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Multimedia Development in Guided Inquiry-Based Learning to Enhance Vocational High School Students' Computational Thinking Skills

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Abstrak

Penelitian ini bertujuan untuk mengembangkan pembelajaran berbasis multimedia dengan model Guided Inquiry-Based Learning guna meningkatkan keterampilan berpikir komputasional siswa Sekolah Menengah Kejuruan dalam menghadapi tantangan era Society 5.0. Metode yang digunakan adalah Research and Development (R&D) dengan model pengembangan ADDIE serta desain eksperimen one-group pretest-posttest untuk mengevaluasi efektivitas produk yang dikembangkan. Multimedia pembelajaran dirancang dengan integrasi permainan edukatif interaktif yang mendukung pembelajaran kontekstual dan pemahaman konsep abstrak. Hasil penelitian menunjukkan peningkatan skor rata-rata dari 41,30 pada pretest menjadi 67,83 pada posttest. Nilai n-gain pada empat elemen berpikir komputasional menunjukkan peningkatan sedang: dekomposisi (0,413), abstraksi (0,283), pengenalan pola (0,263), dan algoritma (0,337). Respon siswa terhadap penggunaan multimedia dan permainan edukatif menunjukkan tingkat kepuasan sebesar 82% yang tergolong dalam kategori “Sangat Baik.” Hasil ini menunjukkan bahwa pembelajaran dengan pendekatan Guided Inquiry berbasis multimedia interaktif efektif dalam meningkatkan keterampilan berpikir komputasional siswa dan sesuai dengan karakteristik pembelajar digital masa kini. Temuan ini merekomendasikan pendekatan ini sebagai strategi inovatif dan praktis dalam pembelajaran informatika di pendidikan vokasi.

Kata Kunci: Berpikir Komputasional; Guided Inquiry-Based Learning; Permainan Edukatif; Pendidikan Vokasi;

Abstract

This study aims to develop multimedia-based learning using the Guided Inquiry-Based Learning model to enhance computational thinking skills among vocational high school students in the context of Society 5.0. The research adopts a Research and Development (R&D) approach following the ADDIE model and employs a one-group pretest-posttest design to evaluate its effectiveness. The developed multimedia integrates interactive educational games to support engagement and conceptual understanding. The results indicate a significant increase in students' computational thinking abilities, with average pretest and posttest scores improving from 41.30 to 67.83. The normalized gain scores show moderate improvement across computational thinking elements: decomposition (0.413), abstraction (0.283), pattern recognition (0.263), and algorithmic thinking (0.337). Student responses reveal an 82% satisfaction rate, categorized as "Very Good," reflecting high levels of motivation and engagement. The use of multimedia and interactive games within a guided inquiry framework effectively supports contextual and abstract learning processes, demonstrating its potential as a practical and innovative solution to strengthen computational thinking skills in vocational education.

Keywords: *Educational Game; Guided Inquiry based Learning; Computational Thinking Skills; Vocational Education;*

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1. INTRODUCTION

One of the pressing problems in vocational education today is the insufficient development of students' computational thinking skills, particularly in programming-related competencies such as decision structures. Many students struggle to systematically break down problems and translate them into structured solutions, which hinders their success in algorithm and programming subjects. This problem becomes more urgent as education enters the Society 5.0 era, where students are expected to master higher-order thinking skills to navigate a technology-driven world (Fricetariani et al., 2023).

Wing (2006) emphasizes that computational thinking—which includes decomposition, abstraction, pattern recognition, and algorithm design—is not only vital for computer science but also for solving complex problems across disciplines. The 2021 PISA framework (OECD, 2018) reinforces its importance by embedding it into assessments of students' problem-solving abilities. However, studies in the Indonesian context reveal persistent difficulties. Supiarmo et al. (2022) found that students are often limited to decomposing problems but fail in abstraction and algorithm design. In vocational schools, particularly in programming subjects, students show low performance on decision structure tasks and report difficulty in understanding abstract programming logic (Pasaribu et al., 2023). Traditional lecture-based instruction further aggravates the issue by failing to connect theoretical concepts with real-world applications (Julianto & Ekohariadi, 2020).

Although the importance of computational thinking is widely acknowledged, its practical integration into vocational high school curricula remains insufficient. Most research has focused on general education settings, with little attention paid to how vocational students—who require more concrete and practice-oriented instruction—develop computational thinking through programming. Furthermore, while Guided Inquiry-Based Learning (GIBL) has shown promise in promoting deeper learning and critical thinking (Lindriani & Suwarna, 2023), and interactive multimedia such as educational games have been linked to increased student engagement (Kurniawati & Nita, 2022), there is limited empirical evidence on their combined application in vocational programming education. This underlines a significant gap in instructional innovation that is tailored to both the cognitive needs of vocational students and the demands of computational thinking.

In response to this gap, the objective of this study is to develop and evaluate a multimedia-enhanced Guided Inquiry-Based Learning model that targets the improvement of vocational high school students' computational thinking skills. Specifically, this research investigates: How effective is the integration of interactive multimedia into Guided Inquiry-Based Learning in enhancing students' computational thinking abilities—especially in mastering decision structures—in vocational education contexts?

2. METHOD

This study employed a Research and Development (R&D) approach aimed at designing and developing an interactive multimedia educational game, *BranchFun*, to enhance vocational high school students' computational thinking skills, specifically in understanding decision structures such as if, if-else, and switch in programming. The development of the media followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as proposed by Sugihartini (2018). To assess the effectiveness of the intervention, a one-group pretest-posttest design was applied, comparing students' performance before and after the learning activity.

The target population of this study consisted of Grade XI students from vocational school enrolled in the Software and Game Development program. The sample was selected through purposive sampling, with a specific focus on a PPLG class in a vocational school in Bandung, which included 23 students. This class was chosen based on its lower average scores compared to other classes, as well as the students' prior exposure to computational thinking and decision structures. This made it a suitable group to address the research objectives.

Two main instruments were used in this study. First, a computational thinking test was administered in the form of multiple-choice questions, 20 items for the pretest and 20 items for the posttest, covering decomposition, abstraction, pattern recognition, and algorithm design within the scope of decision structures. Second, a media evaluation instrument was adopted from the Multimedia Mania 2004, Student Checklist developed by North Carolina State University. This instrument was selected because it assesses key multimedia aspects, including mechanisms, multimedia components, information structure, documentation, and content quality (North Carolina State University, 2004).

The detailed research procedure is illustrated in Figure 1, which visually outlines the steps of the ADDIE model, from analysis to evaluation. The design phase involved developing instructional modules based on GIBL, constructing assessment tools (pretest, posttest, and student worksheets), and designing the *BranchFun* game. The game included guided inquiry elements, allowing students to identify problems, formulate hypotheses, and apply branching logic concepts in realistic programming contexts.

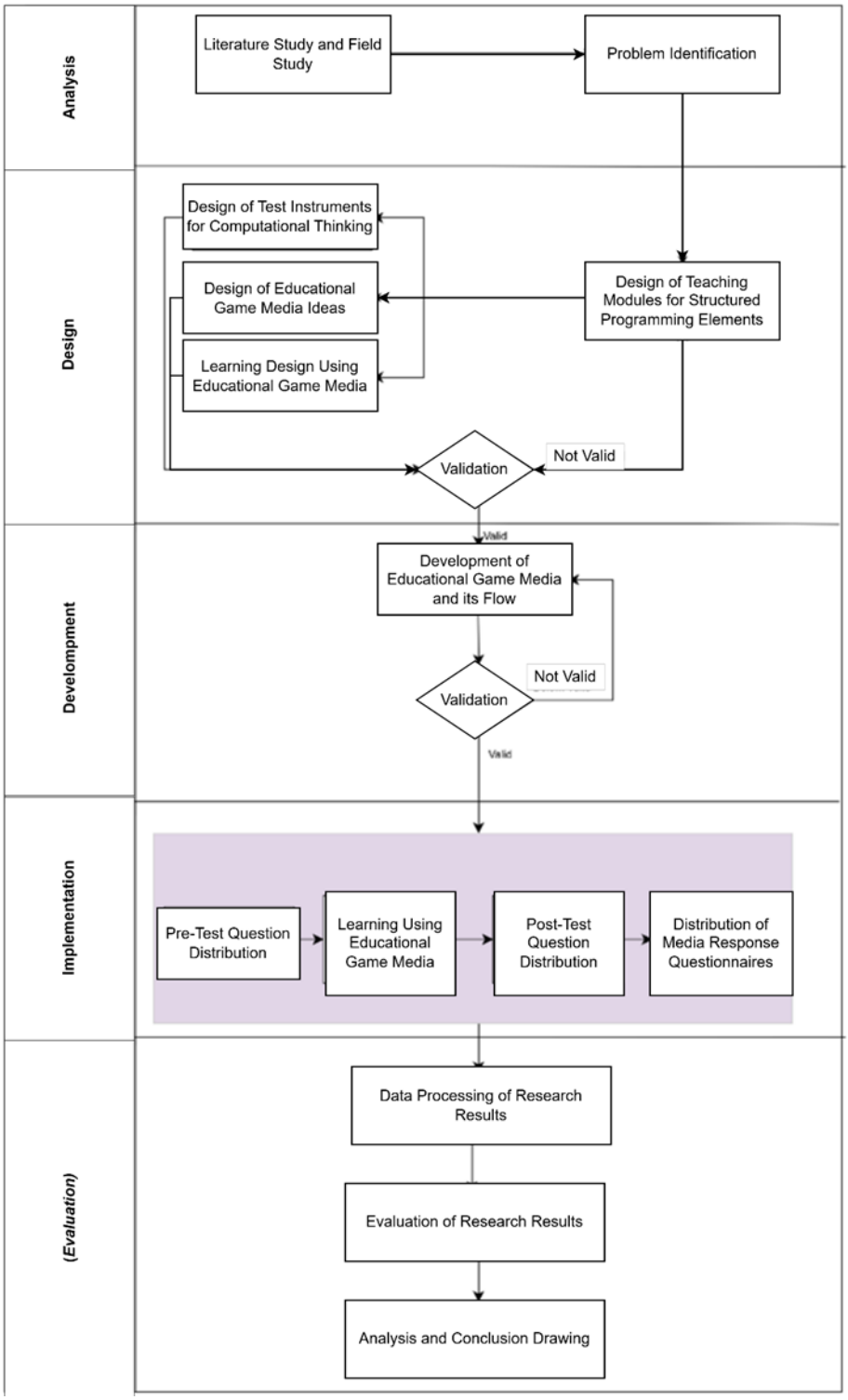

Figure 1. Research procedurs.

During the development phase, the *BranchFun* game was created and validated. It integrated key decision structure topics into an interactive, engaging format with branching exercises. Content and media

validation were conducted using the Multimedia Mania framework. Pilot testing was also carried out to identify and address technical or content-related issues.

The implementation phase involved deploying the BranchFun game in the classroom. Students were first given the pretest (O1) to assess their initial understanding. This was followed by learning sessions using *BranchFun* combined with GIBL strategies (X). After the intervention, a posttest (O2) was administered to measure learning outcomes. A questionnaire was also distributed to collect student feedback regarding the game's usability and educational impact.

In the evaluation phase, data from the pretest, posttest, and student responses were analyzed. Validation results were categorized using a rating scale: 0–25 (Not Good), 26–50 (Less Good), 51–75 (Good), and 76–100 (Very Good). The validity, reliability, difficulty level, and discrimination index of the test items were analyzed to ensure the quality of the instruments (Sugiarto & Gunawan, 2020). Additionally, the effectiveness of the learning intervention was measured using the normalized gain (N-gain). The N-gain results were then classified as High (0.71–1.00), Medium (0.31–0.70), or Low (0.00–0.30), based on Hake (1998). A normality test was also performed to determine whether the N-gain data distribution for upper, middle, and lower-performing students followed a normal distribution.

3. RESULT AND DISCUSSION

1. Analysis Stages

This phase involved a literature review, field study, and analysis of technical requirements to inform the development of an educational game aimed at improving vocational students' computational thinking skills. The literature review explored key concepts related to educational games, Guided Inquiry-Based Learning (GIBL), and computational thinking. Field observations and interviews at SMK Bina Wisata Lembang revealed students' difficulties in mastering branching concepts such as *if*, *else*, and *switch*, mainly due to the lack of interactive learning tools. A diagnostic test combining Bebras-style questions and branching tasks showed low performance, with only 50% of students reaching a satisfactory level. These findings validated the need for an engaging multimedia solution. Technical requirements included Windows 11, Unity, Canva, and mid-to-high-spec hardware to support game development.

2. Design Stages

In this phase, learning objectives, materials, and assessments were developed, followed by the design of a multimedia application named *BranchFun* based on the GIBL model. The game flow includes contextual case studies, mini-games, quizzes, instructional videos, worksheets, and interactive tasks focusing on if-else and switch constructs. A storyboard was developed to visualize the user interface and ensure that each component supports inquiry-based exploration and assessment. The design emphasizes structured interaction, feedback, and engagement, ensuring alignment with pedagogical goals.

3. Development Stage

The development phase involved designing and implementing an educational multimedia game titled *BranchFun*, as well as conducting expert validation using the Learning Object Review Instrument (LORI). The multimedia validation process was carried out by media experts who assessed nine aspects of quality. As shown in Table 1, the results indicate that the multimedia product falls under the "Very Good" category.

Table 1. Multimedia Validation

Evaluation Aspect	Score (%)
Content Quality	75
Learning Goal Alignment	81.25
Feedback and Adaptation	80
Motivation	80
Presentation Design	83.33
Interaction Usability	90
Accessibility	85
Standards Compliance	100
Average	**83.07**

The application begins with a home screen (Figure 2a) that displays the initial user interface featuring a group button for easy navigation. Users then enter the learning section (Figure 2b), where they choose between three stages:

IF ELSE, SWITCH, and QUIZ—each representing a key aspect of branching logic in programming. The session continues with a structured presentation of learning content, including case studies, problem formulation, data collection, and interpretation, all supported by the use of Student Worksheets (Figure 2c).

Figure 2. User Interfaces for Navigation and Learning Stage Selection. a) Homepage, (b) Stage Selection Menu, (c) Learning Session Overview.

Subsequent stages guide users through problem identification and hypothesis formulation (Figures 3a–3d). This includes activities such as replaying instructional videos, selecting IF/ELSE statements in response to scenarios, and using interactive programming examples to strengthen conceptual understanding.

Figure 3. Interfaces for Case Study, Problem Identification, and Hypothesis Formulation
(a) Case Study Display, (b) Problem Space Instructions, (c) Mini Quiz Interface, (d) Hypothesis Input Section

The learning is then reinforced through structured materials and interactive game-based exercises (Figures 4a–4c), including simulations based on weather conditions and a SWITCH logic game modeled on rock-paper-scissors. These components ensure both conceptual depth and learner engagement.

Figure 4. Interfaces for Content Reinforcement and Game-Based Learning
(a) Learning Material Page, (b) Game Level 1 – IF ELSE Logic, (c) Game Level 2 – SWITCH Logic

3.4. Implementation Stage

The implementation stage focuses on assessing the effectiveness of the *BranchFun* game as a learning tool for students. This stage is divided into three key phases: pre-test, treatment, and post-test. The purpose is to measure how well the BranchFun game, based on Guided Inquiry-Based Learning, enhances students' understanding of control structure branching (IF, IF ELSE, and SWITCH).

The pre-test serves as an initial evaluation of students' understanding of control structures, particularly IF, IF ELSE, and SWITCH statements. Two assessments were administered: the first consisted of 15 questions designed to evaluate students' computational thinking abilities, including problem decomposition, pattern recognition, abstraction, and algorithm design. The second set of 20 questions focused specifically on control structure concepts. The results identified areas where students struggled, particularly in applying logical thinking to problem-solving, which provided insights for refining subsequent instructional strategies.

In the treatment phase, the Guided Inquiry-Based Learning model was applied using the BranchFun game. The game guided students through contextual activities designed to promote the discovery and understanding of branching control structures. By engaging in problem-solving tasks that required the use of IF, IF ELSE, and SWITCH statements, students actively participated in applying their knowledge to real-world scenarios. This phase aimed to enhance conceptual understanding through interactive and collaborative learning. Furthermore, students were provided with Learning Activity Sheets (LKPD) to further solidify their understanding of branching concepts. The LKPD helped students reflect on what they had learned by guiding them through the application of these concepts to real-world problems. In addition, the LKPD allowed students to evaluate their understanding and receive feedback from the teacher, reinforcing the learning process.

Following the completion of the BranchFun game and the LKPD activities, students took a post-test to assess their improvement in understanding branching logic. The post-test measured changes in students' logical thinking and their ability to apply branching structures effectively. The pre-test and post-test results were compared to determine the impact of the BranchFun game as an interactive learning medium and the effectiveness of the Guided Inquiry-Based Learning approach.

3.5. Evaluation Stage

The evaluation phase assesses the effectiveness of the *BranchFun* learning media in improving students' computational thinking skills and their response to the interactive educational game. This phase involves statistical testing to measure the improvement in students' understanding and skills, as well as gathering feedback from students on their experience with the game.

A normality test was conducted to determine whether the data from the pre-test and post-test were normally distributed. The test used the Shapiro-Wilk method with the help of SPSS software. The p-values for both tests were greater than 0.05, indicating that the data is normally distributed and meets the assumption of normality. Since both p-values are greater than 0.05, the data is considered to be normally distributed.

The N-Gain test measures the improvement in students' scores from the pre-test to the post-test. The results (Table 2) showed an improvement across all student groups: Upper, Middle, and Lower. The N-Gain scores ranged from 0.38 to 0.90, with most students showing moderate improvement. The results show that all groups demonstrated moderate improvement in understanding control structures.

Table 2. Group Gain Score

Group	Description	Pretest	Posttest	Gain Score
Upper	Maximum Score	60	70	0.42
	Minimum Score	55	65	
	Average	56.78	75.00	
Middle	Maximum Score	50	80	0.40
	Minimum Score	35	45	
	Average	41.88	65.63	
Lower	Maximum Score	30	85	0.60
	Minimum Score	25	65	
	Average	27.50	71.25	

The N-Gain test for each computational thinking indicator, Decomposition, Pattern Recognition, Abstraction, and Algorithm Design (Table 3), showed significant improvements between the pre-test and post-test. The Decomposition indicator showed the highest N-Gain, followed closely by Abstraction and Pattern Recognition. All indicators fell under the "Moderate" improvement category.

Table 2. Group Gain Score

Indicator	Average Pretest	Average Posttest	Gain Score	Criteria
Abstraction	38.3	66.0	0.45	Moderate
Decomposition	48.7	75.6	0.52	Moderate
Pattern Recognition	54.7	75.7	0.46	Moderate

Algorithm Design	23.4	53.9	0.40	Moderate

Students' responses to the interactive multimedia educational game were assessed using the Multimedia Mania Student Checklist. This checklist evaluated various aspects of the game, including its mechanism, multimedia elements, information structure, documentation, and content quality. The results were as follows in Table 4. The overall average score was 82.0%, indicating that the interactive multimedia game was well-received by students. The highest scores were observed in the Documentation (86.1%) and Information Structure (83.5%) aspects.

Table 4. Results of Student Responses to Educational Games

No.	Aspect	Number of Items	Ideal Score	Acquisition Score	Percentage (%)
1	Mechanism	5	460	365	79.3
2	Multimedia Elements	2	230	184	80.0
3	Information Structure	2	460	384	83.5
4	Documentation	2	230	198	86.1
5	Content Quality	5	1495	1213	81.1
	Average				**82.0**

This evaluation phase demonstrates that the *BranchFun* game effectively enhances students' computational thinking skills and is positively received by students. The significant improvements in test scores and the high response rate for the multimedia game's quality suggest that the game has a meaningful impact on students' learning outcomes.

The results of this study support and extend the findings presented in the introduction. Consistent with Wing's (2006) and the OECD's (2018) emphasis on computational thinking as a foundational skill, the implementation of the BranchFun game with Guided Inquiry-Based Learning significantly enhanced students' abilities in decomposition, abstraction, pattern recognition, and algorithm design. The moderate N-Gain scores across all computational thinking indicators, particularly in decomposition (0.52), align with Supiarmo et al.'s (2022) observation that Indonesian students often struggle beyond the initial stages of problem-solving. This study demonstrates that combining interactive multimedia with inquiry-based strategies can help students move beyond simple decomposition and develop more advanced skills, such as abstraction and algorithmic reasoning.

Moreover, the findings offer empirical validation for the use of GIBL and educational games in vocational contexts, addressing the instructional gap noted by Julianto & Ekohariadi (2020) and Kurniawati & Nita (2022). The strong student engagement (average response score of 82%) confirms that such media not only support comprehension but also foster motivation—an essential factor in vocational education where abstract programming concepts often seem disconnected from real-world application. Thus, this study contributes important evidence that supports the practical integration of computational thinking into vocational curricula, particularly through media-enhanced, student-centered pedagogies.

4. CONCLUSION

The results of this study show that the BranchFun educational game, integrated with a Guided Inquiry-Based Learning approach, effectively improves students' understanding of branching control structures (IF, IF ELSE, and Switch) and enhances their computational thinking skills. N-Gain analysis revealed a moderate average improvement (0.49), with consistent gains across all student ability groups. Improvements were also observed across key computational thinking indicators, especially decomposition (0.52). In addition, student responses to the multimedia were highly positive, with an overall satisfaction score of 82.0%, indicating that the game was engaging and well-received. Overall, BranchFun is a promising tool for supporting programming education and fostering active, reflective learning in vocational high schools.

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