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Interactive Multimedia as a More Effective and Engaging Solution for Visual Programming Learning

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Abstract

This study developed and evaluated an interactive multimedia learning product for the Visual Programming course at Sekolah Tinggi Teknologi STIKMA Internasional. Using the ADDIE development model Analysis, Design, Development, Implementation, and Evaluation the research aimed to improve learning effectiveness and student engagement through multimedia-based instruction. The product, designed as an executable (EXE) application, includes six chapters integrating text, animation, video, quizzes, and interactive navigation. Validation involved four experts in content, media, language, and user interface, as well as student trials in both small-group and field settings. Expert validation results averaged 89.26%, categorized as highly valid, while student trials showed an average of 84.8%. Field testing indicated that all students achieved the course passing standard, with scores ranging from 60 to 100. These findings demonstrate that the interactive multimedia effectively enhances students' comprehension, motivation, and learning outcomes. The results are consistent with the Cognitive Theory of Multimedia Learning, which emphasizes the integration of visual and verbal channels to optimize cognitive processing. Practically, the product benefits students, lecturers, and institutions by promoting independent learning and supporting digital transformation in education. Overall, the developed multimedia is considered valid, effective, and feasible as an innovative instructional medium for Visual Programming.

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INTRODUCTION

Learning Visual Programming in higher education, particularly in the Informatics Engineering Study Program at Sekolah Tinggi Teknologi STIKMA Internasional, faces several challenges, particularly in instructional effectiveness and student motivation. Fourth-semester students often encounter abstract and technical concepts that require deep understanding and practical experience. However, conventional learning approaches that remain largely theoretical and lack interactivity tend to limit students' comprehension and enthusiasm (Hasanuddin et al., 2023).

Interactive multimedia has emerged as a potential solution to address these challenges. This medium enables the presentation of materials in the form of audio, video, animation, and simulation, which stimulate multiple senses simultaneously and encourage active student participation. Recent studies have demonstrated that interactive multimedia can significantly enhance students' conceptual understanding and learning retention across various disciplines, including programming (Lin et al., 2025; Haliney et al., 2024). Furthermore, integrating interactive simulation media with collaborative learning models has proven effective in strengthening learners' motivation and autonomy (Mahdiyah, 2025).

In the context of modern education, the utilization of interactive multimedia has become increasingly important to align teaching strategies with the characteristics of the digital generation, who are more responsive to visual and interactive media (Staneviciene & Žekienė, 2025). According to the Cognitive Theory of Multimedia Learning, multimedia instruction that integrates both visual and verbal channels can optimize students' cognitive processes (Mayer, 2021). Recent empirical studies also support that the use of interactive learning content can enhance students' engagement and learning outcomes across cognitive and affective domains (Asmara et al., 2024; Lin et al., 2025).

Meanwhile, visual programming learning requires students not only to comprehend theoretical foundations but also to master technical skills such as programming logic, algorithms, and code structure. The limitations of conventional learning media, which provide minimal opportunities for hands-on practice, hinder the achievement of these competencies. Several studies have shown that the use of interactive multimedia in programming contexts improves students' understanding of algorithms and debugging skills (Maulana et al., 2025; Lin et al., 2025). Therefore, the integration of interactive multimedia is highly relevant for addressing the learning needs of the digital era and supporting the intended learning outcomes of the Informatics Engineering study program.

The interactive multimedia product developed in this research is an executable (EXE) application comprising six chapters of visual programming materials. The product features text, videos, animations, images, interactive buttons, quizzes, and background music designed to reduce learner fatigue throughout the learning process. Moreover, the media is designed to be user-friendly for both instructors and students, equipped with comprehensive usage guidelines covering preparation, implementation, and evaluation stages.

The urgency of this research lies not only in improving the effectiveness of visual programming learning but also in contributing to the development of innovative instructional models applicable to other practice-based courses. Interactive multimedia is inherently flexible and adaptive, making it well-suited to support learning in other disciplines such as computer animation design, English language learning, and STEM education (Subagja et al., 2023). Consequently, this study has the potential to make a significant contribution to advancing digital learning in higher education environments.

Moreover, recent research in higher education emphasizes the growing need to integrate interactive learning environments that enhance students' computational thinking and problem-solving skills. Designing scientific experiments using visual programming languages has been shown to improve students' algorithmic reasoning and self-efficacy in programming tasks (Kalemkuş & Kalemkuş, 2024). Similarly, project-based learning models applied to visual programming courses have successfully enhanced students' engagement, creativity, and cognitive outcomes, fostering more meaningful learning experiences in technology-based disciplines (Marta et al., 2024).

Furthermore, studies on the use of interactive multimedia in vocational and higher education indicate that multimedia-based instruction can transform learning into a more engaging, contextually relevant experience. Such approaches allow learners to connect theoretical programming concepts with practical simulations, promoting deeper understanding and retention (Elfira et al., 2025; Rizqa et al., 2023). In addition, peer-assisted learning (PAL) strategies have been shown to improve student collaboration and achievement in visual programming courses, demonstrating the value of

integrating social learning with digital media (Kusumaningsih et al., 2024).

Systematic reviews on multimedia integration confirm that when instructional design aligns with cognitive and pedagogical principles, it leads to significant improvements in student motivation, engagement, and independent learning (Staneviciene & Žekienė, 2025). These findings are consistent with the Cognitive Theory of Multimedia Learning, which emphasizes dual-channel processing through visual and verbal representations to optimize knowledge construction (Mayer, 2021). Moreover, the design of interactive, environment-based multimedia has been found to improve student focus, reduce cognitive overload, and provide a more immersive learning experience, particularly in digital education (Harisah, 2025).

In summary, integrating interactive multimedia, visual programming, and collaborative learning strategies offers a pedagogically sound solution to the challenges faced in programming education. Such integration supports both technical skill mastery and higher-order thinking, aligning with the demands of the digital era and the principles of modern learning design (Kalemkuş & Kalemkuş, 2024; Marta et al., 2024; Staneviciene & Žekienė, 2025).

In detail, the objectives of this research can be described as follows: (1) to design and develop interactive multimedia for visual programming learning; (2) to develop interactive multimedia to enhance students' understanding of visual programming concepts; and (3) to determine students' perceptions of the use of interactive multimedia in visual programming learning.

RESEARCH METHODS

This research employs a Research and Development (R&D) approach with the objective of producing an interactive multimedia product as a learning medium for the Visual Programming course. The development model used is ADDIE (Analysis, Design, Development, Implementation, and Evaluation), selected for its systematic and flexible characteristics in instructional media development (Subagja et al., 2023).

A. Research Subjects and Location

The research was conducted in the Informatics Engineering Study Program at Sekolah Tinggi Teknologi STIKMA Internasional. The research subjects were fourth-semester students enrolled in the Visual Programming course, totaling 20 participants.

B. Research Procedure

The research followed the five stages of the ADDIE model as follows in Figure 1. A needs analysis was conducted on the curriculum, student characteristics, and learning media requirements. The results indicated that the minimum passing grade (KKM) for the Visual Programming course at Sekolah Tinggi Teknologi STIKMA Internasional is 56.

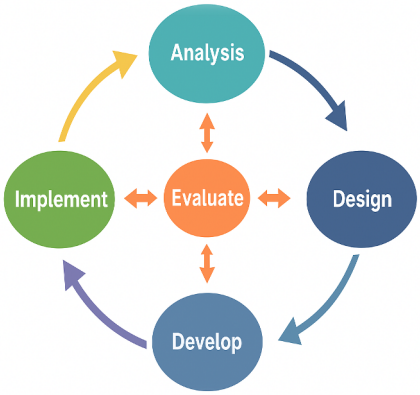

Figure 1. ADDIE model

The analysis also revealed that students prefer computer-based learning; therefore, interactive media are required to integrate code simulations, visual explanations, and exercises with automated feedback (Rizqa & Husni, 2023). In addition, the findings showed that students need learning media that do not easily cause stress when used for extended periods.

The storyboard and user interface design were developed, along with the selection of multimedia elements, including animations, code simulations, and interactive quizzes. Research instruments—including media validation questionnaires, observation sheets, and learning achievement tests—were also prepared (Hasanuddin et al., 2023).

The product was developed using multimedia-based software such as AutoPlay Media Studio 8. Interactive features such as button components, form/page transitions, and interactive evaluation questions were integrated into the application.

The interactive multimedia product was developed based on students' needs, as they require learning media that are engaging and do not cause stress when used for extended periods. This product was validated by several experts, including media, subject-matter, language, and user interface experts.

In addition, the product was tested during classroom learning activities in the Visual

Programming course. Students engaged in self-directed learning using the developed interactive multimedia, while lecturers acted as facilitators. Student activities were observed to assess their level of engagement and their responses to the learning media (Mahdiyah, 2025).

Evaluation was conducted formatively at each stage of development to improve the product and summatively at the end of the implementation phase to assess the multimedia's effectiveness in improving learning outcomes. At this stage, the following results were obtained, see Table 1.

Table 1. Feedback from any Expert and Student

Questionnaire Feedback Source	Feedback
Media expert	Add a "hide close button" feature, in the evaluation section, it is better to show which answers are correct and which are incorrect.
Subject matter expert	Increase the number of evaluation questions to at least 20 items.
Language expert	The expert stated that the language used is already appropriate for students' needs.
UI expert	The colors used appear gloomy
Student	Feedback from the small-group trial indicated that interactive learning multimedia should be used more frequently to create an enjoyable learning atmosphere and prevent students from feeling bored.

C. Product Testing

The testing process consisted of three stages: (1) Expert validation, involving experts in content, media, and interface design; (2) Small-group testing, to assess the usability and attractiveness of the media; and (3) Field testing, involving 12 students to evaluate the product's effectiveness on learning outcomes.

D. Data Analysis Techniques

Data were obtained from validation questionnaires and learning achievement tests. Questionnaire data were analyzed by calculating the average percentage scores of respondents, while the media's effectiveness was evaluated by comparing pre-test and post-test results using descriptive statistical analysis and gain score improvement (Lin et al., 2025). However, in this study, a pre-test was not administered. This decision was made because administering a pre-test may influence how students learn during the intervention. Students may become "oriented" toward specific types of questions, causing post-test results to reflect not only the effectiveness of the intervention but also the effect of prior exposure to the test items. In this context, the use of a post-test only is considered more objective.

RESULT AND DISCUSSION

This research produced an interactive multimedia learning product for the Visual Programming course. The product is an executable (EXE) application comprising six main chapters, with navigation menus, instructional videos, animations, quizzes, background music, and developer information. The product's display is shown in Figures 2 – 6.

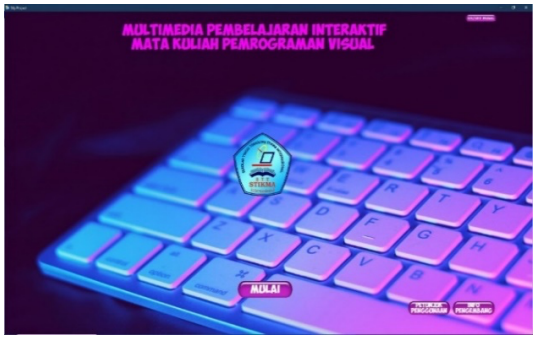

Figure 2. Front page display

Figure 3. Learning material menu page display

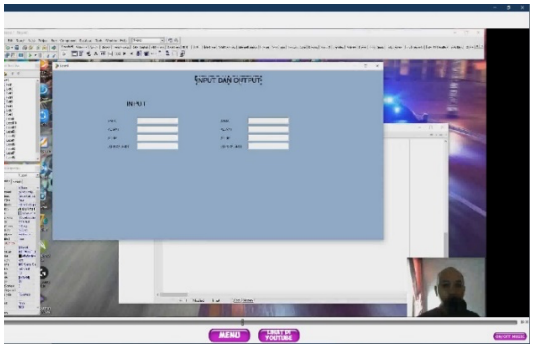

Figure 4. Video page display

Figure 5. Instruction page display

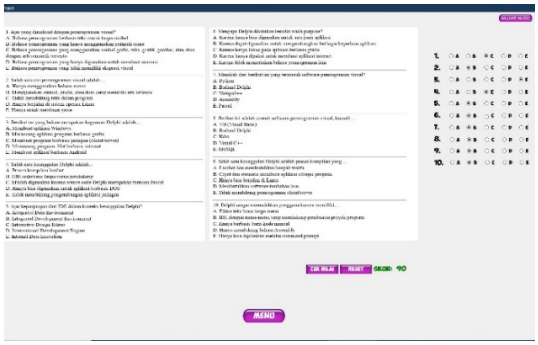

Figure 6. Quiz page display

The product validation was conducted by four experts: a media expert, a content expert, a language expert, and a user interface expert, as well as student testing through both small-group and field trials. The media expert validation yielded a score of 88.4%, categorized as valid and suitable for use. The content expert gave a score of 90%, indicating that the material presented aligns with students' characteristics and supports the achievement of learning objectives.

The language expert validation achieved 90%, confirming that the language used follows proper conventions, is clear, communicative, and appropriate for students' comprehension level. Meanwhile, the user interface expert provided a score of 93.1%, showing that the interface design is easy to understand, logically navigated, and consistent in supporting user comfort.

The small-group trial involved 12 students. The questionnaire results showed an average score of 84.8%, indicating a fairly valid instrument. Students considered the interactive multimedia visually attractive, with engaging music and images that facilitated their understanding of Visual Programming concepts. However, some students suggested improving the background color and video quality for greater clarity.

A field trial was also conducted with 12 students using a post-test instrument. The results showed that 100% of the students met the course passing standard, with a minimum score of 56. Student scores ranged from 60 to 100, with the majority achieving above 90. This indicates that the interactive multimedia effectively enhanced students' understanding and learning outcomes. When combined, the overall average validation score across the four experts and student trials reached 89.26%, falling within the 85–100% range, indicating high validity.

Therefore, the developed Visual Programming interactive multimedia is deemed suitable for use in the learning process. The fact that all students achieved the passing standard further demonstrates the media's effectiveness in improving learning outcomes, consistent with Mayer's findings on the importance of multimedia in facilitating information processing through verbal and visual channels.

Overall, the developed interactive multimedia product met the feasibility criteria set by experts and was proven effective in enhancing students' learning outcomes. Expert validation yielded an average score of 90%, the student trial averaged 84.8%, and the field trial demonstrated 100% achievement of passing standards.

Consequently, this interactive multimedia product holds strong potential as an innovative solution for Visual Programming learning. The formula used to process the learning outcome data is as follows (Arikunto, 2019).

Passing Standard for the Visual Programming Course:

$$PS = 56 \quad (1)$$

Learning Outcome:

$$LO = \frac{TS}{MS} \times 100 \quad (2)$$

Formula to Calculate the Percentage of Students Meeting the Passing Standard:

$$P = \frac{Npass}{Ntotal} \times 100 \quad (3)$$

Caption of the formula:

PS = Passing Standard

LO = Learning Outcome (%)

TS = Total Score obtained by student

MS = Maximum Score

P = Percentage of students meeting the passing standard (%)

N_{pass} = Number of students meeting the passing standard

N_{total} = Total number of students

Table 2. Data from Small-Group Audience/Student Trial Results

No.	Questionnaire Items	Alternative Answers a (4)	b (3)	c (2)	d (1)	Total Score	Max Score	Percentage (%)
1	The attractiveness of the Visual Programming course packaged in interactive learning multimedia	7	5	-	-	43	48	89,5
2	Is the learning material presented in this multimedia easy to understand?	6	6	-	-	42	48	87,5
3	How well are you able to remember the Visual Programming learning material after using the interactive learning multimedia?	3	9	-	-	39	48	81,3
4	The attractiveness of the interactive learning multimedia in motivating you to learn	10	2	-	-	46	48	95,9
5	The attractiveness of the music included in the material in boosting your motivation to learn	6	4	2	-	40	48	83,3
6	The attractiveness of the videos included in the interactive learning multimedia	3	9	-	-	39	48	81,3
7	The attractiveness of the images in the interactive learning multimedia, in your opinion	4	8	-	-	40	48	83,3
8	The attractiveness of the colors used in the interactive learning multimedia, in your opinion	2	7	3	-	35	48	72,9
9	The overall ease of understanding the material in the interactive learning multimedia	6	6	-	-	42	48	87,5
10	Are you more interested in completing the evaluation questions?	6	5	1	-	41	48	85,4
	TOTAL					**407**	**480**	**84,8**
	PERCENTAGE							**84,8**

Table 3. Field Trial Results

Subject Number	Multiple-Choice Test Score	Total Score	Maximum Score	Learning Outcome Test Score	Explanation
1	7	7	10	70	Achieving the Course Passing Standard
2	6	6	10	60	Achieving the Course Passing Standard
3	10	10	10	100	Achieving the Course Passing Standard
4	10	10	10	100	Achieving the Course Passing Standard
5	10	10	10	100	Achieving the Course Passing Standard
6	10	10	10	100	Achieving the Course Passing Standard
7	9	9	10	90	Achieving the Course Passing Standard
8	8	8	10	80	Achieving the Course Passing Standard
9	10	10	10	100	Achieving the Course Passing Standard
10	7	7	10	70	Achieving the Course Passing Standard
11	10	10	10	100	Achieving the Course Passing Standard
12	10	10	10	100	Achieving the Course Passing Standard

The results of this research show that the interactive multimedia developed for Visual Programming learning demonstrated high validity and effectiveness, as evidenced by expert and student evaluations. The average expert validation score of 90% and student trial score of 84.8%, along with a 100% passing rate in field testing, indicate that the multimedia effectively improved students' comprehension and engagement. These findings confirm that interactive multimedia can enhance motivation, cognitive performance, and conceptual understanding, especially in technical and abstract disciplines such as programming (Etyarisky & Marsigit, 2023; Pratiwi et al., 2024; Sidiq et al., 2024).

A. Interpretation of Results

The high validation scores from experts across media, content, language, and user interface dimensions signify that the multimedia fulfilled essential instructional and usability standards. Prior studies emphasize that clear content structure, intuitive interface, and multimedia interactivity contribute to students' cognitive engagement and usability satisfaction (Wibowo et al., 2024; Navarrete et al., 2023). The strong validation by the user interface expert (93.1%) indicates that visual clarity and consistent navigation design reduce cognitive load and promote effective interaction (Çeken & Taşkın, 2022).

Student feedback further revealed that visuals, music, and interactivity made learning more appealing and helped them understand complex programming logic. This aligns with Mayer's Cognitive Theory of Multimedia Learning, which states that meaningful learning occurs when visual and auditory information are integrated to stimulate dual-channel processing (Mayer, 2021). Studies have also shown that multimedia elements such as color, animation, and sound can sustain attention and increase motivation when properly designed (Harisah, 2025; Moriska & Hanif, 2024).

B. Comparison with Previous Research

The student passing rate obtained in this study is consistent with previous empirical findings indicating that interactive multimedia is capable of improving academic achievement and learner satisfaction. For instance, Sidiq et al. (2024) reported that visual programming media improved computational thinking and learning outcomes by 92.7%. Similarly, Hasri et al. (2023) found that AutoPlay Media Studio-based multimedia enhanced thematic learning achievement among elementary students. Septiani et al. (2020) confirmed that interactive multimedia fosters deeper character formation and understanding among students, showing its potential in various educational contexts.

Furthermore, Dina et al. (2019) demonstrated that visual learning environments significantly enhance student comprehension in programming courses, supporting the notion that visualization reduces abstraction barriers in coding education. Kuhlmann et al. (2023) and Navarrete et al. (2023) also emphasized that multimedia tools enhance self-regulated learning and knowledge retention when aligned with cognitive principles. The current research extends these findings by showing that multimedia interactivity and interface usability are equally crucial to ensure accessibility and engagement.

C. Implications for Theory

This study provides further empirical support for multimedia learning theory (Mayer, 2021), affirming that interactive content integrating text, animation, and sound optimizes cognitive processing. By reducing extraneous cognitive load and leveraging both verbal and visual channels, the developed multimedia fosters meaningful learning in complex domains such as programming. The findings also echo Çeken and Taşkın (2022), who highlighted that adherence to multimedia principles across learning environments improves understanding, retention, and learner motivation.

Moreover, Stanevičienė et al. (2025) and Alam (2022) emphasized that interactive multimedia not only facilitates knowledge acquisition but also enhances critical thinking and problem-solving skills through learner engagement. Thus, the success of this study underscores how multimedia-based design can transform passive learning environments into active and constructivist ones, encouraging students to explore and interact with the learning content dynamically.

D. Implications for Practice

For educators and instructional designers, these findings suggest that integrating interactive multimedia into programming courses can improve both engagement and achievement. Hasanah and Sudira (2021) noted that multimedia supports various learning styles and helps bridge the gap between theoretical and practical understanding. Additionally, Mahdiyah (2025) found that Scratch-based programming tools improve comprehension by transforming abstract logic into visual, interactive processes—consistent with current findings in Visual Programming learning.

The inclusion of user feedback is also critical, as small refinements in visuals or video quality can influence students' comfort and immersion (Rizqa & Husni, 2023). Incorporating such feedback ensures continuous improvement of instructional media. Furthermore, multimedia-based approaches can be effectively integrated within flipped-classroom or blended-learning frameworks to promote autonomous learning and collaborative exploration (Pratiwi et al., 2024).

E. Limitations and Future Research

While the results are promising, this study is limited by its small sample size and single-institution setting. Future research should involve larger and more diverse samples, adopt

experimental designs, and analyze long-term effects on motivation and retention. Additionally, as Kuhlmann et al. (2023) suggested, integrating adaptive or AI-based systems could personalize learning experiences and provide real-time feedback. Exploring gamification and immersive technologies such as AR or VR may also expand the pedagogical impact of multimedia learning in programming education.

Furthermore, recent studies reinforce the effectiveness of interactive multimedia in enhancing engagement and conceptual understanding in programming-related courses. Cavanagh and Kiersch (2022) demonstrated that the application of the Cognitive Theory of Multimedia Learning (CTML) using common digital tools significantly improved students' comprehension in technical subjects. Similarly, Zhang and Nouri (2019) found that interactive learning environments, such as Scratch-based platforms, foster computational thinking and creativity in programming education.

Çeken and Taşkın (2022) further emphasized that adherence to multimedia design principles—clarity, consistency, and interactivity—enhances usability and cognitive efficiency. Empirical evidence also shows that properly designed interactive e-textbooks reduce cognitive load and promote sustained attention (Weng et al., 2018).

Moreover, Makransky et al. (2019) revealed that immersive multimedia environments increase learner presence but must balance interactivity with cognitive demand to ensure effective learning. These findings collectively align with the current study, highlighting that interactive multimedia, when structured with sound design principles, can effectively bridge abstract programming logic with visual and experiential learning processes.

CONCLUSION

This study successfully developed an interactive multimedia product in EXE format for the Visual Programming course, which has undergone systematic stages of validation and testing. Based on the validation results, the interactive multimedia was categorized as highly valid. Student trials further reinforced the expert validation results. In addition, the field test demonstrated significant improvement, with all students achieving passing scores ranging from 60 to 100. These findings confirm that the interactive multimedia is not only valid in terms of design but also empirically effective in improving student learning outcomes.

Thus, the product developed in this study not only meets technical standards but also aligns with the theoretical framework of modern multimedia learning.

From a practical perspective, this interactive multimedia provides positive contributions for students, lecturers, and institutions. For students, it enhances motivation, self-confidence, and learning independence. For lecturers, it serves as an instructional tool capable of presenting abstract material in a more concrete manner, thereby saving classroom time.

For institutions, this research indicates the direction of innovative instructional media development that supports digital transformation, particularly in the Industry 4.0 and Society 5.0 eras, which require technological integration in higher education.

Overall, it can be concluded that the developed interactive multimedia is feasible, effective, and has strong potential as an alternative instructional medium for the Visual Programming course. However, this study has several limitations, particularly in terms of sample size, material coverage, and research duration.

Based on these findings, this study provides strong evidence that interactive multimedia is not merely a technical solution but also a pedagogical strategy capable of bridging learning needs in programming education.

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