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Development of a logarithmic module equipped with a jigsaw cooperative model

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Abstract

The teacher's task is to compile lesson plans, books, or modules assess and evaluate. However, the fact is that the low learning outcomes are due to the difficulty level of the book. The results of the 2022 study show that students' scores are below 75, which is 74.80. Urgency, there is a difference between teacher assignments, expectations, and learning outcomes. The research aims to design practical and effective modules. The research method used is Research and Development (R&D): Determination, Design, Development, Implementation, and Evaluation. The subject is high school, and the subject is 32 students. They are collecting data with assessment instruments from material experts, teachers, and students. Modules are measured by practicality through instruments, and tests measure effectiveness. Analysis technique with validation. Average values and interpretations. As a result, the logarithmic module is practical, effective, and can increase value. The validation of material experts and math teachers assessed 92.35% and 91.45% in the very good category. Student assessment of the module is 95.81%, a very good category. Post-test learning outcomes use the 90.28 module, and those that do not use the 68.40 module.

Keywords: cooperative jigsaw model; developmental research; logarithmic module

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Introduction

In achieving student success in mathematics lessons, the teacher has a duty (Jerrim et al., 2022; Sun et al., 2018). The teacher's tasks are to design a lesson plan, prepare teaching modules, prepare learning models, methods, and strategies, prepare assessment indicators, assessment rubrics and assessments, learning evaluation forms and implementation and assessment and Evaluation of interest in learning (Albeshree et al., 2022). Many students struggled with mathematics material, and few obtained learning outcomes below the minimum completeness criteria (Lumbantoruan, 2022a).

In research, Wijaya et al. (2022) said students' interest in learning mathematics was shallow. Suherman and Vidákovich (2022) said the learning outcomes of certain materials considered difficult in high school are low. One of the causes of the low learning interest of students in mathematics is that the teacher does not prepare and arrange the material properly, and it impacts learning outcomes (Haser et al., 2022). Another factor is the low learning outcomes of students in mathematics material because the learning model used by the teacher during the implementation process is not to the conditions of the student's basic abilities (Hamzah et al., 2022). In high school, there is a lot of math material that is considered difficult by students (Staddon, 2022), among them Logarithms, integrals, trigonometry, derivatives, exponents, and trigonometry (Sihwail et al., 2022). Based on the learning outcomes obtained by research from one of the Bekasi public high schools in the 2022 odd semester, the average score for mathematics learning outcomes in logarithmic material is 74.80, even though the minimum completeness criterion score is 75 (Lumbantoruan, 2022b).

Another fact is that the researcher asked the teacher where the problem was, and the teacher answered that there was material that was difficult to teach and difficult for students to understand. The teacher hopes that an appropriate module has been tested (Lumbantoruan, 2022b). The students argue they have difficulty with logarithm material. They hoped that there would be a presentation of material that was easier to understand. Students also hope a more effective model for understanding logarithmic material exists. The module plays a vital role in the smooth learning process of mathematics (Hamzah et al., 2022). Modules are among the most appropriate ways to overcome difficulties (Dosta et al., 2020). Regarding benefits, Halomoan (2022) says that the module is a teacher's tool that aims to 1) help students learn more effectively, 2) help develop self-confidence, 3) everyday language, 4) maximize learning potential; 5) the module reduces teacher involvement; 6) Modules can be model-based.

The Jigsaw cooperative learning model is a type of cooperative learning model that is often used in high schools. The uniqueness of the Jigsaw cooperative learning model lies in its grouping through group discussions (Rahman & Lewis, 2020). The learning model in the logarithmic module so far has only divided the Tampa groups, evenly dividing the abilities of each group. Researchers see a discrepancy between expectations, theories, and facts in the field, so a solution is needed to overcome the problems of teachers and students in developing the mathematics module on logarithms.

This study aims to design a logarithmic material module equipped with a Cooperative Jigsaw model. This study also tested the practicality and effectiveness of the logarithmic module equipped with a cooperative-type jigsaw.

Methods

This study uses a Research and Development (R&D) approach to define, design, develop, implement, and evaluate strategies (Mavrotas & Makryvelios, 2021). The product developed in this research is a math module for logarithms. This module is a tool for learning logarithmic material in class and can be used by students at home (Mishra et al., 2020)**.** The following is the development research flow used.

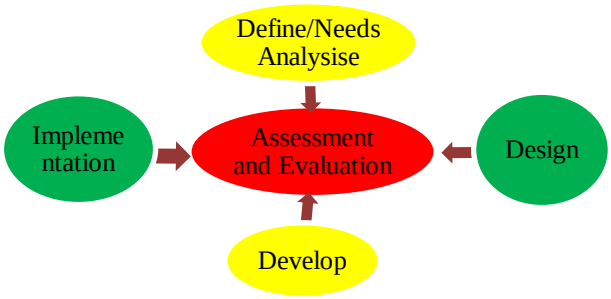

Figure 1. Logarithmic module research flow

Based on Figure 1, this research starts from the define/needs analysis stage. The research seeks and analyzes the needs of teachers and students to increase knowledge and understanding in improving learning outcomes. The second stage is product design. The product of the logarithmic module is designed based on an analysis of the needs of teachers and students when the definition has been carried out. The third stage is development; this stage develops research by providing logarithmic modules to assessors for validation. The validation chosen was a logarithmic matter expert, namely a high school mathematics coordinating teacher, and the second validation was a mathematics teacher. In the fourth stage of implementation, in the implementation stage of the logarithmic module, there were two stages of testing, namely a small-scale trial with ten students, and the second trial was carried out on a large scale with 32 students consisting of one class. The last stage is evaluation; the evaluation stage is carried out in this study to see the practicality of the logarithmic module and the effectiveness of the module by assessing the results of the post-test, analysis of the learning process, evaluating the module development process to evaluating the final product of the logarithmic module. The subjects and objects of this study were schools and high school students, totaling ten people during the small group tryout and 32 people during the large group tryout.

Data collection techniques with validation, module testing, module evaluation, and revision. Initial stage with material expert validation and math teacher validation. Logarithmic module products are given to mathematicians to assess the modules that have been designed. Material experts provide input on the module until the module is said to be valid and feasible to be tested. During the validation process of the assessment instruments provided by this study to measure the feasibility of the logarithmic module, the logarithmic module is said to be

feasible if it has been assessed at 80% and above, which means the module is already in the good category. The second stage is validating the mathematics teacher; the logarithmic module is given to the mathematics teacher to see the material, models, and learning strategies outlined in the module.

The Mathematics teacher provides input on the module until the module is said to be valid. In the third stage, the logarithmic module product was tested on a small scale for ten tenth-grade high school students. This small group trial process took up to one month to produce a product that could be tested on a large scale. In small-group trials, this study provides an instrument to assess the logarithmic module and a test to measure the module's effectiveness on a small scale. The module is suitable for large-scale trials if students' learning outcomes on a small scale are above the minimum completeness criteria, namely above 75 (Pinheiro et al., 2021). Modules valid during small-scale trials were tested on a more significant number of students, namely 32. The large group was given a module during the trial to aid the learning process. The process of learning logarithms takes one month. This study also taught logarithm material to different classes in the large group trials. However, instead of using the logarithm module, schools used the textbook as the primary source of learning. Assessment instruments are given to classes that use modules as learning aids, and post-tests are given to both classes, namely classes that use modules and classes that do not.

Data Analysis Techniques with Validation Evaluation. The module was evaluated by two mathematics experts and four mathematics teachers. The experts used here are senior teachers who are experts in the field of logarithms and teachers who are math coordinators at school. Meanwhile, the math teachers who did the module validation were those who taught logarithms and those who taught in tenth grade. The instrument data was evaluated and analyzed. Students assess the logarithmic module used through instruments with a Likert scale, namely with points 1-5 (Bilal et al., 2020).

$$P = \frac{S}{N} x100\% \quad (1)$$

P = Percentage of Success (%)
S = Total value acquisition
N = Maximum number of values

Table 1. Assessment of module instruments

Score Weight	Alternative Answers
5	very good
4	good
3	enough
2	not good
1	not very good

The data obtained is then measured by the interpretation of the score as follows:

Table 2. Module interpretation (Jebeile & Crucifix, 2020)

Interpretation	Presentation
not very good	0% - 19%
not good	20% - 39%
enough	40% - 59%
good	60% - 79%
very good	80% - 100%

The effective indicators that are calculated are the mastery of classical learning and the increase in learning outcomes between post-tests of students who use logarithmic modules and those who do not. The post-test results for the two classes show an average difference and become the basis for determining the module's effectiveness (Sanaat et al., 2021). To determine classical learning ability can be calculated using the following equation:

$$KB = \frac{NS}{N} x100\% \quad (2)$$

Information:

KB = Learning Completion Criteria

NS = Total Participants above 75

N = Number of students

Table 3. Interpretation of classical completeness (Ndaïrou et al., 2020)

Interpretation	Percentage
very low	0% - 39%
low	40% - 59%
currently	60% - 74%
high	65% - 84%
very high	85% - 100%

Results

The research answers the results of the analysis of the needs of teachers and high school students through the logarithmic material mathematics module, which is equipped with the Jigsaw Cooperative Type model, which has been validated, tested, practical, and effective in the learning process and can improve student learning outcomes.

Define/Needs Analysis

This study found the needs of students and mathematics teachers in the classroom learning process. The teacher students were distributed instruments that contained analysis. This needs analysis starts with an analysis of the needs of students and then continues with an analysis of the teacher's needs. The following are the results of the analysis of student needs.

Student needs. It was found that students had difficulties with logarithmic material. Difficulties in logarithmic material were 24 out of 32 who distributed the students' needs analysis instruments. The students disagreed with the books the teacher used when teaching.

Fourteen students disagreed, 12 moderately agreed, three strongly agreed, two agreed, and one person strongly disagreed. Students expect the material to be designed according to the needs and abilities of students. The results of the analysis of the needs of the students show that the students' difficulty when working on math problems lies in the model. The model referred to by students is the lack of examples appropriate to the questions being tested on them. At the same time, the method's difficulty is as many as 14 people. The difficulty of the method in question is an example of unstructured questions that tend to be challenging to understand. In the fourth question, this study asked about the low learning outcomes of students on the four materials in Tenth-grade high school. Of the four materials, students answered that the low learning outcomes were in logarithms—as many as 26 people whose learning outcomes were below the minimum completeness criteria in logarithmic material. The students expect the module to overcome difficulties and the low learning outcomes they obtain. Difficulties and low student learning outcomes lie in models, methods, and learning outcomes of logarithmic material. As many as 30 students were expecting a logarithmic module.

Teacher Needs Analysis. In this second stage, the needs analysis results were obtained by teachers' researchers. The study conducted interview sessions with four math teachers in senior high schools. The results of interviews with coding researchers are as follows.

Table 4. Coding of interview results with teachers

Interpretation of the three interviewed teachers	The four teachers answered that the teachers they had used so far had been seen as very difficult to understand by the students being taught.	The four teachers answered that they had never prepared material in the form of a module.	The four teachers need modules that have been compiled and tested by validation.	The four teachers used the cooperative learning model	Three people choose logarithm, and one teacher chooses exponents.

Design

In this study, the material and sub-material developed is logarithmic. The following is the design result of the logarithmic material math module: http://bitly.ws/L4fq.

Development

In this development, the research carried out the process of validating the product of the logarithmic math module product to the selected experts. Product validation was given to experts, namely math coordinators at public high schools. Then, the second stage provides the product to be validated by the mathematics teacher in state senior high school 7. The following is a snippet of the results of the validation of material experts and mathematics teachers on the logarithmic module product:

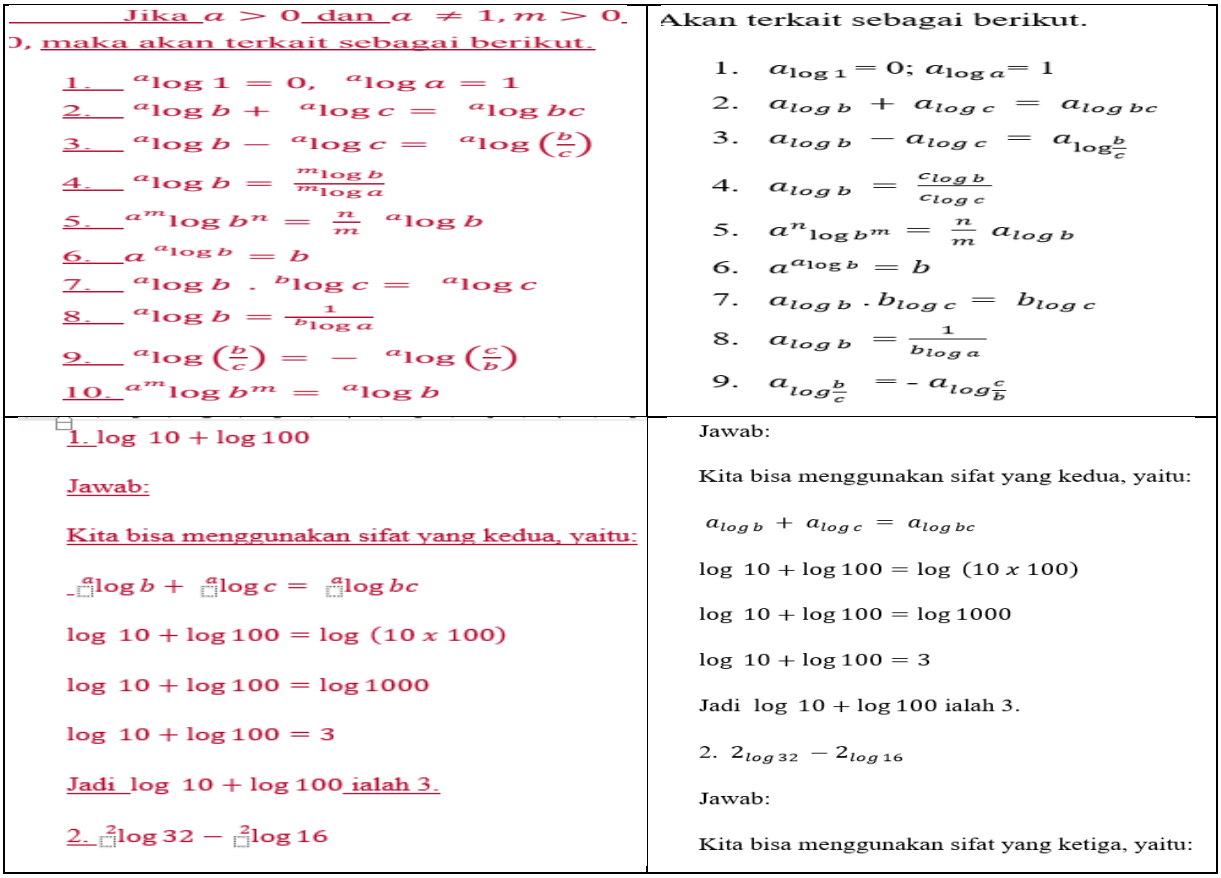

Figure 2. Module development results before and after

Figure 2 shows that the developed module is valid and can be tested on a small scale. Expert expert in the field of logarithmic material. Modules that have been validated provide much input in the discussion questions about the questions in the logarithmic module. Mathematics experts and teachers revised the group discussion model carried out by previous research.

Table 5. Recapitulation of material expert validation instrument assessment results

Indicator	Presentation	Category
module components	92.22%	very good
construction	90.50%	very good
suitability	92.48%	very good
presentation	94.45%	very good
average	92.35%	very good

Table 5 shows the average for all components of the logarithmic material expert assessment with perfect research interpretation with a mean of 93.60%. With an excellent average value, the validated logarithmic module can be tested on a small scale.

Table 6. Recap of the results of the mathematics teacher validation instrument assessment

Indicator	Presentation	Category
Eligibility of module content	92.55%	very good
writing language design	92.44%	very good
design method	93.44%	very good
contextual	90.45 %	very good
evaluation instrument	90.30%	very good
average	91.45%	very good

From Table 6, it can be seen that all components of the logarithmic module assessment given to teachers, on average, get a final score of 92.42%. The average value given is interpreted as a very good category. The results of this assessment will be the end before carrying out trials on a small scale and trials on a large scale.

Small scale implementation/trials and large-scale trials

Random selection was conducted in a small group trial of 10 students in senior high schools. The implementation of the small group trial lasted for one month, starting from the implementation of logarithmic material with the help of the logarithm module to the post-test stage for small group students. The following are the post-test results of 10 small-group trial students. From the test results, students in small groups, after being taught with the help of logarithmic modules, are very high at an average value of 89.10. This value interprets that all students in the class implement the mathematics learning process with logarithmic material with the help of modules above the minimum completeness criteria that have been determined, namely 70. Implementing logarithmic material in the small group lasted for one month. Student Module Assessment Results from Small Groups:

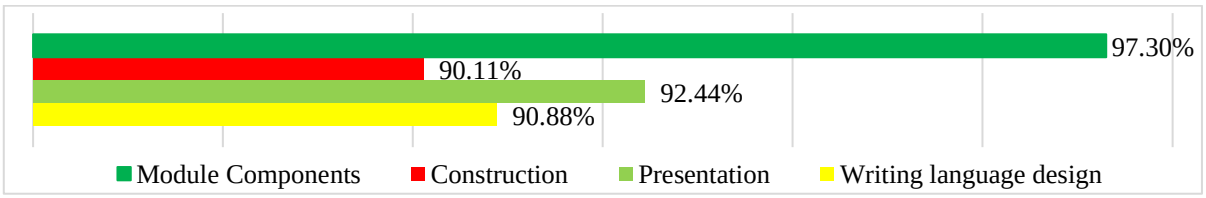

Figure 3. Logarithmic module student assessment

In Figure 3, the highest in all student assessments in small group trials is in the module component. The students argued that the logarithmic module, which had its logarithmic module components arranged very well, was followed by a very good assessment in terms of graphics and module writing language design. The language used in the logarithm module is used in everyday life. This makes it easier for students to understand the purpose and what is being asked in the problem. The language used in logarithmic questions can increase students' interest in reading more about the logarithm module's contents and logarithm material in other books.

Large Group Trial. Before the learning process takes place with the help of the logarithmic module, the researcher first gives pre-test questions. The second stage of the large-scale trial was implementing the logarithmic mathematics learning process with the help of modules and cooperative learning strategies. The process of implementing logarithmic material

lasted one month, and at the final stage, it was given a post-test and distributed module component assessment instruments. The following are the results of the post-test and the students' assessment of the logarithmic module.

Post-Test Results. When the module trial was carried out on 32 students, the mean value was above the standard value of 75, namely 90.28. The logarithmic module is interpreted in a very good category. This module positively impacts the learning process and smoothness for students and teachers in implementing logarithmic mathematics material. The pre-test and post-test values shown on the pie chart show that there is a very significant difference between students before using the logarithmic module and after using the logarithmic module, namely 34.21 during the pre-test and after using the logarithmic module 90.28 during the post-test. The increase obtained by students when using the logarithmic module was 56.07. Learning outcomes using the mean 90.28 module and not the Logarithmic mean 68.40 module.

Table 7. Recapitulation of large group student assessments of the Logarithmic Module

Indicator	Presentation	Category
module components	95.31%	very good
module construction	97.18%	very good
presentation	93.58%	very good
module writing language	97.20%	very good
Average	95.817%	very good

Table 7 shows that, as a whole, students gave very good ratings for all assessment components in the module indicators. Assessment of large group trials with a score of 95.81% means that the derivative module developed is very good.

Discussion

The logarithmic module design is equipped with the Cooperative Jigsaw Model

Based on the research results, the concepts and forms of the mathematics module developed for logarithmic material have been designed, validated, tested on a small scale, and tested on a large scale. This is in line with the results of the study by Hainora Hamzah et al. (2022) and Codreanu et al. (2020b) in increasing students' understanding and knowledge of learning mathematics, educators must have modules and have been validated by experts. The form of this logarithmic module was validated for one month by two mathematicians and one month by four math teachers. The modules are designed with many changes after being validated by mathematicians and teachers. According to the Jigsaw Cooperative Type model, the validator changes the concept of material examples of questions previously designed to the question stage. Material validation suggests that for each sub-matter discussed, examples of questions are made to make it easier for students to understand and know the form of the questions. Mathematics teachers do many revisions to the questions that are used as practice questions in the form of student discussions. The input given by the mathematics teacher aligns with previous findings that the questions developed must be adapted to the model used (Wildeman et al., 2022).

The validation of math material experts and math teachers gave scores of 92.35% and 91.45%, respectively. The value given by this validation can be that the mathematics module for logarithmic material that this study has designed is in the very good category for use in the mathematics learning process for logarithmic material as a tool. This study also found patterns that must be added when compiling material. The findings from this study are that you have to arrange examples of questions sequentially from the sub-material at the beginning of learning to the last sub-material stage. This finding makes students' learning process active in discussing and asking questions of the teacher. The following is a module concept and form that mathematicians and math teachers validated at the final stage: http://bitly.ws/L4f2. This module was developed according to the analysis of the needs of mathematics teachers and class X students.

Logarithmic module practicality

The product of the logarithmic mathematics module developed in this study is very practical. Based on the validation of material experts providing an assessment of all module components, the methods used get an assessment of 92.35%. The material expert validation value is interpreted very well. The results of this material expert validation do not stand alone; the mathematics teacher also validates the logarithmic module product. The assessment results the mathematics teacher gave were very good, with a mean score of 91.45% for all components in the very good category. The practicality of this logarithmic module product is rated very well by material experts and teachers and is considered practical by students.

The value given by students to the logarithmic module that has been designed is in terms of module components 97.30%, graphics 90.11%, how-to present material 92.44%, and language design in writing module material 90.88%. All components of this module are rated in the very good category and are very practical in learning logarithmic mathematics material. Findings align with Hainora Hamzah et al. (2022) that the developed module is practical if developed correctly and gets very good ratings from module users.

The effectiveness of the logarithmic module

The mathematics module for logarithmic material developed in this study is practical and effective, increases understanding knowledge, and improves learning outcomes for mathematics on logarithmic material. This can be seen from the learning outcomes obtained by students when implementing logarithmic material learning with the help of modules. The average result obtained by students after completing the learning process is 90.28. This score is very high and exceeds the minimum completeness criteria of 70. The average score obtained by students before the learning process is 34.21. The post-test score is very much different from the pre-test score, with a difference of 56.07. This confirms that modules developed with the correct development process can improve student learning outcomes significantly; Moons et al., 2022).

The process of implementing logarithmic material was carried out for both classes. One class uses logarithmic modules, and one class does not use logarithmic modules in the learning process. The mean value was obtained by a class that did not use the 64.80 module, while

students who were given the logarithmic module had a mean value of 90.28. The difference in the average score between students who use the module and those who do not use the module is 25.48. This module is an alternative to overcoming students' difficulties understanding logarithmic material. In this study, students also assessed the learning modules and models. The value given by students for the module components developed was 95.31%, module construction 97.18%, presentation method 93.58%, and module writing language 97.20%. All module indicators are considered very well by students. This finding means the logarithmic module equipped with the Cooperative Jigsaw model effectively binds students' understanding and learning outcomes. This aligns with previous development research that effective products can improve mathematics learning outcomes (Liu et al., 2022).

Conclusion

The mathematics module contains practical and effective logarithmic material, adding to understanding and knowledge and improving student learning outcomes. The validation starts from the validation of material experts, and the mathematics teacher gives a very good category rating. The product has also been tested on students in small and large groups, and the results of student assessments of the logarithmic module instrument are in the very good category. The learning outcomes obtained by students are also quite high, with the results obtained from the post-test 90.28. The value of the learning outcomes obtained by these students is inversely proportional to those obtained by students who do not use the logarithmic module as a learning aid, namely 68.40.

These findings indicate that there is a very significant difference between students who use the logarithmic module and students who do not use the logarithmic module. The high learning outcomes using the logarithmic module confirm that the module developed in this study can be used as a tool to expedite the learning process. The weakness of this study is that the product has not been tested by conducting experimental research. Experimental research is urgently needed before mass production is carried out. Suggestions for further research are to conduct trials of this product on a larger scale for students in different schools.

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Conflicts of Interest

In writing this article, there is no conflict of interest between the author and other people.

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Author Contributions

Jitu Halomoan Lumbantoruan: wrote analysis, idea, and review articles; **Evi Deliviana**: Editing and English

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