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The Development of Interactive Multimedia Based on Problem-Based Learning to Enhance Computational Thinking in Computer Hardware Studies

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Abstract:
Efforts to optimize higher-order thinking skills particularly computational thinking (CT) in the field of computer science now heavily rely on the availability of digital learning resources. However, the teaching of computer hardware topics is often delivered through conventional methods, which limits students' ability to understand the relationships between physical components and solve spatial-systematic problems. Addressing this issue, this study was designed to develop an interactive multimedia learning tool that integrates the Problem-Based Learning (PBL) framework to stimulate students' computational thinking skills in the context of computer hardware. The methodological framework employed was Research and Development (R&D) based on the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). A field-scale test was conducted at SMP Negeri 56 Surabaya with 30 seventh-grade students in the Computer Science course, using data collection instruments that included observation, interviews, questionnaires, expert validation, and a computational thinking (CT) test instrument measuring four main dimensions: decomposition, pattern recognition, abstraction, and algorithm formulation.Based on evaluations by subject matter experts, instructional media specialists, and Computer Science educators, this product achieved an average validation score of 92%, placing it in the "highly suitable" category. In terms of effectiveness, there was a significant increase in students' average computational thinking scores, rising from 9.23 on the pre-test to 15.13 on the post-test. Statistical analysis using the Wilcoxon Signed-Rank Test confirmed a statistically significant shift in scores between the pre- and post-intervention phases, as indicated by a Z-score of -4.7 and an Asymp. Sig. (2-tailed) of 0.0000015. Furthermore, the N-Gain index, recorded at 0.57, indicates a moderate improvement in computational thinking skills. These empirical results confirm that the developed PBL-based interactive multimedia is both highly suitable and effective

for supporting the enhancement of students' computational thinking regarding computer hardware within the scope of this study.

Introduction (مقدمة)

The integration of digital technology into modern education has underpinned a shift in the instructional paradigm toward strengthening 21st-century skills, particularly higher-order thinking skills such as computational thinking (CT). In the field of computer science, computational thinking occupies a central position as a foundation that trains students to formulate and solve complex problems systematically through the stages of decomposition, pattern recognition, abstraction, and algorithmic flow design (Aljameel, 2022; Wang & Wong, 2025). Various global education policies have also incorporated elements of computational thinking into the curriculum to accelerate students' digital literacy and analytical skills. In line with this, the findings of Liu et al. (2024) confirm that the emphasis on computational thinking at the elementary and secondary school levels continues to show an upward trend, although it is still marked by challenges related to teachers' pedagogical readiness to integrate this conceptual domain into classroom activities. Furthermore, other literature confirms that computational thinking has now evolved into a cross-disciplinary competency that underpins innovation and problem-solving abilities across various scientific fields (Hurt et al., 2023; Warsiyah et al., 2022). Given these dynamics, the development of new instructional approaches capable of transforming computational thinking so that it can be applied in a practical and contextual manner within computer science has become an urgent priority.

Although the Merdeka Curriculum framework has addressed this need by incorporating computational thinking competencies into the computer science curriculum, the practical application of learning on computer hardware topics still faces significant obstacles (Tofel-Grehl et al., 2022). Instruction on computer architecture and physical components at the lower secondary level is, in fact, still dominated conventional methods, such as one-way content delivery and the passive use of presentation slides (Lubacha-Sember et al., 2023). Such an approach leads students to merely memorize technical terms without truly understanding the functional relationships between components, system operating mechanisms, or hardware-based problem-solving. The nature of computer hardware which involves concrete objects and interactions between subsystems actually requires visualization tools and dynamic learning experiences to foster a deep conceptual understanding. Widiningrum et al. (2021) demonstrate that the use of digital visualization, interactive simulations, and technology-based media is highly effective in boosting learning motivation while optimally accelerating the understanding of computational thinking compared to traditional instructional methods. Therefore, the design of contemporary learning media must be oriented not only toward delivering content but also toward providing students with opportunities to actively analyze problems (Lubacha-Sember et al., 2023; Vives et al., 2024).

To address these instructional challenges, one approach that can be optimized is the development of interactive multimedia based on Problem-Based Learning (PBL). The interactive multimedia format facilitates the integration of various content formats ranging from text, illustrations, animations, video recordings, simulations, to instant feedback thereby creating a far richer and more contextual learning ecosystem (Lubacha-Sember et al., 2023).When integrated with the PBL framework, these multimedia tools shift their role from merely conveying information to serving as an active learning environment that guides students in identifying the root causes of problems, analyzing contributing factors, weighing various solution options, and executing solutions in a systematic manner (Kusaeni et al., 2024). Several previous studies have demonstrated that the Problem-Based Learning framework has a significant positive impact on the development of computational thinking, as students are encouraged to engage directly in the process of investigation, independently organize their understanding, and evaluate the solutions they formulate (Pratiwi & Akbar, 2022; Suhendar et al., 2021). However, the use of PBL-oriented interactive multimedia has thus far been dominated by the fields of science, mathematics, character education, and database systems, while its application to computer hardware topics specifically aimed at enhancing computational thinking remains relatively limited.

A review of the literature on previous research reinforces the fact that interactive multimedia based on Problem-Based Learning plays a strategic role in enhancing the quality of learning. A study by Hermawan et al.(2025), which designed PBL media using the ADDIE model for database material, successfully achieved a high level of validity while also making a positive contribution to strengthening students' computational thinking. In line with these findings, research by Devi et al. (2025) and Siregar (2019) confirmed that PBL-based learning tools met the criteria for feasibility, practicality, and effectiveness based on a series of expert reviews and field trials. However, there are limitations in the scope of previous studies because their focus tended to be on general cognitive learning outcomes, broad problem-solving, or topics outside of computer hardware. Computer hardware education still requires media support capable of bridging the physical concepts of hardware with problem-solving activities that develop computational thinking indicators (Hodges et al., 2020; Rafiq et al., 2023). Therefore, the development of PBL-based interactive multimedia specifically tailored to computer hardware content is crucial because it can present visual representations, interactive activities, and contextual problems that align with the characteristics of this topic.

Based on a synthesis of various previous studies, several gaps have emerged that serve as the starting point for this research (Oduro et al., 2024). First, previous PBL-based interactive multimedia development has primarily focused on measuring cognitive learning outcomes or general problem-solving skills, while computational thinking has not been prioritized as a central focus in media design. Second, research on computational thinking has so far been predominantly concentrated in the fields of programming, robotics, and STEM approaches, whereas its application to foundational computer systems topics such as computer hardware remains limited (Chevalier et al., 2020). Third, no PBL-based interactive multimedia design has yet been found that can integrate the visualization of physical computer components, problem-solving processes, and computational thinking indicators into a single, structured media unit. Based on this, this study offers novelty through the development of Problem-Based Learning (PBL)-based interactive multimedia focused on computer hardware learning to accelerate students' computational thinking (Hermawan et al., 2025). The distinguishing strength of this study lies in the media design, which does not merely present the subject matter of computer hardware but aligns each stage of PBL with systematic activities that train indicators of decomposition, pattern recognition, abstraction, and algorithm formulation.

In light of the aforementioned issues and the theoretical-practical gap, this study aims to develop Problem-Based Learning (PBL)-based interactive multimedia on computer hardware that is validated, practical, and effective in enhancing students' computational thinking. This study adopted the Research and Development (R&D) method, conducted at SMP Negeri 56 Surabaya during the odd semester of the 2026/2027 academic year, involving seventh-grade students in the Computer Science course. The R&D approach was chosen because its testing characteristics are oriented toward the creation of educational products through systematic stages, ranging from needs identification, design, development, testing, to final evaluation (Mulia & Lena, 2021). The ADDIE model was applied as the foundation for development because it provides a structured workflow while allowing for continuous product improvement through formative evaluation. Through the implementation of this study, the resulting multimedia is expected to contribute theoretically to the design of PBL-based learning media in the field of computer science education, while also serving as a practical solution for educators in creating dynamic, interactive computer hardware instruction that fosters the development of higher-order thinking skills (Putra et al., 2024).

Method (منهج)

This research project was conducted at State Junior High School No. 56, Surabaya, during the first half of the 2026/2027 academic year. The study utilised the Research and Development (R&D) methodology to design interactive multimedia resources based on the Problem-Based Learning (PBL) model, specifically for the topic of computer hardware components. The research procedure comprised the following stages: needs analysis, design, prototyping, field implementation, and product evaluation. Data collection was carried out through observation, interviews, questionnaires and tests, which were subsequently evaluated using both quantitative and qualitative descriptive methods to assess the validity, usability and effectiveness of the multimedia resource developed.

Research Design

This study employed a Research and Development (R&D) design focused on designing an integrated, interactive multimedia instrument for Problem-Based Learning (PBL) on the topic of computer hardware to accelerate students' computational thinking (Tirahna et al., 2024). The R&D framework is defined as a research methodology oriented toward creating and testing the reliability of educational products to ensure they meet standards of validity, practicality, and effectiveness through a systematic development cycle. The tangible outputs developed in this study include interactive multimedia tools tailored to students' characteristics and designed to meet the computer science learning outcomes outlined in the Merdeka Curriculum.

This research project employs a research and development (R&D) approach, with the primary objective of creating interactive multimedia resources based on the Problem-Based Learning (PBL) model for the subject area of computer hardware, in order to optimise students' computational thinking skills. The R&D approach itself is understood as an investigative procedure that does not merely focus on testing a theory, but also produces valid, user-friendly and effective educational outputs through a structured design process (Hodges et al., 2020). In this study, the designed tool takes the form of interactive multimedia media specifically tailored to the characteristics of the learners and the learning requirements of the Computer Science subject within the framework of the Merdeka Curriculum.

The design framework employed is based on the ADDIE model, which comprises five main phases: Analysis, Design, Development, Implementation and Evaluation. The selection of the ADDIE model was based on its ability to provide a structured workflow, starting from the analysis of requirements through to the final evaluation of the product, thereby enabling the creation of a learning tool that meets the criteria of validity, practicality and effectiveness. Furthermore, this framework is flexible in nature, allowing for improvements to be made at each stage based on the findings of formative evaluation. Thanks to this mechanism, the multimedia resources developed can be tailored precisely to the characteristics of the users and achieve optimal quality before being formally implemented in learning activities.

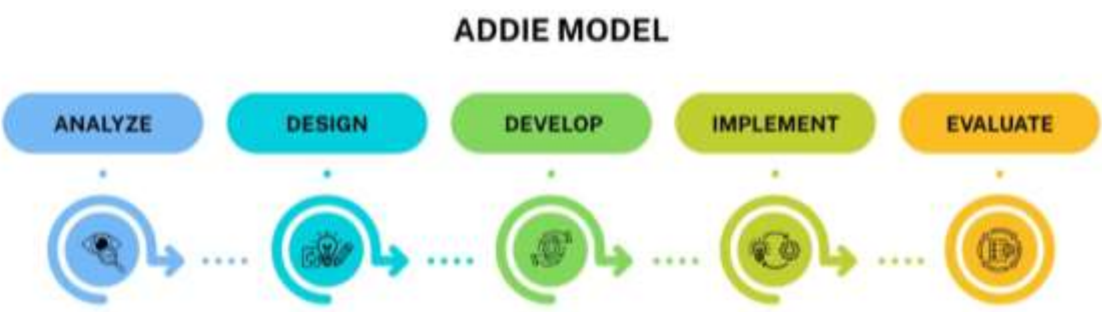

Figure 1. Development of the ADDIE Model

Research Participants

The research was conducted at State Junior High School 56, Surabaya, throughout the odd semester of the 2026/2027 academic year. The participants comprised Year 7 pupils studying the subject of Information Technology, with a focus on computer hardware. The sample was selected using purposive sampling. This decision was based on the consideration that the pupils had completed the foundational digital literacy learning in line with the learning outcomes of the Merdeka Curriculum. During the validation phase, the review of the product involved two subject matter experts, two media experts, and an Information Technology teacher acting as a teaching practitioner. The media was then tested with the pupils through small-group trials and field trials to gather data on the practicality and effectiveness of the interactive multimedia designed. The research was conducted at State Junior High School 56 in Surabaya throughout the odd semester of the 2026/2027 academic year. The participants comprised Year 7 pupils studying the subject of Computer Science, with a focus on computer hardware. The sample was selected using purposive sampling. This decision was based on the consideration that the pupils had already completed the foundational digital literacy learning in line with the learning outcomes of the Merdeka Curriculum. During the validation phase, the product review involved two subject matter experts, two media experts, and an Information Technology teacher acting as a teaching practitioner. The multimedia was then tested with the pupils through small-group trials and field trials to gather data on the practicality and effectiveness of the interactive multimedia designed.

Research Instruments

The data collection methods in this study utilised an assessment toolkit comprising both test-based and non-test-based instruments. The non-test-based instruments included activity observation sheets, interview guides, and a feasibility assessment questionnaire, which were submitted to subject matter experts and media experts to assess the quality standards of the designed teaching materials. These validation sheets employed a five-point Likert scale, ranging from a score of one for the 'strongly disagree' category to a score of five for the 'strongly agree' category. The scope of the assessment covered content, linguistic aspects, presentation techniques, visual layout, navigation controls, the level of interaction, and alignment with the steps of Problem-Based Learning.

Furthermore, a student feedback questionnaire was distributed to measure the practicality of the media following its direct use in the classroom. To assess the effectiveness of the product, this study employed computational thinking tests administered before the learning activities began (pre-test) and after the material had been fully delivered (post-test). The computational thinking parameters assessed included decomposition, pattern recognition, abstraction and algorithm design. Throughout the media implementation phase, student activity observation sheets were also used to gather supplementary data on the level of student engagement during the teaching and learning activities.

Data Analysis Techniques

The research data were analysed using quantitative and qualitative descriptive analysis. The data from the expert validation were analysed using the feasibility percentage, calculated using the formula :

$$\text{Feasibility Percentage} = \frac{\sum X}{\sum X_i} \times 100\%$$

Description:

ΣX = total score achieved

ΣXi = maximum score

The results of the calculations were then interpreted on the basis of the eligibility criteria set out in Table 1.

Percentage	Category
81–100%	Well worth it
61–80%	Suitable
41–60%	Quite Decent
21–40%	Not Quite Up to Standard
0–20%	Unsuitable

Data on practicality was obtained from questionnaires completed by teachers and pupils, then analysed using the same percentage formula and interpreted according to the product's practicality categories.

The effectiveness of multimedia was analysed using the Normalised Gain (N-Gain) value, calculated using the formula:

$$N\text{-Gain} = \frac{\text{Post-test Score} - \text{Pre-test Score}}{\text{Maximum Score} - \text{Skor Pre-test}}$$

The N-Gain scores were interpreted in accordance with Hake's categories, namely: high if the value is greater than or equal to 0.70, moderate in the range of 0.30 to 0.69, and low if less than 0.30. Meanwhile, qualitative information gathered through interviews, direct observation and input from expert assessors is analysed using an interactive analysis method comprising the stages of data reduction, information presentation and the formulation of conclusions. This multimedia learning tool is categorised as highly suitable if it achieves a score of between 90 per cent and 100 per cent. Conversely, if the score is below 61 per cent, the tool must undergo improvements before being implemented in teaching and learning activities.

Results (نتائج)

Needs Analysis

The needs assessment phase drew upon the findings of direct observations carried out on 24 March 2026 at State Junior Secondary School No. 56, Surabaya, during a Year 7 Computer Science lesson. This observation was carried out to identify the teaching situation, the use of learning resources, and the obstacles encountered by pupils when learning about the physical components of a computer. Based on the findings of this review, it was identified that there is an urgent need for teaching materials capable of providing a more dynamic learning experience through visual presentations, opportunities for interaction, and problem-solving activities. Consequently, an interactive multimedia tool based on the Problem-Based Learning model was designed as an alternative solution to meet the students' needs. This teaching tool was specifically developed to help students master the theory of computer hardware whilst optimally honing their computational thinking skills.

Product Design and Development

The results of the needs analysis formed the basis for the start of the design and construction phases of an interactive multimedia system oriented toward Problem-Based Learning (PBL) in the field of computer hardware. During the design phase, the development of the media architecture focused on aligning the instructional flow, interface layout, practicality of the navigation system, and content mapping to meet the learning outcomes for Computer Science. The digital learning environment developed integrates various content formats such as text narratives, decorative-descriptive images, animations, and interactive elements to stimulate active student engagement while facilitating conceptual understanding of the physical components of computer systems. This media framework is structured so that students can progress systematically, beginning with an understanding of foundational concepts, identifying the root causes of problems, formulating alternative solutions, and finally assessing learning outcomes.

The construction phase produces an interactive multimedia output that includes a home page, main navigation, content area, problem-based activity modules, and an evaluation section. The home page serves as the visual identity of the media, while the main menu functions as a control center for efficiently accessing all learning features. In the content section, information about computer hardware is presented through text descriptions, scaled visualizations, and graphical maps to clarify functional roles and interrelationships among physical components. In addition to presenting the subject matter, this multimedia product provides contextual case simulations that prepare students to analyze technical issues with hardware, diagnose problems, identify root causes, and determine the most precise solutions.

The Problem-Based Learning model is integrated through learning stages that place students at the center of the learning process. Students not only receive information about computer components but are also engaged in problem-solving through exploration and decision-making activities. These activities are designed to support the development of computational thinking indicators, namely decomposition breaking down problems into simpler parts pattern recognition identifying relationships between components abstraction selecting key information and algorithm design formulating systematic problem solving steps. With this design, PBL based interactive multimedia serves not only as a medium for delivering content but also as a tool for practicing computational thinking in the context of computer hardware learning. The layout of the opening page and the main menu of this Problem-Based Learning-standard interactive multimedia is illustrated in Figure 2.

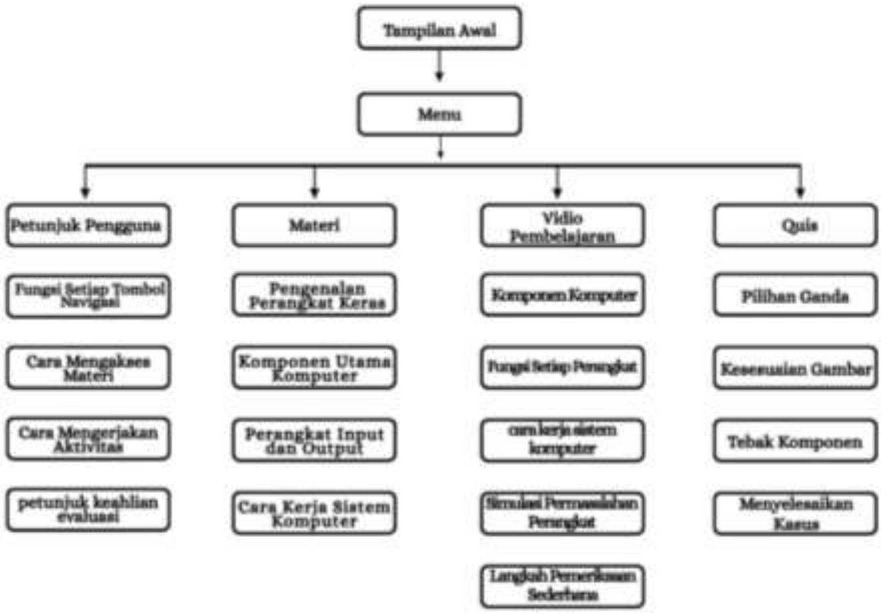

Figure 2. Interactive Multimedia Layout Design

Results of the Feasibility Validation of Interactive Multimedia

A product feasibility testing phase was carried out to ensure the quality of the interactive multimedia, based on the Problem-Based Learning model, prior to its direct use by pupils. This validation process involved three assessors: a subject matter expert, an educational media expert, and a teacher of the Computer Science subject. The quality of the teaching material was evaluated using a Likert-scale questionnaire, with assessment criteria covering content, visual presentation techniques, linguistic aspects, interface layout, navigation system, level of interaction, and alignment with the stages of the Problem-Based Learning model.

Table 2. Expert Validation Results

Validator	Percentage	Category
Subject Matter Expert	92%	Well worth it
Media Expert	94%	Well worth it
IT Teacher	90%	Well worth it
On average	**92%**	**Well worth it**

Referring to the data in Table 2, the validity test results show that the interactive multimedia tool achieved an average percentage score of 92 per cent, with a rating of 'highly suitable'. The subject matter assessor awarded a score of 92 per cent, indicating that the content, presentation of concepts and educational alignment met the suitability standards. Meanwhile, the media expert awarded a score of 94 per cent, indicating that the visual layout, navigation controls and level of interaction of the digital tool are in line with the criteria for modern learning tools. The evaluation by the Computer Science teacher also recorded a score of 90 per cent, again in the 'highly suitable' category. These results suggest that this multimedia product is ready for use in Computer Science learning activities and meets the needs of the pupils. Taking into account the overall assessment results, this interactive multimedia tool, based on the Problem-Based Learning model, has been declared to have fully met the eligibility standards and is ready to proceed to the field implementation stage.

Results of a Test of the Effectiveness of Multimedia on Computational Thinking

The effectiveness of interactive multimedia tools was evaluated by comparing students' scores on computational thinking tests taken before (pre-test) and after (post-test). This study involved thirty pupils who took part in a learning process using media based on the Problem-Based Learning model. The evaluation process was carried out by comparing the difference in pupils' average scores and measuring the extent of improvement through the calculation of Normalised Gain (N-Gain) scores.

Tabel 3. Descriptive Statistics of Pre-test and Post-test Results

Statistik	Pra-tes	Tes pasca-tes
Number of pupils	30	30
Minimum value	6	9
Maximum value	12	20
On average	9,23	15,13

As shown in Table 3, a significant increase in pupils' average scores was evident following the use of interactive multimedia based on the Problem-Based Learning model. The average pre-test score, which was initially 9.23, rose to 15.13 when the post-test was conducted. This increase of 5.90 points demonstrates a tangible improvement in pupils' abilities following their participation in learning activities using the teaching materials that had been designed.

Results of the Statistical Analysis of the Pre-test and Post-test

Before conducting tests to detect differences between pre-test and post-test scores, a normality test must first be carried out in order to determine the appropriate statistical method. The normality test utilised the Shapiro-Wilk procedure, which was applied to the differences between pre-test and post-test scores. Full details of the normality test findings are then presented in Table 4.

Table 4. Results of the Shapiro-Wilk Normality Test

Data	Statistics	Signature
Difference between Pre-test and Post-test	0.899	0,008

Based on the findings of the data distribution analysis, a significance level of 0.008 was obtained, which is below the threshold of 0.05. This indicates that the data distribution does not follow a normal pattern. Consequently, the analysis comparing the results before and after the trial was continued by applying a non-parametric statistical method, namely the Wilcoxon Signed-Rank Test.

Table 5. Results of the Wilcoxon Signed-Rank Test

Testing	Value
Z	-4,7
Asymptomatic. Significance (two-tailed)	1,5E-06

Based on the results of the Wilcoxon test, a significance value of 0.0000015 was recorded, which is below the threshold of 0.05. These findings confirm that there is a highly significant difference in pupils' thinking skills between before and after using interactive multimedia based on the Problem-Based Learning model.

Results of the N-Gain Analysis

The assessment of pupils' progress in competencies is also carried out using the Normalised Gain (N-Gain) measure. The N-Gain calculation is used to measure the degree of improvement in pupils' abilities based on a comparison of their scores before and after the learning activity. The details of the N-Gain calculations are set out in full in Table 6.

Table 6. N-Gain Calculation Results

Components	Value
Average N-Gain	0,57
Category	Currently

Based on the findings of the analysis, the average N-Gain score was 0.57, which falls within the 'moderate' category. This result confirms that the use of interactive multimedia based on the Problem-Based Learning model has proven successful in boosting pupils' computational thinking skills during learning activities. Considering the overall results of the validity tests and the evaluation of the product's effectiveness, the teaching tool developed has been shown to fully meet the standards of suitability and is capable of supporting the improvement of pupils' competencies in the subject area of computer hardware.

Discussion (مناقشة)

This research successfully implemented an interactive multimedia design based on Problem-Based Learning (PBL) in the field of computer hardware, focused on accelerating students' understanding of computational thinking (Hermawan et al., 2025). Adopting a Research and Development (R&D) method based on the ADDIE model, the learning tool developed here integrates concept presentation, visualization of physical computer system components, problem-simulation modules, and cognitive assessment instruments. The integration of PBL principles into this multimedia format enables students to go beyond merely absorbing hardware material; instead, they become accustomed to analyzing problems, mapping functional interrelationships among components, and systematically devising problem-solving scenarios. This instructional approach aligns with the ideas of Liu et al. (2024), who emphasize the importance of active learning strategies focused on analysis, decision-making, and solution formulation in fostering computational thinking skills at the elementary and secondary school levels.

Based on the feasibility testing, this multimedia product achieved an average validation score of 92% with a "highly feasible" rating, derived from evaluations by subject matter experts (92%), media experts (94%), and computer science teachers (90%). This result demonstrates that the designed media meets reliability criteria in terms of content coverage, interface aesthetics, navigational practicality, interactivity, and alignment with the PBL process. This finding reinforces the results of Hermawan et al. (2025) study regarding the effectiveness of PBL-based multimedia developed using the ADDIE model in producing high-validity products that effectively foster computational thinking. Furthermore, these empirical findings align with the argument by Putra et al. (2024) that PBL-oriented interactive media can enhance the quality of the learning process by presenting more contextual problem-solving activities. Nevertheless, the novelty of this study lies in its focus on exploring media specifically related to computer hardware, unlike the majority of previous studies, which tended to explore the database domain or other computer science topics.

The enhancement of computational thinking following the use of interactive multimedia demonstrates that the integration of PBL principles can create a dynamic and participatory learning experience. Field data show a significant increase in students' average scores, rising from 9.23 on the pre-test to 15.13 on the post-test. The results of the Wilcoxon Signed-Rank Test validate these findings with a Z-score of -4.7 and an Asymp. Sig. (2-tailed) of 0.0000015, confirming a statistically significant shift in ability between before and after the media intervention. This decrease in probability indicates that the surge in students' scores represents a statistically significant difference, not merely descriptive data variation. These results reinforce the findings of Hongquan et al. (2021), who stated that problem-based learning methods effectively hone computational thinking skills by engaging students in analyzing challenges, designing solution strategies, and reflecting on the formulated solutions.

The N-Gain index calculation yielded a value of 0.57, placing the media's effectiveness in the moderate category. The fact that the improvement did not reach the high range indicates that students' improvements in computational thinking were also influenced by external variables, such as students' initial ability levels, the duration of media exposure, the intensity of student engagement while analyzing case simulations, and the quality of teacher guidance in the classroom. Nevertheless, these findings remain consistent with the conclusions of Hayati et al. (2023) and Seputra et al. (2025), which affirm the potential of PBL-based multimedia to boost student learning outcomes following the validation and field testing processes. Furthermore, these findings reaffirm the view that the development of computational thinking does not rely solely on programming content but can be fostered through problem-solving in foundational computer science topics such as computer hardware (Azmi & Ummah, 2021; Lubacha-Sember et al., 2023).

Comprehensively, the research findings confirm that the interactive multimedia based on Problem-Based Learning (PBL) that was developed meets validity criteria and has proven effective in enhancing students' computational thinking regarding computer hardware material. The primary scientific contribution of this study lies in the formulation of instructional media that successfully integrates the visualization of physical components, problem-solving instructions, and indicators of computational thinking into a cohesive digital ecosystem. However, the generalizability of these research results is still limited to the seventh-grade test subjects at SMP Negeri 56 Surabaya; therefore, replication in different learning environments, school levels, or student characteristics still requires verification through further research.

Conclusion (خاتمة)

This study successfully implemented an integrated interactive multimedia design based on Problem-Based Learning (PBL) for computer hardware material in the 7th-grade

Computer Science course at SMP Negeri 56 Surabaya by applying the ADDIE model of Research and Development (R&D). This educational tool was developed to optimize the instructional process through a combination of interactive content presentation and case-solving simulations aligned with the PBL framework. Based on expert evaluations, the resulting product was rated as highly suitable, with an average validation index of 92%, encompassing evaluations by subject matter experts (92%), media experts (94%), and Computer Science teachers (90%). These results demonstrate that this interactive medium comprehensively meets all feasibility criteria, including depth of content, visual aesthetics, ease of navigation, level of interactivity, and the accuracy of the applied learning framework.

The effectiveness of this PBL-based interactive multimedia was measured through a comparative evaluation of students' computational thinking skills before and after the media intervention. Field data showed an increase in the average student score from 9.23 on the pre-test to 15.13 on the post-test. Statistical analysis using the Wilcoxon Signed-Rank Test confirmed a statistically significant shift with a p-value of 0.0000015, while the N-Gain index of 0.57 indicates a moderate improvement in computational thinking. Based on these empirical findings, this PBL-based interactive multimedia product has been proven to be highly suitable and effective in facilitating seventh-grade students' learning of computer hardware within the scope of this study. Further research is expected to expand the scale of the pilot study and enrich the multimedia features to test the product's reliability in a wider range of instructional contexts.

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