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Development of a Guided Discovery-Based Scientific Approach Module for Enhancing Problem-Solving Skills

Hari Wantoro[a,1], Muhammad Misbahul Afandi[b,2], Deny Hadi Siswanto[c,3]
[a]Mathematics Education, PGRI Yogyakaerta University, Yogyakarta, Indonesia
[a]Psikologi Education, Mercubana Yogyakarta University, Yogyakarta, Indonesia
[a]Master of Mathematics Education, Ahmad Dahlan University, Yogyakarta, Indonesia
[1]wantoro22@gmail.com, [2]misbahulafandi97@gmail.com, [3]2207050007@webmail.uad.ac.id

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ABSTRACT

This study aims to develop a mathematics learning module based on a scientific approach with guided discovery to enhance the problem-solving skills of eighth-grade students. The research employs a development method following the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The findings indicate that: (1) The developed learning module meets the criteria of validity, practicality, and effectiveness in improving students' mathematical problem-solving skills; (2) In terms of validity, the module is considered valid based on expert assessments, with an average score of 3,1 from module experts and 3.3 from subject matter experts, including lecturers and mathematics teachers; (3) Regarding practicality, the module is deemed practical based on student responses, with an average score of 3,16; (4) In terms of effectiveness, the Paired t-test results show a significance value (sig. 2-tailed) of 0,000 < 0,05, leading to the rejection of H_0, indicating that the mathematics learning module is effective in enhancing problem-solving skills, with an improvement of 0,39 categorized as small. After using the module, all students (100%) scored above the minimum competency standard, with an average score of 83,96. Thus, the mathematics learning module based on a scientific approach with guided discovery meets the criteria of validity, practicality, and effectiveness in enhancing the problem-solving skills of 4 Sewon State Junior High School.

Keywords: ADDIE, Scientific Approach, Guided Discovery, Mathematical Problem Solving

Corresponding Author:
Hari Wantoro, Mathematics Education of PGRI Yogyakarta University
wantoro22@gmail.com

INTRODUCTION

In the era of modern educational advancements, teachers are required to continuously innovate in classroom learning [1]. Traditional teaching methods, which were previously conventional, now need to be developed into more creative and innovative approaches to make

learning more engaging and effective [2]. Teachers also bear the responsibility of transforming students' mindsets regarding the subjects they teach, especially subjects often perceived as difficult, such as mathematics. With a more interactive approach, students can become more motivated to learn, making mathematics less intimidating and instead turning it into an easy-to-understand and enjoyable subject [3]. Learning innovation not only benefits students but also enhances teachers' professionalism in education. This aligns with efforts to improve the quality of education in Indonesia, ultimately aiming to achieve the national educational goals of creating an intelligent and competitive generation.

Mathematics is one of the most important subjects at all levels of education, from elementary school to higher education [4]. According to [5], mathematics plays a significant role in daily life, whether in simple activities such as calculating expenses and managing finances or in more complex scientific fields such as engineering, economics, and information technology. Additionally, mathematics is crucial in the development of modern science and technology [6]. Therefore, students' ability to understand mathematical concepts must continually be improved so they can apply them in everyday life and future career development [7], [8]. However, in reality, many students still struggle to grasp mathematics, particularly when solving problem-solving questions.

Problem-solving in mathematics is one of the essential skills students must master, as it is closely related to critical and analytical thinking abilities [9]. However, in practice, many students face difficulties in solving mathematical problems. They often feel confused about understanding concepts, choosing appropriate strategies, and structuring correct solutions. These difficulties can be caused by various factors, both internal and external to the students [10]. Internally, students who do not have a solid grasp of basic concepts will struggle to apply them to problem-solving tasks. Externally, a lack of interactive teaching methods and insufficient opportunities for students to engage in critical thinking can lead to low motivation and poor comprehension of the material being taught.

A preliminary study conducted by the researcher in class VIII-C at 4 Sewon State Junior High School on August 7, 2024, revealed that students' mathematical problem-solving skills were still relatively low. This was evident from the pretest results on Number Patterns, which showed that many students had not yet met the minimum competency standards. Out of 32 students who took the pretest, only 2 met the minimum passing score, while the rest scored below the required standard. The minimum competency threshold for mathematics in this school is 70, indicating that many students require additional guidance. The analysis showed that many students had difficulty solving problems, with some not even attempting to answer the questions. This highlights the need for innovative teaching methods that can help students better understand concepts and improve their problem-solving skills in mathematics.

Based on observations and interviews with mathematics teachers at 4 Sewon State Junior High School, it was found that the teaching methods used in the classroom were still dominated by lectures. This approach provides limited opportunities for students to actively engage in the learning process, making them more passive and less able to grasp the material effectively [11]. Additionally, the learning resources used were still limited, with students relying mainly on textbooks as their primary reference for learning. However, by utilizing more diverse learning resources, students can develop a greater interest in understanding mathematical concepts [12], [13]. Therefore, a more effective instructional strategy is needed to enhance students' comprehension of the subject matter and encourage them to participate more actively in the learning process.

One potential solution is the development of a structured learning module designed to help students learn independently or in groups [14]. A module is a teaching material that is written in an easy-to-understand language according to students' level of knowledge [15]. By using a

module, students can learn with minimal teacher guidance, allowing them to become more independent in understanding the concepts being taught. Additionally, the module can include various engaging learning activities, such as concept exploration, practice questions, and collaborative tasks, which enhance student participation in learning. According to [16], a module should be able to replace the educator's role in explaining the material, ensuring that students can achieve a solid understanding even without direct teacher instruction. Therefore, developing an effective module is essential to improving the quality of mathematics education in schools.

As an innovative step to enhance students' mathematical problem-solving skills, the researcher developed a learning module based on the scientific approach [17]. The scientific approach aims to familiarize students with understanding mathematical concepts through systematic scientific methods [18]. In this approach, students are encouraged to observe, formulate problems, develop hypotheses, collect data, analyze data, draw conclusions, and communicate their findings. This method allows students to actively construct their own understanding, ensuring that they do not merely memorize formulas but deeply comprehend the concepts. According to Helena et al. [19], learning with the scientific approach is designed to enable students to actively explore and investigate concepts based on scientific methods.

METHOD

This research falls into the category of research and development (R&D). This method is used to produce a specific product while also testing its effectiveness [20]. The product developed in this study is a mathematics learning module using a guided discovery-based scientific approach, aimed at enhancing students' mathematical problem-solving abilities in the topic of relations and functions. The development model employed is ADDIE, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

In the analysis stage, a review of the mathematics curriculum on the topic of relations and functions is conducted by identifying core competencies, basic competencies, and students' characteristics. The design stage involves structuring the module framework, planning evaluation tools, and developing assessment instruments. Subsequently, the development stage includes drafting the module, consulting with academic supervisors, and validating it with module and content experts to ensure product quality before implementation.

The implementation stage involves testing the module on eighth-grade students (Class VIII-C) at 4 Sewon State Junior High School, followed by administering a student response questionnaire to measure the practicality and effectiveness of the module. The evaluation stage is carried out by analyzing any weaknesses found during the research to refine the product. Research data is collected through observation, questionnaires, and learning outcome tests. Observations are conducted to assess the implementation of learning using the module, while questionnaires are distributed to experts and students to evaluate the validity and practicality of the module. Tests are used to measure the module's effectiveness based on students' problem-solving abilities after using the module. Through this approach, the study aims to develop a valid, practical, and effective learning module to enhance students' mathematical thinking skills.

RESULTS AND DISCUSSION

Result

A. Analysis

The analysis stage in this research includes curriculum analysis and analysis of student characteristics. Curriculum analysis was carried out on class VIII mathematics learning at 4

Sewon State Junior High School which used the 2013 Curriculum. In the 2013 Curriculum, relationship and function material is included in basic competencies, namely describing and expressing relationships and functions with various representations, as well as solving problems related to relationships and functions using various representations. Researchers then describe basic competencies into indicators of competency achievement, which include aspects of knowledge and skills. Knowledge indicators include understanding the concepts of relationships and functions and their presentation in various forms, while skill indicators include solving problems related to relationships, functions and their presentation in various forms of representation.

Analysis of student characteristics was carried out based on interviews with mathematics teachers and observations in learning in class VIII-C of 4 Sewon State Junior High School. The results of the analysis show that students are less active in learning, with only a few students actively answering questions and doing assignments on the blackboard, while others tend to be busy and pay less attention when the teacher explains. The learning process is still dominated by the lecture method, and the teaching materials used are limited to textbooks and modules which contain a lot of material. Based on these characteristics, efforts are needed to increase students' active participation in mathematics learning. Therefore, researchers developed a mathematics learning module with a scientific approach based on guided discovery to improve students' problem solving abilities.

B. Design

The results of the design stage include the systematic preparation of a module framework, consisting of various parts such as concept maps, glossaries, and learning activities. The systematic presentation of material is arranged based on core competencies and basic competencies in the order of understanding relationships, functions and forms of presentation. Evaluation is carried out through practice questions and competency tests to improve students' problem solving abilities. The assessment instrument refers to the [21], using a Likert scale to assess the validity and practicality of the module based on aspects of presentation, language, graphics, and integration with a scientific approach based on guided discovery. The following is the design of the function relationship module.

Fig 1. Cover

Fig 2. Foreword

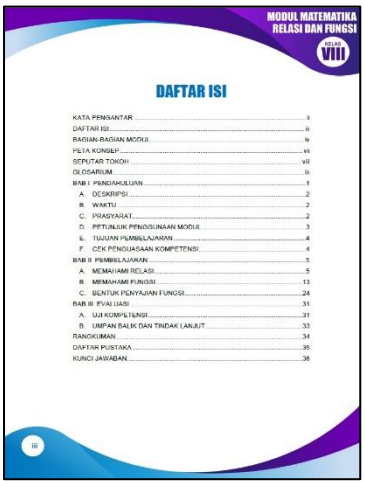

Fig 3. List of contents

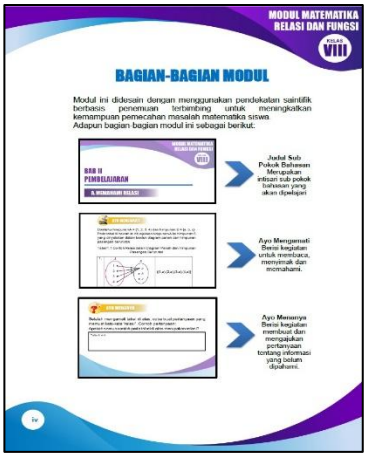

Fig 4. Module Section

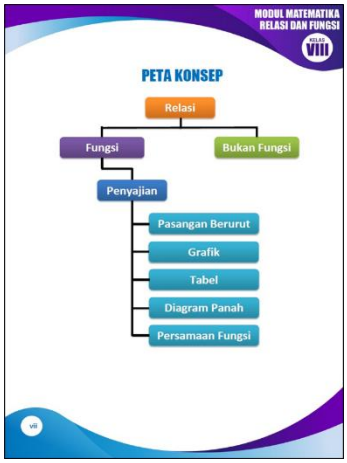

Fig 5. Concept maps

Fig 6. Mathematical Figures

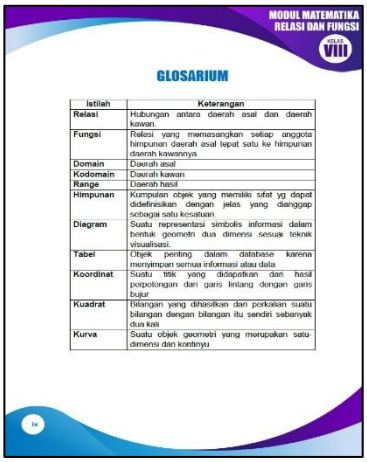

Fig 7. Glosarium

Fig 8. Introduction

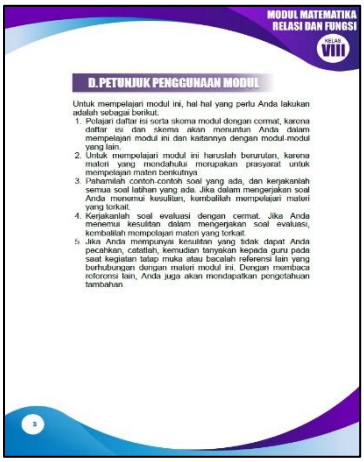

Fig 9. Module Instructions

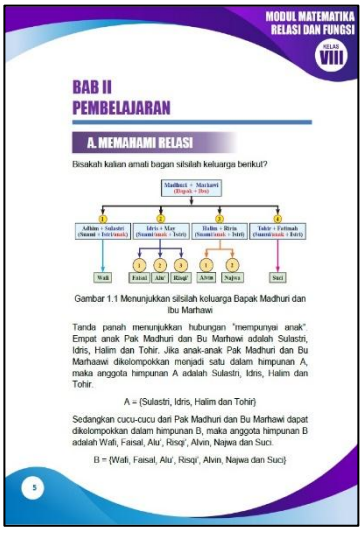

Fig 10. Material

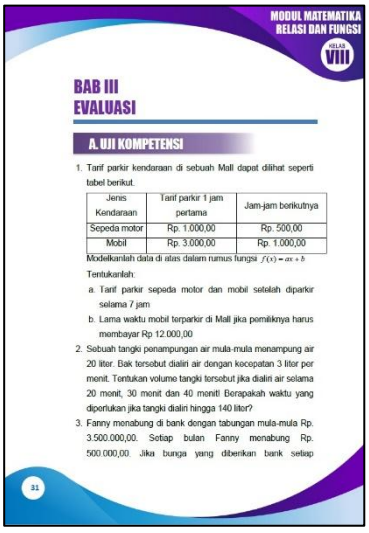

Fig 11. Evaluation

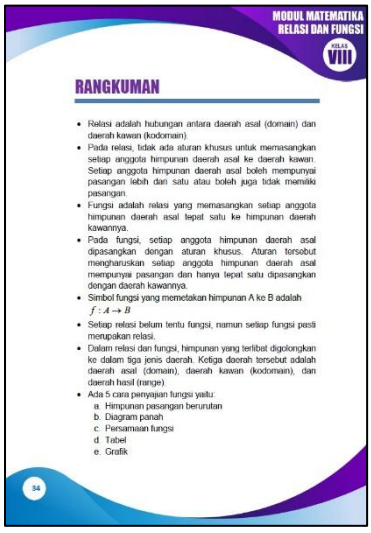

Fig 12. Summary

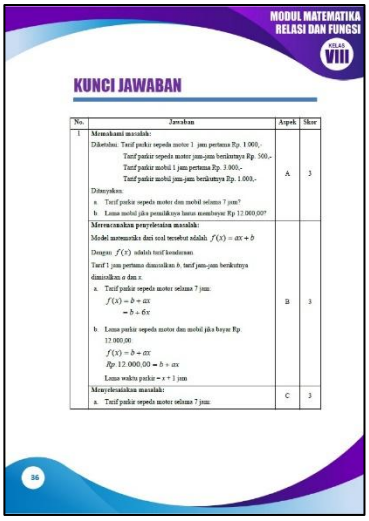

Fig 13. Answer key

Fit 14. Bibliography

Furthermore, developing the design of the assessment instrument is also the focus in this design stage. This functional relations module assessment instrument was developed based on guidelines from [22] media and content experts, as well as modifications from [23] for student response questionnaires. All questionnaires use a Likert scale consisting of five answer choices. This scale is used to evaluate the quality of products produced in the function relationship module

C. Development

At this stage, the designed module will undergo validation by media and material experts. The module expert assessment sheet was carried out by a lecturer at PGRI Yogyakarta University. The results of the assessment sheet are as follows.

Table 1. Results of Module Expert Assessment Sheet

No	Aspect	Mean	Quantitative Criteria	Qualitative Criteria
1	Presentation	3	Good	Valid
2	Language	3	Good	Valid
3	Graphics	3	Good	Valid
Total Score		9		
Overall Average		3	Good	Valid

Based on the table above, according to the expert lecturers the module as a whole has an average score of 3. The quality of the module can be determined by converting the average score with conversion guidelines on a scale of 4. From the results of the average conversion it can be concluded that according to the module expert lecturers, The module was declared "Valid" and the module expert lecturer stated that the mathematics learning module with a scientific approach based on guided discovery to improve the mathematical problem solving abilities of class VIII SMP students was worthy of being tested with revisions according to suggestions from the module expert lecturer. Meanwhile, the material expert assessment sheet is carried out by a material expert lecturer and mathematics teacher. The material expert lecturer comes from PGRI University Yogyakarta with the results data from the assessment

sheet presented in the following table.

Table 2. Results of Analysis of Assessment Sheets by Material Expert Lecturers

No	Aspect	Total	Mean	Quantitative Criteria	Qualitative Criteria
1	Content Eligibility	48	3	Good	Valid
2	Presentation	33	3	Good	Valid
3	Integration with a scientific approach based on guided discovery	18	3	Good	Valid
Total Score		99	9		
Overall Average		33	3	Good	Valid

Based on the table above, according to material experts, the overall average score is 3. The quality of the module can be determined by converting the average score with conversion guidelines on a scale of 4. From the results of the average conversion, it can be concluded that according to material experts, it is declared "Valid". The material expert stated that the mathematics learning module with a scientific approach based on guided discovery to improve the mathematical problem solving abilities of class VIII SMP students is worth testing with revisions according to suggestions from material expert lecturers. The material expert assessment sheet was also carried out by a class VIII mathematics teacher at 4 Sewon State Junior High School. The result data from the assessment sheet is presented in the following table.

Table 3. Analysis Results of Assessment Sheets by Material Expert Mathematics Teachers

No	Aspect	Total	Mean	Quantitative Criteria	Qualitative Criteria
1	Content Eligibility	55	3,4	Good	Valid
2	Presentation	38	3,4	Good	Valid
3	Integration with a scientific approach based on guided discovery	20	3,3	Good	Valid
Total Score		113	10,1		
Overall Average		37,6	3,3	Good	Valid

Based on the table above, according to material experts, the overall average score is 3,3. The quality of the module can be determined by converting the average score with conversion guidelines on a scale of 4. From the average conversion results, it can be concluded that according to material experts, it is declared "Valid". The material expert stated that the mathematics learning module with a scientific approach based on guided discovery to improve the mathematical problem solving abilities of class VIII SMP students is worthy of being tested with revisions according to suggestions from material expert mathematics teachers.

D. Implementation

After the mathematics module was deemed suitable for use by module and content experts, it was implemented in the learning process. The module trial was conducted at 4 Sewon State

Junior High School, with the research subjects being eighth-grade students (Class VIII C). A total of 32 students participated in the trial, which took place from October 18 to 22, 2024. In the learning implementation, students could work individually or in groups. Individual learning was applied when they worked on exercises that required independent thinking, while group work, consisting of 2–4 students, was used for discussions. In addition to discussion activities, group learning allowed students to collaborate, work together, and assist each other when a group member encountered difficulties.

At the beginning of the learning process using the module, students initially struggled to understand the material. However, with the teacher's guidance and brief explanations, they gradually grasped the concepts and engaged in discussions effectively. During the trial, the teacher acted only as a facilitator and guide in the learning process. This role was evident when students faced difficulties in solving problems presented in the module. At the end of each session, the researcher administered a learning outcome test to assess students' mathematical problem-solving abilities after using the module. Following the test, students were asked to complete a response questionnaire. Below are the results of the student response analysis.

Table 4. Analysis of Student Response Questionnaire Results

Aspect	Benefits	Presentation	View
Total per aspect	393	601	931
Average per aspect	3,07	3,13	3,23
Criteria per aspect	Praktis	Praktis	Praktis
Total		1925	
Overall Average		3,16	
Criteria		Praktis	

Based on the table above, it can be concluded that the module has an overall average of 3,16 and has the "Practical" criterion.

E. Evaluation

After implementing it, the next step is to carry out an evaluation using a mathematical problem solving ability test that was previously tested first. A summary of the test results can be found in the following table

Table 5. Summary of Trial Results

No	Validity ($r_{table} = 0,435$)		Reliability (*Cronbach's Alpha*)		Difficulty Level		Differentiating Power		Information
	r_{count}	Criteria	Value	Criteria	DL	Criteria	DP	Criteria	
1	0,953	Valid	0,803	Reliabel	0,61	Currently	0,32	Enough	Used
2	0,711	Valid			0,62	Currently	0,32	Enough	Used
3	0,458	Valid			0,61	Currently	0,22	Enough	Used
4	0,887	Valid			0,62	Currently	0,28	Enough	Used
5	0,847	Valid			0,61	Currently	0,31	Enough	Used

Based on Table 4, question numbers 1, 2, 3, 4 and question number 5 have validity results with valid and reliable criteria, moderate difficulty index, sufficient distinguishing power, so that these 5 question numbers can be used. After the instrument is valid and reliable, it is then used during the pretest and posttest. The results of the preset are then tested for normality as

follows.

Table 6. Normality Test Results

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.150	32	.063	.936	32	.069
Posttest	.135	32	.148	.955	32	.200

a. Lilliefors Significance Correction

Based on table 6 above, the Shapiro-Wilk significance value can be seen with pretest data 0,069 > 0,05 and posttest 0,200 > 0,05. So it is concluded that both data are normally distributed. After that, the researcher then carried out the Paired Sample T-test using SPSS-25 software. The results of the Paired Sample T-test are presented in the following table.

Table 7. Paired Samples Test Results

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-1041.625	1177.769	208.202	-1466.256	-616.993	-5.003	31	.000

Based on table 7 above, the sig value. (2-tailed) is 0,000 < 0,05, so H_0 is rejected so there is a difference in student learning achievement before and after learning using the module. The following is a description of the pretest and posttest scores.

Table 8. Descriptive Statistics of Pretest and Posttest Results

Descriptive Statistics						
	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Pretest	32	50.00	90.00	2353.33	73.54	10.22
Posttest	32	73.00	95.00	2686.65	83.95	6.10

Based on the results of descriptive statistics, there were 32 students who took the pretest and posttest. In the pretest, the lowest score obtained by students was 50,00, while the highest score was 90,00, with a total score of 2.353,33. The average student pretest score was 73,54 with a standard deviation of 10,22, which shows that there is quite a large variation in students' initial abilities. After being given treatment, the posttest results showed an increase in student scores. The lowest score on the posttest increased to 73,00, while the highest score reached 95,00. The total posttest score was 2.686,65 with an average score of 83.95, indicating an increase compared to the pretest. Furthermore, to determine the increase in student learning achievement, it can be calculated using the N-Gain formula as in equation 1 below.

$$\langle g \rangle = \frac{S_{post} - S_{pre}}{SMI - S_{pre}} = \frac{83{,}98 - 73{,}54}{100 - 73{,}54} = \frac{10{,}42}{26{,}46} = 0{,}39 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Based on the calculation results above, it can be seen that the N-Gain result is 0,39 in the

small category

Discussion

The results of this study indicate that the development of a mathematics learning module using a guided discovery-based scientific approach contributes positively to improving students' problem-solving abilities. This module was systematically designed based on curriculum analysis and student characteristics. In the 2013 Curriculum, the topic of relations and functions is an essential part of basic competencies, emphasizing conceptual understanding and representation in various forms [24],[25]. However, classroom observations in Class VIII-C at 4 Sewon State Junior High School revealed that learning was still dominated by lecture methods and lacked activities that required active student engagement. This finding aligns with [26] research, which found that lecture-based approaches in mathematics learning tend to reduce student participation.

The design phase of this study resulted in a module that includes a concept map, glossary, and structured learning activities based on a guided discovery-based scientific approach [27]. The evaluation section in this module was designed to enhance students' problem-solving skills through exercises and competency tests developed according to national education standards Depdiknas [21]. This approach is relevant to the study by Siswanto & Susetyawati [28], which demonstrated that the scientific approach in mathematics learning helps students develop a deeper understanding of concepts and enhances their critical thinking skills.

Module validation was conducted by media and subject matter experts, yielding results that indicate a high level of validity [29]. Based on assessments from lecturers at Universitas PGRI Yogyakarta and mathematics teachers, aspects such as presentation, language, and integration with the scientific approach received an average score of 3, categorized as valid and suitable for testing. These findings support research Rohmah et al., [30], which states that systematically developed and expert-validated learning modules have a higher level of effectiveness in supporting students' learning processes.

The module implementation in class VIII-C at 4 Sewon State Junior High School involved 32 students who worked on exercises both individually and in groups. The results showed that, initially, students experienced difficulties in understanding the module. However, with teacher guidance, they were able to adapt and engage in discussions effectively. The teacher played the role of a facilitator, assisting students when they encountered challenges in solving problems. This aligns with Putri et al., [31] findings, which suggest that the teacher's role as a guide in guided discovery-based learning enhances student participation and their ability to solve mathematical problems.

The evaluation of the module's implementation was conducted through learning outcome tests and student response questionnaires. The average student response scores for aspects of appearance, presentation, and usefulness of the module were 3,07, 3,13, and 3,23, respectively, categorized as "Practical." These results indicate that the module was effectively used in learning and was positively received by students. This finding is reinforced by the study of [32], which found that the use of interactive modules in mathematics learning improves student engagement and the effectiveness of their conceptual understanding.

Overall, this study demonstrates that developing a mathematics learning module with a guided discovery-based scientific approach is an effective solution for enhancing students' problem-solving abilities. From curriculum analysis, design, validation, implementation, and evaluation, this module has been proven to be of high quality and suitable for use in learning.

This research contributes to the development of innovative teaching materials in mathematics education and supports previous studies that emphasize the importance of discovery-based learning in improving students' problem-solving skills.

CONCLUSION

Based on the research results previously explained, the mathematics module can be said to be valid, practical and effective based on the assessment of module experts, material experts, student response questionnaires, observations of learning implementation, as well as test results of mathematical problem solving abilities. From the validity aspect, this module obtained valid criteria based on the results of module expert assessments with an average of 3,1, as well as material expert assessments by lecturers and mathematics teachers with an average of 3,3. Meanwhile, from the practical aspect, the module was considered practical to use based on the results of student responses to using the module with an average of 3,16. From the effectiveness aspect, the research results show that the tailed sig.2 value is 0,000 < 0,05, so H_0 is rejected. This means that the mathematics learning module is effective in improving the mathematical problem solving abilities of class VIII students at 4 Sewon State Junior High School. After using this module, 100% of students obtained a score above the minimum completeness with an average of 83,96. Thus, this mathematics module is suitable for use as teaching material in learning.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHORS

Hari Wantoro is a Mathematics Education student at PGRI Yogyakarta University. As a student, he was active in designing learning tools using certain learning approaches, especially in mathematics subjects. Not only that, he is active in participating in campus student activities. He can be reached at wantoro22@gmail.com.

Muhammad Misbahul Afandi is a psychology student at Mercubuana University, Yogyakarta. As a student, he is active in participating in various kinds of training related to adolescent psychologists which he will later use to measure stress levels in high school adolescents in participating in learning. He can be reached at misbahulafandi97@gmail.com

Deny Hadi Siswanto is a masters student in mathematics education at Ahmad Dahlan University. As an educator, he is determined to design innovative and efficient teaching methods to increase student participation and understanding. He actively monitors each student's learning progress, ensuring they receive the guidance they need to achieve academic success. He can be reached at 2207050007@webmail.uad.ac.id