However, various reports indicate that students' mathematical literacy in Indonesia remains relatively low, especially in understanding concepts(OECD, 2023). The Program for International Student Assessment (PISA) data show that most students are still at basic levels of ability and are not yet able to apply mathematical concepts in real-life contexts (OECD, 2023).

One challenging material for students is rational numbers. This concept includes fractions, decimals, and percents, which are the basis for advanced material such as

algebra and comparison. Research shows that students often experience misconceptions in understanding the operation of rational numbers, especially in connecting symbolic representations with conceptual meanings (Hasanah, 2020). This difficulty affects students' low learning outcomes and weak mathematical problem-solving skills.

One indication of problems in the field is that students' mastery of learning is still below the expected criteria. Several preliminary studies show that many students have not yet achieved the minimum mastery level in subjects that require strong conceptual understanding. Learning processes that are still teacher-centered and dominated by lecture methods make students less active, resulting in a shallow understanding of the material that does not last long (Sari et al., 2024).

Nationally, similar problems have also been found in various studies. A study by Suharsono & Pratiwi (2022) shows that more than 60% of junior high school students have difficulty understanding the concept of fractions. In addition, other research found that students' low math skills were due to a lack of connection between the material taught and real-life contexts. This shows that mathematics learning remains abstract and less meaningful to students. To overcome these problems, a learning approach is needed that can relate mathematical concepts to students' real experiences. One of the recommended approaches is contextual learning, also known as Contextual Teaching and Learning (CTL). This approach allows students to build understanding through direct experience and real-life situations, making the concepts learned more meaningful (Johnson, 2020). Research shows that contextual approaches can significantly improve student motivation, engagement, and learning outcomes (Juniwati et al., 2020).

In addition to the learning approach, the availability of teaching materials also plays an important role in supporting learning success. Teaching modules are a form of teaching materials that can help students learn independently and systematically. Well-designed modules can improve understanding of concepts and facilitate more structured learning (Widodo, 2021). However, the reality is that many modules still have not optimally integrated contextual approaches. Some previous research has developed context-based modules, but most continue to focus on other subjects, such as algebra and geometry. Research on rational numbers is still very limited, especially at the junior high school level. In addition, most studies only assess aspects of validity and practicality, without examining in depth the effectiveness of modules in improving student learning outcomes.

Other relevant research was conducted by Sari et al. (2025), who developed a website-based mathematics learning media with contextual problems on the topic of SPLDV (System of Linear Equations in Two Variables). The results of their study showed very high validity across content, media, and effectiveness in improving students' contextual problem-solving abilities. Meanwhile, Adiastuty et al. (2025) developed an interactive e-module for arithmetic sequences and series in the Canva application, achieving expert validation from material and media experts and an N-Gain effectiveness score. Both studies confirm that the development of technology-based media and teaching materials, combined with a contextual approach, contributes to improving students' mathematical problem-solving abilities. Based on these findings, this research fills the existing research gap by developing a context-based teaching module on rational numbers that specifically integrates real-world problems into every learning component and comprehensively tests its effectiveness using N-Gain analysis (Nurjehan, 2024).

Based on this study, there are specific research gaps, namely: (1) there has not been much research that has developed contextual-based teaching modules specifically on rational number material; (2) the limitations of systematic integration of contextual problems in the teaching module; (3) the lack of research that comprehensively tests the effectiveness of the module through statistical analysis such as N-Gain; and (4) the lack of research based on field empirical data that shows the urgency of developing teaching materials.

The urgency of this research is further strengthened by the Independent Curriculum's emphasis on context-based, student-centered learning. Teachers are required to design learning that is relevant to students' real lives, making the learning process more meaningful. Without supporting teaching materials, this curriculum will not run optimally (Simarmata & Soesanto, 2023).

The novelty of this study lies in its departure from the previous study: the development of teaching modules based on contextual learning, specifically focused on rational number material, which is still rarely researched compared to other topics such as algebra and geometry. In addition, the modules developed systematically integrate real-life problems into each stage of learning, not just as additional examples. This research not only tests the validity and practicality but also comprehensively analyzes the effectiveness of the modules through statistical tests such as N-Gain and empirical field

data, indicating a low level of understanding of students' concepts. Thus, this research makes a new contribution to the development of mathematics teaching materials that are contextual, needs-based, and empirically tested to improve learning quality. Therefore, this study aims to develop a contextual learning-based mathematics teaching module on rational number materials.

METHODS

This research uses a 4D development model consisting of Define, Design, Develop, and Disseminate stages, but is limited to the Develop stage(Laurens & Laamena, 2020). Operationally, research procedures are carried out systematically, starting from needs analysis to product trials (Sugiyono, 2022).

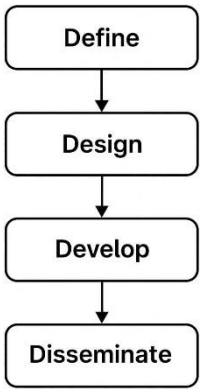


Figure 1. Steps of the 4D development model

At the Define stage, the researcher conducted an initial analysis of learning needs, student characteristics, and students' difficulties with rational number material through observation and interviews. This stage aims to collect empirical data as a basis for developing teaching modules that address field needs.

Stages Design It was carried out by designing an initial product in the form of a teaching module based on contextual learning. Activities at this stage include preparing the module structure, determining competencies, preparing materials, presenting contextual problems, and preparing research instruments such as validation sheets, questionnaires, and learning outcome tests. The module design is systematically arranged to support meaningful learning and aligns with students' characteristics.

The Develop stage is a product development stage that involves validation by one material expert and one media expert, both of whom are lecturers at Ma'arif University of Lampung. The learning practitioner is a mathematics teacher at Ma'arif 5 Metro Junior High School. Product revisions based on validator input, as well as limited student trials.

The students involved in the limited trial were 23 grade VII students from SMP Ma'arif 5 Metro, who were included in the small sample. The use of small samples in developmental research is justified because the primary purpose of R&D research is to test the feasibility and initial effectiveness of the product, not to generalize the population at large.

According to Creswell (2021), development research at the initial trial stage (limited trial) can use small samples to obtain preliminary data on product quality before large-scale trials are conducted. In addition, research by Hertzog (2020) indicates that a small sample size can still yield valid results in educational research when the analysis is appropriate, and the research is exploratory or developmental. The use of purposive sampling techniques also strengthens internal validity as subjects are selected based on characteristics relevant to the research objectives. Thus, the number of 23 students is considered adequate to test the practicality and initial effectiveness of the developed teaching modules.

Stages Disseminate was not carried out in this study due to limited time and a research focus on the development of valid, practical, and effective products. However, the resulting products still have the potential to be disseminated in future research(Istiningsih et al., 2020).

The data analysis technique in this study uses both qualitative and quantitative descriptive analyses. Qualitative descriptive analysis is used to process data in the form of comments, criticisms, and suggestions from validators, teachers, and students. Quantitative descriptive analysis is used to process assessment score data from validators, response questionnaires, and test results. The formula used to calculate the percentage of feasibility and practicality is:

$$\text{Percentage} = \frac{\text{Total score obtained}}{\text{Ideal maximum score}} \times 100\%$$

The criteria for interpretation of feasibility and practicality refer to the categories presented in Table 1.

Table 1. Eligibility and Practicality Interpretation Criteria

Percentage (%)	Categories
81% – 100%	Very Feasible / Very Practical
61% – 80%	Feasible / Practical
41% – 60%	Quite Feasible / Quite Practical
21% – 40%	Less Practical / Less Practical
0% – 20%	Not Feasible / Impractical

The table of eligibility and practicality interpretation criteria serves as a guideline for interpreting the results of expert validation and teacher and student responses to the developed teaching modules. With a clear range of percentages and categories, researchers can objectively assess product quality. In addition, this table simplifies decision-making regarding the revision or feasibility of using modules, making the analysis carried out more systematic, standardized, and easy to understand (Afifah et al., 2022). To measure the effectiveness of the teaching module, the N-Gain formula presented in Table 2 is used.

Table 2. N-Gain Formula

N-Gain value (g)	Categories
$g > 0.70$	Height
$0.30 \leq g \leq 0.70$	Medium
$g < 0.30$	Low

The N-Gain formula table serves as a guideline for measuring and interpreting the level of improvement in student learning outcomes before and after the use of teaching modules. The researcher can assess how effectively the module improves students' understanding of the material studied. In addition, this table provides a clearer, standardized picture of the quality of learning outcomes improvement, making it easier to conclude the success of using teaching modules in the learning process (Suandi et al., 2025).

A grid of research instruments was used during data collection to assess the quality of the contextual learning-based mathematics teaching module developed. The instruments used include aspects of validity, practicality, and effectiveness obtained from various data sources, namely material experts, media experts, teachers, and students, and presented in Table 3.

Table 3. Research Instrument Grid

No	Assessment Aspects	Data Source	Instruments	Number of Items
1	Validity of the Material	Material Expert	Subject Matter Expert Validation Sheet	10
2	Media Validity	Media Member	Media Expert Validation Sheet	12
3	Practicality	Math Teacher	Teacher Response Questionnaire	18
4	Practicality	Students	Student Response Questionnaire	18
5	Effectiveness	Students	Pretest-Posttest Tests	5

The table aims to provide a systematic overview of the types of instruments used in the research, the aspects measured, the data sources, and the number of statements or questions. With this grid, the data collection process becomes more directed and structured, to ensure that all important aspects in the development of teaching modules, namely validity, practicality, and effectiveness, can be measured comprehensively. In addition, this table clarifies the relationship between the research objectives and the instruments used, ensuring that the research results are more accurate and accountable (Kementerian Pendidikan Kebudayaan, 2023).

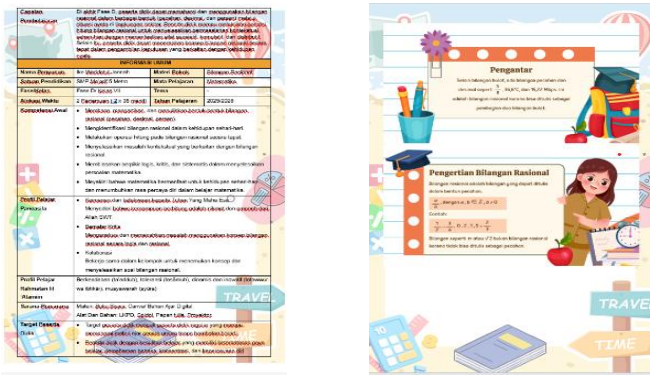
RESULTS AND DISCUSSION

The results showed that the mathematics teaching module based on contextual learning on rational number material met the valid, practical, and effective criteria, as shown by the validation results of subject matter experts (76%) and media experts (80%), teacher responses (90%), student responses (77.78%), as well as an increase in learning outcomes with an N-Gain value of 0.47 (medium category). These findings are consistent with constructivist theory, which states that effective learning occurs when students actively build knowledge through meaningful learning experiences. In the developed modules, students not only receive information but also engage in contextual activities such as problem-solving and reflection, thereby enabling independent knowledge construction (Schunk, 2020). The integration of the seven components of Contextual

Teaching and Learning in the module, namely constructivism, questioning, discovery, learning community, modeling, reflection, and authentic assessment, has been proven to have a positive impact on student engagement and understanding (Nainggolan et al., 2023).

Figure 2. Cover Design of Contextual Learning-Based Mathematics Teaching Module

This can be seen in the increase in students' average score from 61.83 to 79.43 and in the increase in learning completeness from 8.7% to 95.7%. These findings are in line with research by Aziz (2023), which states that contextual learning can improve understanding of mathematical concepts through real-world linkages (Azis, 2023).



(a) (b)

Figure 3. (a) Display of the Teaching Module; (b) Display of Module Content

From the aspect of validity, the results of the expert assessment show that the module has been in accordance with the characteristics of the students and the learning objectives. This indicates that the module's presentation of the material has considered the stages of cognitive development of junior high school students. The validation results from the subject matter experts are presented in Table 4.

Table 4. Material Expert Validation Results

No	Aspects	Number of Items	Scores Obtained	Max Score	Introduce yourself	Categories
1	Front Cover	2	7	10	70%	Worthy
2	Introduction	2	7	10	70%	Worthy
3	Material	4	15	20	75%	Worthy
4	Presentation	2	9	10	90%	Highly Worth It
Total		**10**	**38**	**50**	**76%**	**Worthy**

The validation results of the material experts showed that the mathematics teaching module based on contextual learning of rational numbers received a score of 38 out of 50 (76%) and was included in the feasible category. The highest aspect is the suitability of the material to grade VII and the learning objectives, each of which received a score of 5 (very feasible). The results of the validation of media experts are presented in Table 5.

Table 5. Media Expert Validation Results

Yes	Aspects	Number of Items	Scores Obtained	Max Score	Introduce yourself	Categories
1	Cover Quality	3	13	15	86,67%	Highly Worth It
2	Physical Design	2	6	10	60,00%	Quite Decent
3	Model Construction	4	17	20	85,00%	Highly Worth It
4	Writing Systematics	3	12	15	80,00%	Worthy
Total		**12**	**48**	**60**	**80,00%**	**Worth**

Media expert validation obtained a score of 48 out of 60, with 80% included in the feasible category. The highest aspects are found in the attractive cover design, the completeness of the module components, and the suitability of the structure with CTL, each of which received a score of 5 (very decent). This shows that the teaching module has an attractive design and structure that aligns with the contextual learning approach (Silalahi et al., 2024). According to the theory of cognitive development, students at the formal operational stage begin to think abstractly but still need concrete contexts to understand mathematical concepts (Mayer, 2020). Therefore, the use of real-life contexts in modules is an important factor in improving the understanding of the concept of rational numbers.

In terms of practicality, the high response rates of teachers (90%) and students (77.78%) indicate that the modules are easy to use, interesting, and support the learning process. This aligns with research (Hafijah, 2024) that shows that context-based teaching materials can improve teachers' ease in managing learning and increase student involvement. In addition, attractive visual displays and communicative language also contribute to increasing students' motivation to learn.

In terms of effectiveness, the increase in learning outcomes, with an N-Gain of 0.47, indicates that the module has a significant impact on student understanding. The results of the pretest and posttest for 23 grade VII students at SMP Ma'arif 5 Metro are presented in Table 6.

Table 6. Student Pretest and Posttest Results

Pretest	Posttest	N-Gain	Categories
6,83%	79,43	0,47	Medium

Analysis of pretest and posttest data showed a significant improvement in student learning outcomes after using contextual learning-based teaching modules. The average pretest score of 61.83 increased to 79.43 in the posttest, by 17.60 points, indicating a significant difference between the pretest and posttest scores. This shows that context-based teaching modules are effective in improving students' understanding of rational numbers.

N-Gain analysis shows an average increase of 0.47, placing it in the medium category. As many as 95.7% of students experienced an increase in the medium category and 4.3% in the high category. These results align with research that found that the use of context-based modules increased mathematical problem-solving ability in the medium category. Although the improvement is in the moderate category, it already shows that the contextual approach is effective in helping students understand mathematical concepts (Elbehary, 2024).

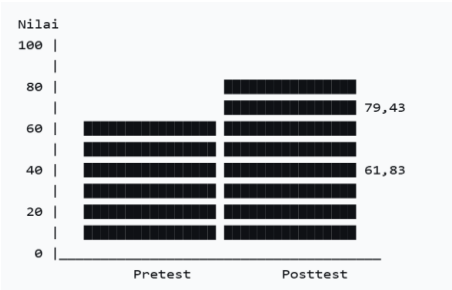


Figure 4. Pretest and Posttest Average Comparison Bar Chart

This finding aligns with the results of Adiastuty et al. (2025), who reported that an interactive Canva-based e-module improved students' mathematical problem-solving abilities, with an N-Gain score of 0.61 in the moderate category. This improvement occurs because the interactive and context-based module design helps students build understanding gradually through meaningful learning experiences. Furthermore, Sari et al. (2025) also proved that website-based learning media with contextual problems on SPLDV material achieved an excellent practicality level (82.82%) and an effectiveness rate of 77.01%. The similarity of results across these three studies indicates that integrating real-world contexts into media or teaching materials—whether in the form of websites, interactive e-modules, or printed modules—can consistently improve students' conceptual understanding and mathematical problem-solving abilities, particularly in abstract topics such as rational numbers, SPLDV, and sequences and series.

Cognitively, improvements in student learning outcomes can be explained by the schema activation mechanism. When students face contextual problems, they relate new information to experiences they already have. This process strengthens the cognitive structure and makes it easier to understand abstract concepts. According to information processing theory, meaningful learning occurs when new information is integrated with existing knowledge in long-term memory (Mayer, 2020).

In addition, improvements in the problem-solving aspects (understanding problems, planning, implementing, and re-checking) indicate the development of students' metacognitive abilities. The greatest improvement in re-checking indicates that students are beginning to get used to reflecting on the results of their work. This aligns with research (Ilhan, 2022), which indicates that reflective learning can improve students' metacognitive abilities and self-regulation.

From a learning motivation perspective, the use of real-world context in the module gives the material studied meaning, thereby increasing students' intrinsic motivation. This can be seen from the increased interest and participation of students during learning. According to motivational theory, the relevance of the material to real life is an important factor in increasing student engagement (Ryan & Deci, 2020).

Compared with previous research, this study has the advantage of a more systematic integration of context across the module's sections. Many previous studies only used

context as an additional example, whereas in this study, context is at the core of the learning process. This aligns with Johnson's (2020) view that contextual learning must place real experience at the center of learning.

However, the N-Gain value in the medium category shows that there is still room for improvement. This may be due to several factors, including limited implementation time, students' adaptation to new learning models, and relatively small sample sizes. In addition, students need time to adapt to learning approaches that demand higher liveliness and independence (Lestari, 2021).

Overall, this study's results show that context-based teaching modules can improve understanding of rational numbers through a meaningful, interactive, and real-world learning process. The integration of constructivist and CTL theories in the module significantly improves learning outcomes, student involvement, and the development of students' cognitive and metacognitive abilities.

CONCLUSION

Based on the results of the study and discussion, it can be concluded that the context-based mathematics teaching module on rational numbers for seventh-grade junior high school students that was developed meets the criteria for validity, practicality, and effectiveness. This is indicated by the results of material and media expert validations, which fall into the feasible category, as well as teacher and student responses that demonstrate a high level of practicality. In addition, the module has proven effective in improving student learning outcomes, as evidenced by an increase in average scores from pretest to posttest and an N-Gain value of 0.47 in the moderate category. These findings indicate that integrating the Contextual Teaching and Learning (CTL) approach can create meaningful learning experiences, enhance student engagement, and support the active construction of knowledge in accordance with constructivist principles.

However, this study has several limitations, including a relatively small sample size and a focus on a single class in a single school, which limit the generalizability of the findings. Furthermore, the short implementation period may have affected the optimal use of the module in the learning process. Therefore, future research is recommended to involve larger, more diverse samples, test the module across different mathematics topics, and integrate digital technology to enhance learning interactivity. Further studies may

also explore in greater depth the impact of the module on students' critical thinking skills, creativity, and independent learning.

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