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Development of E-Modules Based on Inquiry-Based Learning to Support Junior High School Students' Creative Thinking Skills on Flat-Side Space Structure Material

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ABSTRACT

This study aims to develop an e-module based on Inquiry-Based Learning (IBL) to enhance junior high school students' creative thinking skills, particularly on flat-sided geometric shapes. The research was motivated by the low level of student creativity in mathematics, often attributed to conventional, teacher-centred learning methods. The research employed a Research and Development (R&D) approach, utilising the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The participants were eighth-grade students from SMP Negeri 16 Kota Jambi. The developed e-module was validated for practicality and effectiveness. The effectiveness was assessed through a pretest-posttest design, demonstrating a significant improvement in students' creative thinking abilities across four key indicators: fluency, flexibility, originality, and elaboration. The average N-gain score of 0.79 indicates a high category of effectiveness. These findings suggest that integrating IBL with digital learning media provides an effective instructional tool for fostering students' mathematical creativity. Therefore, the IBL-based e-module is recommended as an innovative alternative to support student-centred learning and the development of higher-order thinking skills in mathematics.

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1. INTRODUCTION

Creative thinking skills are one of the essential competencies crucial in the 21st century and must be developed in the learning process, especially in mathematics learning. According to Junaedi et al. [1], creative thinking enables students to generate new ideas when solving math problems. However, initial observations at SMP Negeri 16, Jambi City, showed that students' creative thinking skills, especially in flat-sided spatial geometry materials, were still relatively low. This low achievement is reflected in students' inability to explore various problem-solving strategies and rely on rote procedures. In the current digital era, students are no longer interested in monotonous learning processes; instead, they tend

to utilise the sophistication of existing technology. This results in students lacking creative thinking skills. Based on the initial test, most students have not demonstrated an understanding of concepts and variations in problem-solving strategies, as they remain unengaged and unmotivated to explore alternative methods or construct their understanding. Regrettably, students no longer have the mode or materials to learn.

One of the factors contributing to low creative thinking ability is the dominance of conventional learning approaches or models, such as lecture and memorisation methods, which primarily focus on the teacher in the classroom. Teachers are more active than their students in these methods. According to Sarifah and Nurita [2], learning that relies solely on lectures causes students to become passive and less motivated to think deeply or creatively. Therefore, an alternative approach is needed to stimulate cognitive activity and student exploration in learning. The approach must be adjusted to meet the needs of students in the classroom while also stimulating creative thinking skills outside of it. These findings underscore the need for a paradigm shift from teacher-centred to student-centred instruction, where learners actively construct knowledge rather than passively receive it.

The Inquiry-Based Learning (IBL) approach is an effective method for encouraging active student involvement during the learning process, as it invites students to discover concepts through their own discoveries [3], [4], [5], [6], [7]. According to Artigue and Baptist [8], it provides students with opportunities to develop their approaches to constructing scientific knowledge. Through inquiry-based learning, students are encouraged to ask questions, investigate, analyse, and draw their conclusions, which encourages students to hone their creative thinking skills through the investigations they conduct, the questions they make, the analysis of the discoveries they make or the hypotheses they formulate or the questions they make, and being able to conclude all the learning processes and stages they have made [9], which can directly improve creative thinking skills. IBL not only fosters student autonomy but also aligns with the principles of constructivist learning, in which knowledge is formed through direct experience, collaboration, and critical reflection [10], [11], [12], [13], [14].

In addition to learning models, media, such as e-modules, are crucial in supporting independent and interactive learning. In schools still using printed media, which can make students feel bored while reading, an electronically integrated module is designed to facilitate the learning process [15], [16], [17], [18], [19]. The use of electronic learning media is constructive for students, not only making it easier for them through the learning process but the design designed to attract students' interest to continue using e-modules and easy access methods only through mobile phones or cellphones that students have often used or using computers or laptops, notebooks or tablets. Digital media have the potential to provide interactive, multimedia-rich environments that stimulate learner engagement and increase motivation, especially among digital-native students.

According to Maryam et al. [20], e-modules are digital open materials designed to be used independently by students with an attractive and easily accessible appearance. Thus, the development of e-modules based on Inquiry-Based Learning is one of the strategic solutions to enhance the creative thinking skills of junior high school students in mathematics learning, particularly in the context of flat-sided spatial structures. Using

electronic learning media combined with an inquiry-based learning model is suitable for enhancing students' creative thinking skills. Therefore, this study aims to develop an IBL-based e-module that is practical, valid, and effective in enhancing students' creative thinking, particularly in mastering complex geometry content. This combination is expected to provide pedagogical innovation and empirical evidence supporting technology-assisted inquiry learning.

2. METHOD

This type of research is part of Research and Development (R&D), which aims to produce an e-module product based on Inquiry-Based Learning and test its quality through validity, practicality, and effectiveness. The development model used is the ADDIE model, which comprises five main stages: analysis, design, development, implementation, and evaluation [21]. This model was chosen because it offers a systematic framework for developing instructional products with continuous feedback at each phase. Each stage in the ADDIE process was implemented sequentially to ensure the quality and relevance of the resulting e-module [21], [22], [23].

The population in this study consisted of all students in class VIII of SMP Negeri 16 Kota Jambi for the 2024/2025 academic year. Sample selection was conducted using a purposive sampling technique based on class availability, readiness to use e-modules, and recommendations from mathematics teachers. The class has 30 students. This purposive sampling ensured that the selected class had access to adequate digital devices and teacher support to implement the e-module effectively. Ethical considerations, such as informed consent from participants and institutional approval, were also obtained before data collection.

The research design used is a one-group pretest-posttest design. In this design, students are first given a pretest to determine their initial creative thinking abilities. After that, students participate in learning using the Inquiry-Based Learning e-module as the treatment, and then they are given a posttest to measure the increase in creative thinking abilities following the treatment. This design enables the researcher to measure the direct effect of the intervention on student performance by comparing the pretest and posttest scores within the same group. Although it lacks a control group, this design is appropriate for initial trials of educational products in classroom contexts.

The independent variable in this study is the use of e-modules based on Inquiry-Based Learning. In contrast, the dependent variable is students' creative thinking skills as measured based on four indicators according to Munandar [24], namely: (1) fluency, (2) flexibility, (3) originality, and (4) elaboration. These indicators were selected to reflect the multidimensional nature of creative thinking in mathematics education and were operationalised through item descriptors and rubric-based assessment. Data collection techniques used include:

1. Observation and initial interviews to analyse needs, student characteristics, and readiness of the learning environment.
2. Questionnaires consist of content and design validation, practicality, and student response questionnaires.

3. Written tests (pretest and posttest), in the form of 4 descriptive questions, were designed to measure the four indicators of creative thinking.

Two content experts and a pedagogical expert validated all instruments to ensure content validity and appropriateness for the target group. The reliability of the instruments was also measured using Cronbach's Alpha coefficient for the questionnaires. The research steps are carried out through three main stages, namely:

1. Preparation: Initial study, preparation and validation of instruments, and development of e-modules prototypes.
2. Implementation: implementation of pretest, learning using e-modules for 4-6 meetings, and implementation of posttest
3. Data analysis: evaluation of the validity, practicality, and effectiveness of the e-module, as well as improving students' creative thinking skills.
   Each stage was documented carefully to maintain the transparency of the development process, and the trial phase was conducted under teacher supervision in a regular classroom setting.

Data analysis was conducted to assess the quality of the e-module based on aspects of validity, practicality, and effectiveness, as well as to calculate the improvement in students' creative thinking skills after using the e-module. The data analysis technique was quantitative descriptive, utilising the Likert scale and calculating the N-gain percentage. The Likert scale was applied to the questionnaire data to evaluate user perception, while the N-gain score was used to determine the extent of learning improvement between pretest and posttest scores. The threshold for effectiveness was based on standard benchmarks: N-gain < 0.3 (low), 0.3–0.7 (moderate), and > 0.7 (high).

3. RESULTS AND DISCUSSION

This study involved 30 students from Class VIII-J of SMP Negeri 16 in Jambi City, who were the research subjects. The research design employed a pretest-posttest approach with 30 students as respondents. An initial assessment was conducted before and after the trial activities, which were facilitated through learning using e-modules designed according to the learning flow and following the syntax of Inquiry-Based Learning. The designed assessment's parameters include creating a descriptive test comprising four questions, each addressing a distinct aspect of creative thinking: fluency, authenticity, originality, and elaboration. The results of the trial, conducted with pretest testing, showed that most students scored low, with an average of 43.20, indicating a low category and suggesting that they had not yet developed creative thinking skills. After using e-modules in mathematics learning, especially flat-sided spatial geometry material, the average posttest score increased significantly to 88.89 after treatment was administered to each respondent, with a substantial increase indicating that the use of e-modules designed and developed by researchers is highly effective in improving students' creative thinking skills.

3.1 Results

3.1.1 Results of N-Gain Analysis of Creative Thinking Ability

In the section on the effectiveness of the use of e-modules that have been tested and students have filled out questionnaires to determine the significant increase in students' creative thinking skills, researchers analysed data obtained from the results of distributing student response questionnaires or questionnaires on the effectiveness of using e-modules using the N-Gain calculation, which was carried out overall on respondents. The results of the study and calculations from the N-Gain table show that the average N-Gain score of students is 0.79 or 79%, which, in percentage form, based on the category from the N-gain table, the score that obtained a percentage of 0.97% is included in the high category and is effectively used by students. Details of the calculation for the N-gain results are presented in Table 1.

Table 1. Average N-Gain of Students

No.	Student Code	Pretest	Posttest	N-Gain	Category
1.	R1	40,62	96,87	0,95	High
2.	R2	56,25	93,75	0,86	High
3.	R3	53,12	87,50	0,73	High
…	…	…	…	…	…
4	R4	15,00	32,00	1,00	High

(1)

Most students from the calculation data results obtained a percentage value (73.3%) which showed an increase in the use of e-modules given to students with a high category, and there was also a quarter of students only getting a percentage value of 3.3% after the treatment was given with the use of e-modules for students who were in the category above the low classification. This shows that the application of e-modules based on Inquiry-based learning significantly impacts the development of students' creative thinking skills through the designed e-modules. With the changes that were initially made, the average student presentation value of 43.20 increased by 0.41%, so the use of e-modules can support students' creative thinking skills in mathematics, especially the sub-material of flat-sided space shapes.

3.1.2 Prerequisite Test and Indicator Analysis

In the initial prerequisite test and test indicators, testing is conducted on each tool or parameter used to assess the product's validity and effectiveness. While this test indicator is also in line with the initial prerequisite test before the researcher goes into the field, the researcher makes a test indicator first, which is a reference for the researcher in seeing the variables to be observed and tested whether each indicator is following the subject being observed after the researcher makes the test indicator, the next step is to test the initial prerequisites which are the initial stage in conducting research and testing each test indicator made by the researcher whether it is feasible or not.

3.1.2.1 Normality Test

N-Gain data is classified as normality data, whose testing is carried out using the Kolmogorov-Smirnov test. The Kolmogorov-Smirnov test is carried out to test data samples taken from populations or treatments that are normally distributed or to assess the normality of the data. The results of the Kolmogorov-Smirnov test analysis show a significance value of greater than 0.05, indicating that the N-Gain data from 30 samples are normally distributed (normality). Thus, after establishing that the normality test is normally distributed, the researcher conducts parametric hypothesis testing in the next stage. After the researcher conducts the indicator test, they begin testing the initial prerequisites, the first stage of conducting the research. This involves evaluating each test indicator to determine whether it is feasible to implement in the field.

3.1.2.2 Hypothesis Test

To determine the effectiveness of using e-modules based on Inquiry-Based Learning to improve students' creative thinking skills, the researcher conducted a paired sample t-test. Based on the normality test results conducted at the beginning, normally distributed data were obtained. A paired sample t-test was then carried out, comparing the pretest and posttest results, making this method suitable for hypothesis testing. The test results showed a significance value (2-tailed) of 0.000 <0.05, so H_0 was rejected, and H_1 was accepted. This indicates a significant difference between the pretest and posttest results obtained in the field, and the use of e-modules based on Inquiry-Based Learning effectively improves students' creative thinking skills, as evidenced by the normality test data and hypothesis tests conducted.

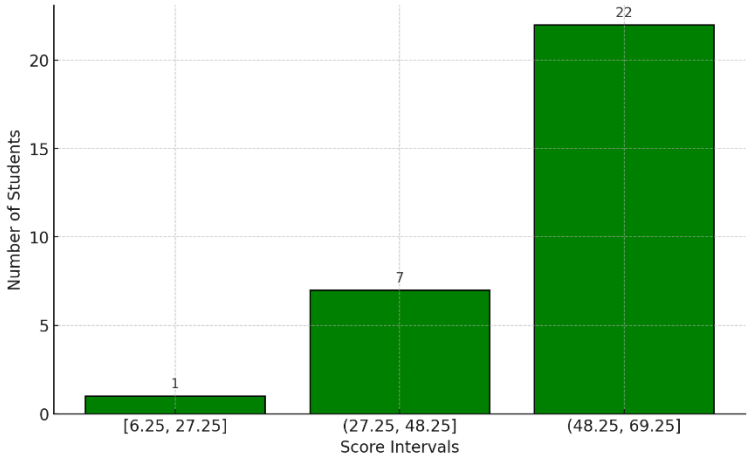

Figure 1. Distribution of students' pretest scores

Figure 1 illustrates the distribution of students' pretest scores before implementing the Inquiry-Based Learning (IBL) e-module. The total number of participants was 30 students, and their scores were grouped into three class intervals: [6.25–27.25], [27.25–48.25], and [48.25–69.25].

Based on the data, only one student (3.3%) scored within the lowest interval [6.25–27.25], indicating minimal creative thinking ability before the intervention. Seven students

(23.3%) fell within the second interval (27.25–48.25], reflecting a low to moderate level of creative thinking. Notably, the majority of students—22 out of 30 (73.3%)—scored within the third interval (48.25–69.25], suggesting that most students possessed moderate creative potential, though still below the threshold for high-level creative thinking (typically above a score of 70).

This distribution confirms that before using the IBL-based e-module, students generally had not yet reached an advanced stage of creative problem-solving. The concentration of students in the middle score range, combined with the complete absence of students in the high-score category, reinforces the need for instructional innovation to enhance creative thinking. In particular, this highlights the importance of implementing learning approaches that actively engage students in inquiry, exploration, and independent reasoning rather than relying solely on conventional, teacher-centred instruction.

The pretest results, therefore, serve as a crucial baseline indicator that justifies the development and application of the IBL e-module as a targeted intervention. By addressing the observed deficiencies in students' creative performance, the e-module was designed to foster improvement in all four dimensions of creative thinking: fluency (the ability to generate multiple ideas), flexibility (the capacity to approach problems from different perspectives), originality (the generation of unique or novel responses), and elaboration (the ability to explain and develop ideas in depth). By integrating these elements, the e-module aims to improve scores and promote deeper cognitive engagement and autonomy in problem-solving.

Creative thinking ability in this study was assessed using these four indicators. For each indicator, students' pretest and posttest performance were compared to determine the improvement achieved after using the IBL e-module. The results of this analysis are presented in Table 2, which displays the average N-Gain values for each dimension. This table provides a more detailed picture of how the intervention influenced each aspect of creative thinking, helping to identify which components of student creativity were most responsive to the learning model implemented.

Table 2. Average N-Gain Based on creative thinking ability indicators

No.	Indicator	N-Gain	category
1.	*Fluency*	0,82	High
2.	*Flexibility*	0,76	High
3.	*Originality*	0,71	High
4.	*Elaboration*	0,68	High

3.2 Discussion

The distribution of pretest scores revealed that before using the Inquiry-Based Learning (IBL)-based e-module, students had not yet reached an advanced stage of creative problem-solving. The absence of students in the high-score category and the concentration of scores in the middle range confirm that most learners lacked mastery in creative thinking. Only one student (3.3%) scored in the lowest interval [6.25–27.25], while seven students (23.3%) fell into the moderate-low interval (27.25–48.25]. The majority, 22 students (73.3%), were clustered in the interval [48.25–69.25], suggesting moderate potential but

insufficient depth in creative problem-solving. These findings reinforce the importance of innovative instructional strategies supporting inquiry and active exploration.

The pretest outcomes thus serve as a critical baseline for assessing the impact of the IBL e-module intervention. Designed to address four key dimensions of creative thinking—fluency, flexibility, originality, and elaboration, the module aimed to elevate students' ability to engage with mathematical problems through guided investigation. Each indicator was evaluated using a pretest-posttest design, and the resulting N-Gain scores demonstrated measurable improvements. Table 2 presents the average N-Gain values per indicator: fluency (0.82), flexibility (0.76), originality (0.71), and elaboration (0.68). These scores indicate consistent improvement across all domains, with fluency showing the most significant gain and elaboration the least.

This four-week intervention revealed a significant improvement in students' creative thinking skills after implementing the IBL-based e-module. The high performance in fluency indicates that students were increasingly able to generate diverse and original ideas, even without prior exposure to the problems. In contrast, the relatively lower score in elaboration suggests that although students could produce ideas, some still encountered difficulty in explaining or detailing those ideas effectively. This outcome highlights the need for more explicit scaffolding within the module, such as guided prompts, writing frames, or rubrics, to strengthen students' elaborative reasoning and expression.

The high average N-Gain of 0.79 provides strong empirical support for the effectiveness of the IBL approach in enhancing students' creative thinking. Through its structured phases—orientation, conceptualisation, investigation, conclusion, and discussion—the IBL model empowers learners to think critically and reflectively, transitioning from passive recipients to active constructors of knowledge. This aligns closely with the core tenets of constructivist learning theory, which emphasise knowledge-building through contextual, hands-on engagement.

In addition to its pedagogical foundations, integrating IBL with digital media was crucial in enhancing the learning environment. The e-module's interactive features—including visual supports, self-guided inquiry tasks, and mobile accessibility—helped increase student engagement and motivation. Unlike static printed modules, the digital format promoted flexibility, allowing students to navigate the content independently while revisiting inquiry stages as needed. This digital-inquiry synergy appears particularly well-suited to support the four creative thinking indicators by combining open-ended exploration with accessible, technology-enhanced learning tools.

The findings from this study resonate with previous research. For example, Şen et al. [25] found that inquiry-based learning significantly enhanced students' mathematical reasoning and creativity. Similarly, Scott and Friesen [9] demonstrated that inquiry instruction supports higher-order thinking and reflection, while Junaedi et al. [1] showed that students perform better in creative mathematical tasks when engaged in investigative activities. These converging results confirm that embedding IBL in digital e-modules is a highly effective strategy for cultivating creativity in mathematics learning, particularly in abstract topics such as flat-sided spatial geometry.

Nonetheless, certain limitations must be acknowledged. First, the absence of a control group limits the ability to attribute causality solely to the intervention. Second, the relatively short duration (four weeks) may not fully reflect the potential for long-term learning retention and deeper conceptual transfer. Future research should employ quasi-experimental or longitudinal designs with more diverse samples. Moreover, including qualitative data—such as student reflections or teacher observations—could offer richer insights into how learners internalise and apply inquiry-based thinking beyond the classroom.

In summary, the results of this study underscore the potential of IBL-based e-modules as a powerful pedagogical innovation. This approach supports 21st-century learning goals and provides a practical, scalable solution for enhancing the quality of mathematics instruction, particularly by improving students' creative thinking competencies across diverse educational contexts.

4. CONCLUSION

Based on the results and discussion, the Inquiry-Based Learning (IBL) e-module developed in this study demonstrated a statistically significant impact on the creative thinking skills of junior high students in flat-sided spatial geometry. The evidence lies in the high mean N-gain of 0.79, with the greatest improvement in fluency (idea generation) and the smallest in elaboration (idea detailing). These findings confirm the e-module's large effect size and practical relevance for mathematics education.

This work offers an important empirical contribution: integrating IBL pedagogy with interactive digital media is a scalable pathway to nurturing higher-order thinking, especially mathematical creativity. The module's design—anchored in the orientation, conceptualisation, investigation, conclusion, and discussion stages—could foster reflective and exploratory learning behaviours.

Theoretically, the findings support constructivist learning theory, demonstrating that meaningful knowledge construction occurs when students actively engage in inquiry, collaborate, and refine their ideas rather than passively receiving information.

Mathematics teachers can adopt IBL-based e-modules as an effective alternative to conventional worksheets. Successful classroom implementation requires clear guidance, well-structured questioning, and purposeful discussion facilitation so that all creative-thinking indicators—particularly elaboration—develop optimally.

A final limitation concerns the single-group design and short intervention window; future studies should include control groups, extended timelines, and qualitative data (e.g., learner reflections) to examine long-term retention and the nuanced processes underpinning creative thinking growth.

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