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Implementation of Interactive Modules using Problem-Based Learning Models in Programming Algorithm Courses

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Abstract

This research is based on the problem of low logical thinking skills of PTIK students in programming algorithms, and cannot be optimized through traditional teaching methods. the main thing of the research is to design and assess interactive modules based on the Problem Based Learning (PBL) model to improve the logical thinking skills of PTIK students. The research method used is the Research and Development (R&D) approach with the ADDIE model which includes the stages of Analysis, Design, Development, Implementation and Evaluation. These stages involve determining needs, organized planning, digital product development, implementation in a real learning context, and thorough evaluation. The resulting module combines the features of a live coding editor to support practice. The findings of this study indicate that this interactive module is very useful and practical to implement. Expert validation confirmed that in terms of functionality, ease of use, reliability and efficiency, the module has good quality, and the module also proved successful in improving the logical thinking skills of PTIK students. In conclusion, the PBL-based interactive module can be considered as a practical and effective learning tool. The new discovery in this research is the provision of an innovative integrated digital learning solution, which directly supports the improvement of logical thinking skills in the field of programming.

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INTRODUCTION

The advance of information technology and communication (TIK) has transformed the education landscape by making it possible to develop innovative digital learning resources that support independent and interactive learning (Amalia et al., n.d.; Kusuma et al., 2018; Rahayu et al., n.d.). In vocational education, especially in informatics and computer studies, high-quality learning resources are crucial for preparing students for both academic and professional success (Al Fayumi & Widodo, 2025). Subjects such as HTML, CSS, and PHP not only provide foundational knowledge for website development but also enable students to practice and enhance logical thinking, equipping them to face real-world challenges effectively.

However, most existing modules in vocational education have limitations in terms of content accuracy, interactivity, and adaptation ability with the students' needs (Amalia et al., 2024; Asfiya et al., 2024; Endaryati et al., 2021). Many modules are not aligned with curriculum competencies, while others lack engaging features that stimulate motivation and foster deeper cognitive processes (Javadikasgari et al., 2018; Koulouri et al., 2014; Laswadi et al., 2023; Tsai et al., 2023). Previous research revealed that the developed teaching resources lacked a systematic design model, which resulted in suboptimal learning outcomes (Ruth Colvin Clark & Richard E. Mayer, 2009; Showkat et al., 2024; Zedadra et al., 2019). Research on enhancing learning achievement with technology has emphasized the integration of useful principles, pedagogical, and interactive learning strategies to maximize students' engagement and performance (Lee et al., 2024; Ruihong, 2024).

Many studies have successfully shown the effectiveness of interactive modules in increasing students' learning output in various domains (Nurrokhman et al., 2025; Wardani et al., 2025). As a finding revealed by Fang et al. (2023), Xiong & Suen (2018), and Yang et al. (2021) stated that learning tools such as interactive digital learning significantly improve conceptual understanding and application skills. This finding is in line with Safitri et al. (2024) and Wilke & Magenheim (2019), who stated that in vocational lessons, learning modules equipped with media can improve motivation and achievement. However, the research that focused on a systematic interactive module to improve pedagogical quality and technical function, which has been validated by feasibility, practicality, comprehensiveness, and effectiveness tests, is limited (Djouab & Bari, 2016; Zainuddin & Miftahul, 2019).

This research aimed to solve the gap by developing an interactive module through the ADDIE model (Adeoye et al., 2024). The research purposes are: (1) developing an interactive module, (2) evaluating module feasibility through experts' validation, (3) assessing practicality based on users' feedback, and (4) measuring effectivity in enhancing students' logical thinking skills through a quasi-experimental design. This research expects to contribute to theoretical and practical aspects of technology-based learning by providing guidance and proof to design an interactive module that is effective for vocational education.

METHOD

Research Design

This research adopted a quasi-experimental design with a non-equivalent control group. This research also involved two classes, namely the experimental class (PTIK B) and the control class (OTIK A), that were assigned without randomization. The experiment class received learning by using a developed interactive module, while the control class used a conventional module. The presented research followed the ADDIE design model, which consisted of Analysis, Design, Development, Implementation, and Evaluation.

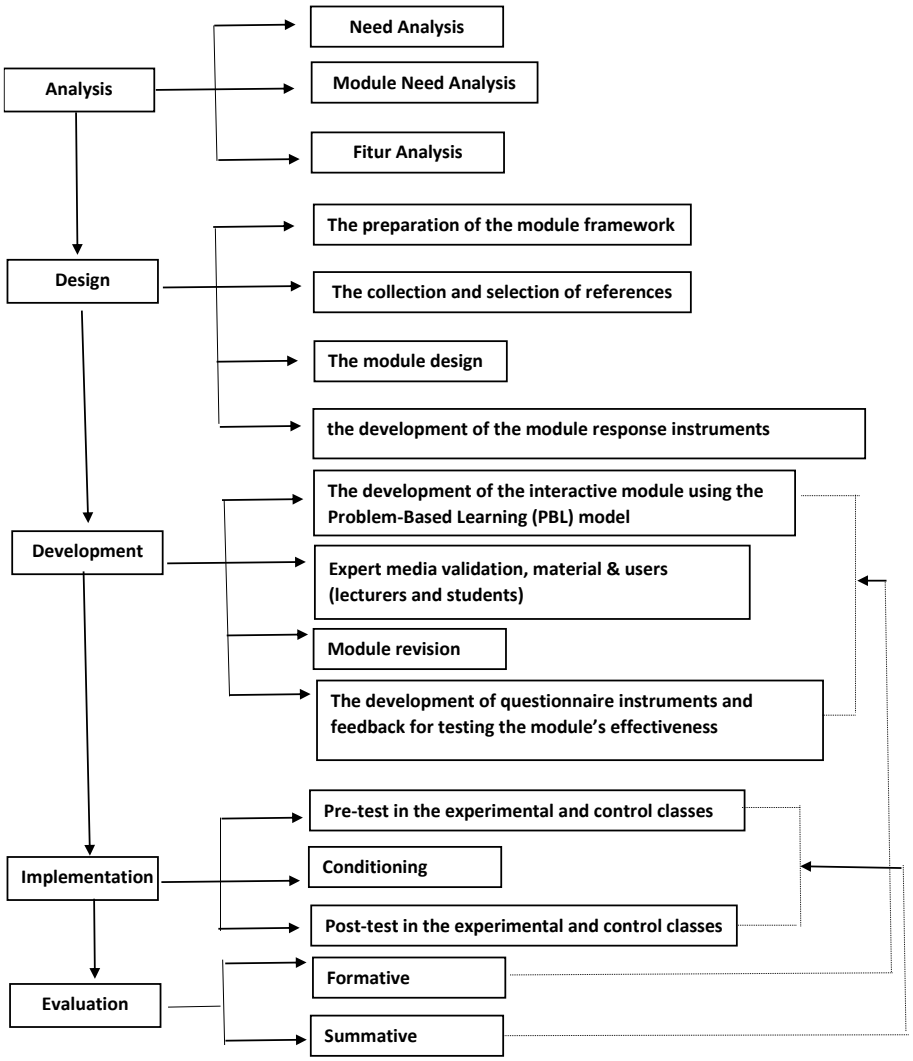


Figure 1. ADDIE

Research Sample

The research sample consisted of 60 students of Informatics and Computer Engineering Education. The participants were divided into two groups: 30 students from PTIK B served as the experimental group, while 30 students from PTIK A served as the control group.

Table 1. Research Design

Group	*Pre Test*	*Treatment*	*Post Test*
Experiment	$Experiment_1$	X	$Experiment_2$
Control	$Control_1$	-	$Control_2$

Research Instruments

The research instruments used in this study consisted of three categories. First, a feasibility test instrument that had been used to assess interactive module quality, such as HTML, CSS, and PHP, based on the ISO 9126 quality standard, especially functionality and usability aspects. This instrument was done by two materials experts and two media experts by using a checklist with a 'yes-no' dichotomy scale and a Likert scale. Furthermore, the data were analyzed by using Content Validity Ratio (CVR) to measure content validity.

$$\text{CVR} = \frac{\left(Ne - \frac{N}{2}\right) - 1}{\frac{N}{2}}$$

Percent of Agreement (PoA)

Percent of Agreement (PoA) was used to measure the reliability score among the validators.

$$\text{Percent of Agreement (PoA)} = \left(\mathbf{1} - \frac{\boldsymbol{\Sigma}\ \textbf{difference score}}{\textbf{Maximum Score}}\right) \boldsymbol{x}\ \mathbf{100\%}$$

Second, the practicality test instrument in the form of questionnaires was given to the lecturers and students to assess the users' practicality, content clarity, and module attractiveness. The data were analysed with the Reproducibility Coefficient (Kr)

$$K_r = 1 - e/n \qquad \underline{x} = \frac{\sum X}{n}$$

Scalability Coefficient (Ks)

Third, the effectiveness test instrument is a test that assesses logical thinking ability, which consists of multiple-choice and essay questions. The questions were validated by using biserial-point correlation.

$$KR - 20 = \frac{k}{k-1}\left(1 - \frac{\sum pq}{\sigma^2}\right)$$

While reliability was calculated by applying the Kuder-Richardson Formula 20 (KR-20)

$$r_{pbis} = \frac{M_1 - M_0}{S_t}\sqrt{\frac{pq}{n}}$$

Difficulty Index

The difficulty index indicates the level of difficulty of a question and is calculated based on the proportion of correct answers relative to the total number of participants.

$$TK = \frac{B}{N}$$

Data Analysis

The data collection technique had been completed in three steps. The first step is expert validation, where the two material experts and media experts assessed the interactive module by using a feasibility instrument. The calculation result is counted based on CVR and PoA score. The second stage is a practicality test, where the questionnaire was given to lecturers and students after using an interactive module. The Kr and Ks score was calculated to assess the consistency and scalability of respondents' answers. Next, the third stage is an effectiveness test. The test began by giving a pre-test to the experimental and control classes. After that, the two groups joined in the learning process (the experimental class adopted an interactive module while the control class used a conventional method). Then, at the end of learning, the researcher gave a post-test for each group. The difference between the pre-test and post-test scores was analyzed using the N-Gain, as follows:

$$n - Gain = \frac{Post\ test\ score - Pre\ test\ score}{Maximum\ score - Pre\ test\ score}$$

To assess the effectiveness, N-Gain is calculated using equation 9. Before the researcher tested the hypothesis, the data were tested to determine normality by using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

Furthermore, the data were analyzed to examine variance using Levene's test of homogeneity. The difference in learning output between the experimental and control classes was analysed using an independent t-test with a significance score of 0.05.

RESULT AND DISCUSSION

Development

The interactive module was developed through a Research and Development approach (R&D) with the ADDIE model (analysis, design, development, implementation, and evaluation). The analysis stages comprised the identification of students' learning needs in the Algorithm and Programming subject in the Computer and Informatics Education. The next stage is designing a learning structure that integrates theoretical explanation, coding exercises, and interactive simulation through a development platform.

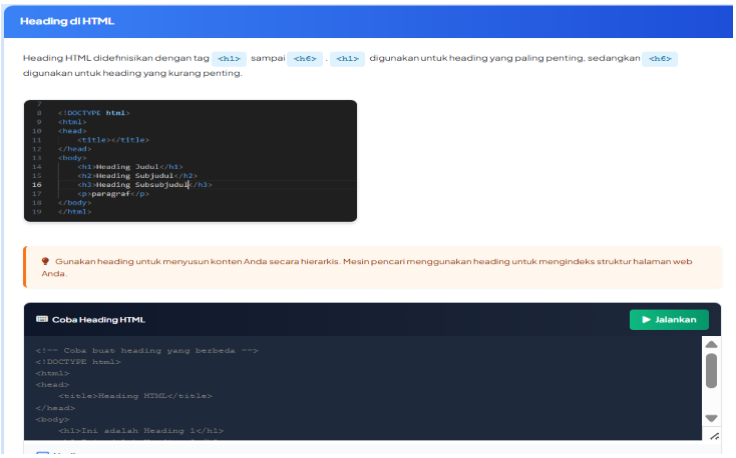


Figure 2. Interactive Module

In the development phase, instructional content was made by using a modular format that guides students to learn step by step. These visual elements, such as syntax highlighting, screenshots, and an interactive code editor, were integrated to increase users' interactions. The module function and usage were designed and aligned with the quality standards of 9126 ISO software.

The implementation stage involved module application to the two groups (control and experiment) to evaluate the practicality and effectiveness. The evaluation comprised expert validation (material and media experts), a practicality test with lecturers and students, and an effectiveness test using logical thinking skills through a pre-test and a post-test.

The result of the development process showed that the final product not only fulfilled the technical specification of the interactive module but also integrated a learning strategy that supports independence and active learning. This finding is in line with digital learning that fulfilled instructional design principles and software quality standards, which created higher engagement and better learning achievement.

Interactive Module Feasibility

The feasibility test of the HTML, CSS, and PHP interactive module was assessed by two materials experts and two media experts by adopting ISO 9126, especially in the aspects of function and usage. Table 2 summarizes expert evaluation results based on Content Validity Ratio (CVR). The data showed that all items were evaluated and passed the validity threshold, the content of the interactive module interface was in accordance with the expected learning objective.

Table 2. Material Expert Validity

No	Statements' summary	Validator 1	Validator 2	Validator Dichotomy 1	Validator Dichotomy 2
1	Statement aligns with aspects of functionality/usability	4	3	1	1
2	Reflects the feasibility indicators of the interactive module	3	3	1	1
3	Distinguishes the roles of material and media experts	3	2	1	0
4	Sentences are easy to understand	4	4	1	1
5	Technical terms are used consistently	3	4	1	1
6	Free from ambiguity	2	2	0	0
7	Can be evaluated objectively	4	3	1	1
8	Uses an appropriate 1–4 scale	4	4	1	1
9	The number of items is sufficient	3	2	1	0
10	The questionnaire is feasible for use	4	4	1	1

The Percentage of Agreement (PoA) score also exceeded the recommended threshold of 75%, confirming the consistency among expert evaluations. This finding is consistent with previous studies, which demonstrate that the application of ISO 9126 criteria enhances the validity and reliability of digital learning resources.

Table 3. Percent of Agreement

No	Statements' summary	Validator 1	Validator 2	Validator Dichotomy 1	Validator Dichotomy 2
1	Aligned with functionality/usability	4	3	Yes	Yes
2	Represents feasibility indicators	3	3	Yes	Yes
3	Differentiates the roles of experts	3	2	Yes	No
4	Sentences are easy to understand	4	4	Yes	Yes
5	Consistency in technical terms	3	4	Yes	Yes
6	Free from multiple interpretations	2	2	No	No
7	Statements are objective	4	3	Yes	Yes
8	An appropriate scale is used	4	4	Yes	Yes
9	The number of indicators is sufficient	3	2	Yes	No
10	The questionnaire is feasible for use	4	4	Yes	Yes

The high feasibility score indicates that the developed interactive module meets the functional requirements of web-based learning media, including content accuracy, cross-device interoperability, and compliance with relevant educational standards. This ensures that the module is ready for practical implementation in classroom settings.

Table 4. Media Expert Validation

No	Statements' summary	Validator 1	Validator 2	Validator Dichotomy 1	Validator Dichotomy 2
1	Aligned with functionality/usability	4	4	1	1
2	Accurately represents the indicators	4	3	1	1
3	Clearly distinguishes expert roles	3	2	1	0
4	Language is easy to understand	4	3	1	1
5	Technical terms are consistent	3	3	1	1
6	Free from double meanings	2	2	0	0
7	Statements can be evaluated objectively	4	3	1	1
8	Scale is appropriate for evaluation	3	4	1	1
9	The number of indicators is sufficient	3	2	1	0
10	The questionnaire is feasible	4	4	1	1

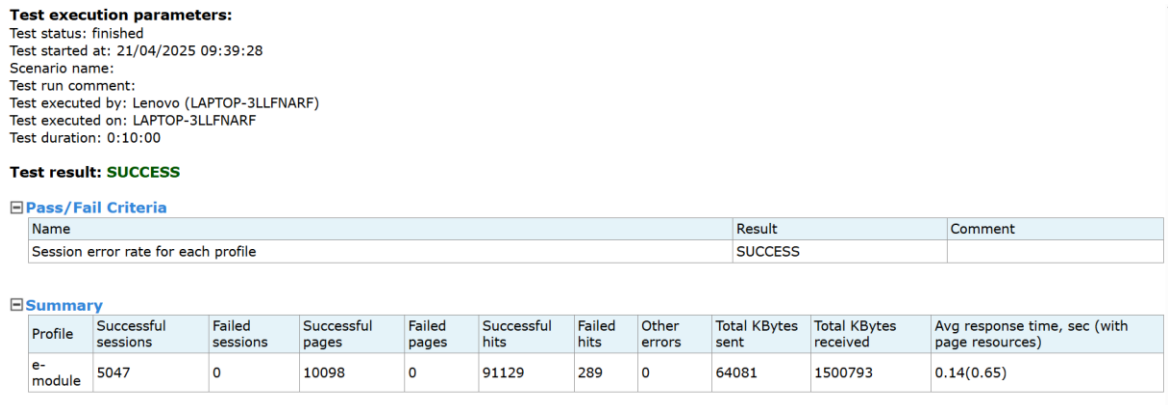
Based on the calculation of the Content Validity Ratio (CVR), it was found that 7 out of 10 items achieved a CVR score of 1.0, indicating complete agreement between the two validators that these items are essential and relevant for evaluating the feasibility of digital learning media.

The inter-rater reliability test for media experts was conducted using the Percent of Agreement (PoA) technique, aimed to measure the consistency between the two experts' assessments of the interactive module feasibility instrument.

Tabel 5. Percent of Agreement

No	Statements' summary	Validator 1	Validator 2	Validator Dichotomy 1	Validator Dichotomy 2
1	Aligned with functionality/usability	4	4	Yes	Yes
2	Represents feasibility indicators	4	3	Yes	Yes
3	Differentiates the roles of experts	3	2	Ya	No
4	Sentences are easy to understand	4	3	Yes	Yes
5	Consistency in technical terms	3	3	Yes	Yes
6	Free from multiple interpretations	2	2	No	No
7	Statements are objective	4	3	Yes	Yes
8	An appropriate scale is used	3	4	Yes	Yes
9	The number of indicators is sufficient	3	2	Ya	No
10	The questionnaire is feasible for use	4	4	Yes	Yes

The calculation of the Percentage of Agreement (PoA) for the e-module feasibility questionnaire, as assessed by media experts, also showed a score of 80%, indicating that 8 out of 10 statements were validated with identical ratings from both validators. Furthermore, the reliability test of the Problem-Based Learning (PBL)-based interactive module was conducted using Web Application Performance Testing (WAPT) software to evaluate the stability and consistency of system performance when accessed simultaneously by multiple users.



Test execution parameters:
Test status: finished
Test started at: 21/04/2025 09:39:28
Scenario name:
Test run comment:
Test executed by: Lenovo (LAPTOP-3LLFNARF)
Test executed on: LAPTOP-3LLFNARF
Test duration: 0:10:00

Test result: SUCCESS

Pass/Fail Criteria

Name	Result	Comment
Session error rate for each profile	SUCCESS	

Summary

Profile	Successful sessions	Failed sessions	Successful pages	Failed pages	Successful hits	Failed hits	Other errors	Total KBytes sent	Total KBytes received	Avg response time, sec (with page resources)
e-module	5047	0	10098	0	91129	289	0	64081	1500793	0.14(0.65)

Figure 3. WAPT (Web Application Performance Testing)

Based on the test results, the interactive module achieved a GTmetrix Grade A, with a Performance score of 94% and a Structure score gained 92%. These results indicate that the system demonstrates excellent code structure and page loading speed.

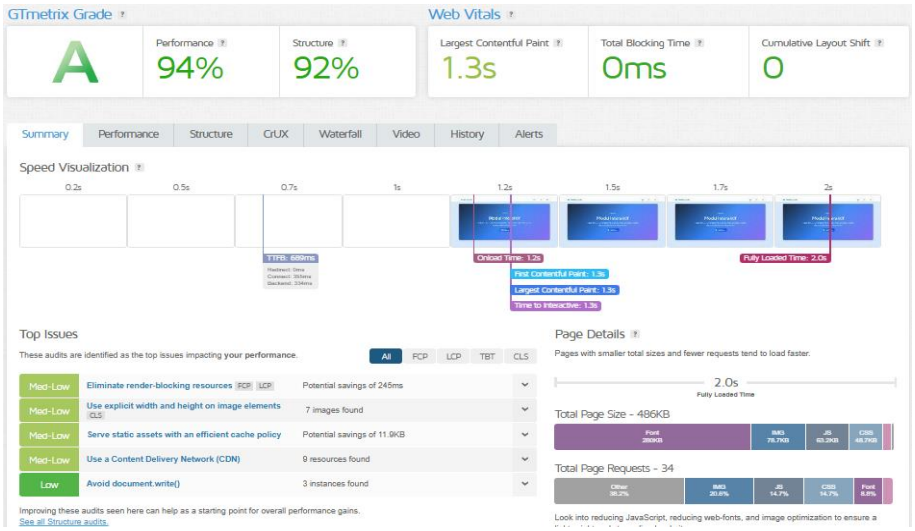


Figure 4. GT Matrix Efficiency Testing

With a relatively small page size of 486 KB and an efficient number of 34 requests, the interactive module demonstrates high performance and is feasible for use in digital learning contexts.

Interactive Module Practicality

The Coefficient of Reproducibility (Kr) indicates the degree to which respondents' response patterns can be consistently reproduced under the assumptions of a cumulative scale.

$$Kr = 1 - (\frac{15}{10\ x\ 20})$$
$$= 1 - (\frac{15}{200})$$
$$= 1 - 0{,}075$$
$$= 0.925$$

The Kr score of 0.925 exceeded the recommended minimum threshold of 0.90, indicating that the practicality questionnaire for the interactive module demonstrates high consistency and is suitable for measuring practicality on a cumulative scale. The Coefficient of Scalability (Ks) reflects the extent to which the questionnaire items can distinguish different levels of practicality among respondents. The formula used is as follows:

$$Ks = \frac{(0.925 - \frac{1}{5})}{(1 - \frac{1}{5})} = \frac{0.875}{0.95} = 0.921$$

Module Interactive Effectiveness

The improvement of students' logical thinking skills after using the Problem-Based Learning (PBL)-based interactive module was analyzed using the N-Gain calculation. The results showed that the average N-Gain value was 0.91, equivalent to 91%, which falls into the high category according to the N-Gain classification developed by Hake (1998). The classification is as follows: an N-Gain value above 0.7 indicates a high level of improvement; a value between 0.3 and 0.7 indicates a moderate improvement; and a value of 0.3 or lower indicates a low level of improvement. The effectiveness test of the PBL-based interactive module on students' logical thinking skills further revealed a difference in average scores between the experimental group and the control group.

Table 6. Group Statistic (Independent test)

	Class	N	Mean	Std. Deviation	Std. Error Mean
Logical Thinking	Post-test of Experiment Class	30	90.0900	5.803388	1.059549
	Post-test of Control Class	30	67.2667	5.218887	0.952834

Table 7. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
N-gain	Equal variances assumed	1.329	.254	16.585	58	.000	23.63333	1.42497	20.780	26.485
	Equal variances not assumed			16.585	57.358	.000	23.63333	1.42497	20.780	26.486

DISCUSSION

The interactive module development of HTML, CSS, and PHP was designed by ADDIE, and ISO 9126 software quality standards ensured pedagogical and technical robustness (Djouab & Bari, 2016; Lee et al., 2024; Zainuddin & Miftahul, 2019). The integration of interactive elements such as syntax highlighting, live code previews, and structured learning tasks was intended to enhance learner engagement and comprehension. This design aligned with previous studies (Manuel et al., 2019; Maulana, 2025; Popović & Naumović, 2016; Priyaadharshini et al., 2020; Wahroni et al., 2024), which emphasized that combining instructional design principles with software quality benchmarks enhanced usability and learning efficiency in digital learning environments.

The feasibility test, which involved two material experts and two media experts, yielded high scores in terms of functionality and usability (Puspito, 2024). The CVR values indicated that all assessment items met the validity threshold, while the Percentage of Agreement exceeded the 75% standard, confirming evaluator consensus. These findings demonstrate that the interactive module not only fulfills the functional requirements of digital learning resources but also provides a user-friendly interface that supports smooth navigation and content accessibility. Furthermore, this result is consistent with previous studies (Amalia et al., n.d.; Asfiya et al., 2024; Endaryati et al., 2021), which emphasize that interactive modules with high functionality and usability contribute to greater learning continuity and learner satisfaction.

The practicality evaluation was measured through the Coefficient of Reproducibility (Kr) and Coefficient of Scalability (Ks), which demonstrated high reproducibility and acceptable scalability. The data depicted that the interactive module is easy to understand, can be applied consistently across different learning groups, and does not require extensive additional guidance. The practicality is crucial in the higher education context (Kartikasari et al., 2024). Darmawan et al. (2015) explained that interactive modules enhance learner autonomy and reduce dependence on direct instructor intervention.

The effectiveness test, conducted using a quasi-experimental design, revealed that students in the experimental class achieved significantly higher N-Gain scores compared to those in the control class. This finding indicates that the interactive module successfully enhanced logical thinking skills, as further supported by the significant results of the independent t-test ($p < 0.05$). The validity was depicted in item analysis, where reliability gained KR-20 > 0.70, an appropriate difficulty level, and a satisfactory discrimination index of the test items were found. These findings are consistent with previous studies (Abdelmoneim et al., 2022; Ruihong, 2024), which reported that interactive and contextually relevant modules improve higher-order thinking skills by providing problem-based and exploratory learning experiences (Su et al., 2025).

The results of this study demonstrate that the developed interactive module not only meets technical quality criteria but also achieves

pedagogical objectives by effectively supporting student learning. This dual achievement, which fulfills both instructional and software quality standards, positions the interactive module as a replicable model for other courses in higher education.

CONCLUSION

This study successfully developed an interactive module based on the ADDIE model and ISO 9126 software quality standards. Validation by material and media experts confirmed that the module meets high standards of functionality and usability, as evidenced by strong CVR values and a high Percentage of Agreement score. The practicality test demonstrated that the module is user-friendly, adaptable to various learning contexts, and supportive of independent learning. Furthermore, the effectiveness test, conducted through a quasi-experimental design, revealed that the module significantly enhanced students' logical thinking skills, as reflected in higher N-Gain scores and statistically significant differences between the experimental and control groups.

Item analysis demonstrated that the evaluation instrument possessed strong validity, high reliability, appropriate difficulty levels, and a satisfactory discrimination index of the test items. Collectively, the developed interactive module not only meets both technical and pedagogical quality criteria but also provides a replicable model for technology-enhanced learning in higher education. The integration of instructional design principles with software quality standards offers a practical approach to creating digital learning resources that are effective, engaging, and sustainable. Future research may extend this model to other subject areas and examine its long-term impact on students' higher-order thinking skills and learning autonomy.

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