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Development Of An Interactive Website-Based Learning Media For C++ Operator Topics In Informatics Education

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Abstract: Computational thinking has become an essential competency in informatics education, yet many senior high school students still encounter difficulties in understanding fundamental programming concepts, particularly C++ operators. This study aims to develop and evaluate an interactive website-based learning media for C++ operator topics to support the improvement of students' computational thinking skills. The learning media integrates structured instructional materials, interactive programming games, and formative quizzes within a single web platform to promote active and self-paced learning. The study employed a one-group pretest–posttest design involving ten students from grades 10 to 12 who were members of the IT Club at a partner senior high school. Students completed pretests and posttests to measure their computational thinking performance before and after using the learning media. The effectiveness of the developed media was evaluated using the Normalized Gain (N-Gain) analysis to determine the magnitude of learning improvement. The results show that the average pretest score increased from 21.00 to 51.00 in the posttest, with an average N-Gain value of 0.37, which falls into the medium improvement category. These findings indicate that the developed interactive website-based learning media effectively supports students' understanding of C++ operators and contributes to the development of computational thinking skills through engaging and interactive learning activities.

1. INTRODUCTION

Computational Thinking (CT) has become a core competency in informatics education, as it equips students with the ability to analyze problems, design algorithms, and apply logical reasoning in solving computational tasks. CT skills are particularly important in programming education, where students are required to understand abstract concepts and translate them into structured code [1], [2]. One of the most fundamental programming concepts at the secondary school level is the use of operators in C++, which serve as the basis for expressions, conditional statements, and control structures in more advanced programming topics [3]. Insufficient mastery of these basic concepts may hinder students' learning progression and limit the development of their computational thinking skills. However, based on interviews conducted with informatics teachers at a partner senior high school in Depok, many students still experience difficulties in understanding C++ operators. This problem is exacerbated by the limited availability of interactive learning media that can support students' conceptual understanding and active engagement in learning. As a result, learning activities tend to rely

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on conventional instructional methods, which may not optimally facilitate the development of CT skills.

From a computational thinking perspective, learning C++ operators is not limited to understanding programming syntax but also involves developing fundamental cognitive processes required for problem solving. Arithmetic operators require students to perform numerical decomposition and abstraction by translating mathematical operations into programming expressions. Relational operators encourage logical evaluation through comparisons that form the basis of decision-making structures, while logical operators require students to combine multiple conditions using Boolean reasoning [4]. These activities engage several core dimensions of computational thinking, including abstraction, pattern recognition, logical reasoning, and algorithmic thinking, because students must analyze problem conditions, determine appropriate operators, and construct correct computational expressions to achieve the desired program behavior

Previous studies have demonstrated the potential of web-based learning media in supporting teaching and learning processes. Kuswanto [5] reported that web-based learning media developed using the ADDIE model were feasible and effective for use in software engineering courses, although the utilization of web-based media in learning was still considered suboptimal. Similarly, Nur et al. [6] developed interactive web-based learning media with a gamification approach for basic CSS material, achieving high validity scores for both material and media aspects. These findings indicate that web-based learning media can provide interactive and engaging learning experiences when appropriately designed. At the secondary education level, Fitri et al. [7] highlighted that the absence of learning media contributed to students' low understanding of ICT subjects, and their web-based learning media was considered feasible and effective for supporting learning activities. In addition, Sipahutar et al. [8] through a systematic literature review, emphasized that HTML and JavaScript are widely used to build interactive web-based learning media. However, the study also underlined that the effectiveness of such media is not determined solely by the technology employed, but by the integration of sound instructional design and appropriate implementation contexts.

Despite these contributions, most previous studies have focused on the feasibility, validity, or general learning outcomes of web-based learning media. Limited research has specifically examined the effectiveness of interactive web-based learning media in improving students' computational thinking, particularly on foundational programming topics such as C++ operators at the senior high school level. Moreover, empirical evidence linking web-based interactivity to measurable improvements in CT skills remains insufficient. In this study, computational thinking is operationalized through students' ability to analyze programming expressions, recognize logical patterns, evaluate relational and logical conditions, and apply appropriate C++ operators to solve computational problems. These competencies were measured using pretest and posttest instruments consisting of problem-solving questions on C++ operators, which represent core dimensions of CT, including logical reasoning, abstraction, and algorithmic thinking.

To address these limitations, this study proposes the development and implementation of an interactive website-based learning medium designed specifically for C++ operator material. The media integrates instructional design principles with interactive features to support students' problem-solving and logical reasoning processes. The effectiveness of the proposed media is evaluated by comparing students' pretest and posttest scores as indicators of improvements in computational thinking performance. Therefore, the objective of this study

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is to examine the effectiveness of an interactive website-based learning medium in improving students' computational thinking on C++ operator material in senior high school.

2. METHODOLOGY

This study employed a quantitative research approach with a pre-experimental design. The research design used was a one-group pretest–posttest design, in which a single group of participants was observed before and after the implementation of the learning intervention [9]. This design was selected to examine changes in students' computational thinking after using the interactive website-based learning media, without involving a control group. The overall research process followed the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model [10]. In this study, the effectiveness of the developed learning media was evaluated during the Evaluation phase of ADDIE using the one-group pretest–posttest design.

Participant

The participants of this study consisted of 10 students who were members of the IT Club at a partner senior high school in Depok. The IT Club includes students from grades X, XI, and XII, allowing the participants to represent different levels of prior programming experience. The inclusion criteria for participants were: (1) active membership in the school's IT Club, and (2) prior exposure to basic programming concepts. No exclusion criteria based on gender or academic achievement were applied. The selection of IT Club members was intended to ensure that participants had sufficient interest and basic familiarity with informatics, enabling them to engage effectively with the learning media and the C++ operator material. The learning media was developed using the ADDIE model, which consists of five stages:

1. Analysis : The analysis stage involved identifying students' learning difficulties related to C++ operators through interviews with informatics teachers at the partner school. This stage also included curriculum analysis and identification of learning objectives related to computational thinking skills.
2. Design : In the design stage, the structure of the learning media, learning flow, instructional content, and interactive features were planned. Learning activities were designed to encourage problem analysis, logical reasoning, and practice through examples and exercises.
3. Development : The learning media was developed as an interactive website using HTML, CSS, and JavaScript. The website included learning materials, interactive examples, and practice tasks related to C++ operators to support active learning.
4. Implementation : The developed media was implemented in a limited trial involving the selected participants. Students accessed and used the learning media during the learning sessions as guided by the researcher.
5. Evaluation : The evaluation stage focused on assessing the effectiveness of the learning media using a one-group pretest–posttest design. Students completed a pretest before using the media and a posttest after the learning intervention [11].

3. RESULTS AND DISCUSSION

Result

The following section presents the results of this research. The first result is a flowchart, which illustrates the sequence of processes and the overall workflow developed in this study. It provides a clear visual representation to help understand each step systematically. A flowchart is a graphical representation that illustrates the sequence of processes, decision

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points, and system flows in a structured manner [12]. In this study, the flowchart is used to describe the navigation flow of the interactive website-based learning media. The system begins at the Hero Page, which functions as the main entry point for users. From this page, users can select one of three main learning features: the Material Page, Game Page, or Quiz Page. Each feature provides a different learning experience, ranging from conceptual understanding to practice and evaluation. After completing activities on each page, users are given the option to return to the main menu, allowing flexible navigation throughout the learning process. The overall system flow is illustrated in Figure 1.

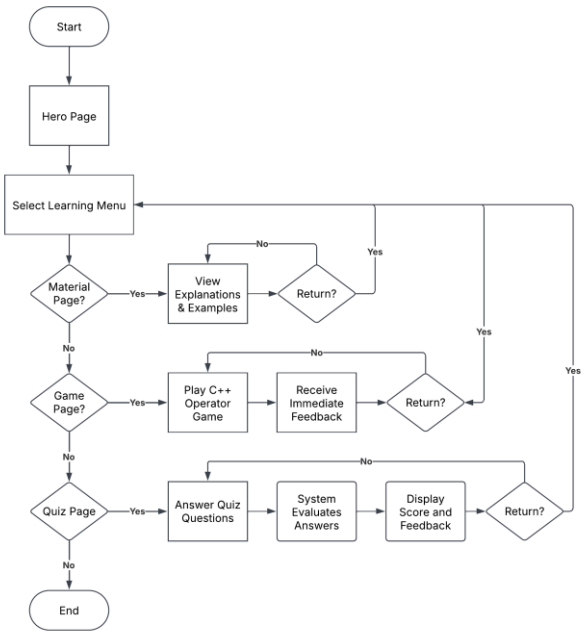


Fig 1. Flowchart of the Interactive Website-Based Learning Media

The first page of the Interactive Website-Based Learning Media is the Hero Page, The Hero Page functions as the main entry point of the learning media and plays a crucial role in attracting users' attention and motivating them to engage in learning activities. This page is designed to provide an overview of the learning experience while encouraging students to actively explore the available features. From a pedagogical perspective, the Hero Page is intended to build initial engagement and curiosity by presenting learning as a challenge-based activity [13]. Visual elements such as animated operator cards (arithmetic, relational, and logical operators) are included to introduce key concepts visually and contextually. Subtle animations and gradient effects are used to enhance user experience without distracting from learning objectives. The "Start Mission" button serves as the primary call-to-action, directing users to the main learning menu. This interaction supports intuitive navigation and aligns with the flowchart design presented earlier. The overall appearance and interaction flow of the Hero Page are shown in Figure 2.

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Fig 2. Hero Page of the Interactive Website-Based Learning Media

The second page of the Interactive Website-Based Learning Media is the Material Page. The Material Page is designed as the core learning component of the interactive website-based learning media. This page provides structured explanations of C++ operators to support students' conceptual understanding and the development of computational thinking skills. The material presentation emphasizes clarity, contextual examples, and logical progression from basic to more complex concepts. The content is divided into three main sections: arithmetic operators, relational operators, and logical operators. Each section is presented in a card-based layout, where every operator is accompanied by a concise explanation and annotated C++ code examples. The navigation bar enables seamless switching between the Material Page, Game Page, and Quiz Page, supporting an intuitive learning flow as previously described in the system flowchart. The visual appearance and layout of the Material Page are presented in Figure 3.

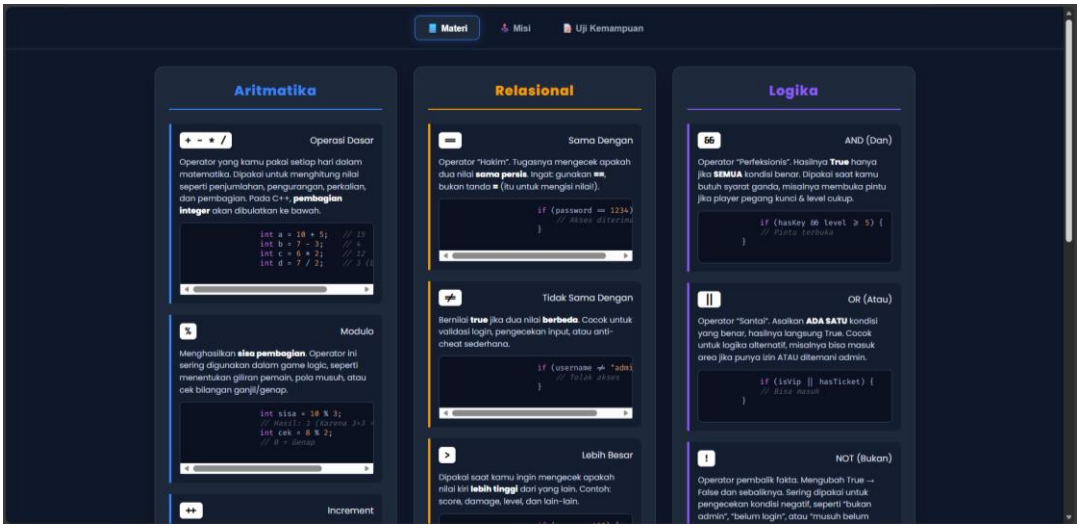


Fig 3. Material Page of the Interactive Website-Based Learning Media

The third page of the Interactive Website-Based Learning Media is the Game Page. The Game Page is designed as an interactive learning environment that applies game-based learning

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principles to strengthen students' understanding of C++ operators. This page transforms programming exercises into a problem-solving game scenario, where students are required to select the correct operator to complete missing segments of code. Each game level presents a contextual programming problem that requires students to analyze the code structure, identify the intended logic, and choose the appropriate operator. Immediate feedback is provided for both correct and incorrect answers, allowing students to reflect on their mistakes and reinforce correct conceptual understanding through explanation messages displayed after each interaction. The visual appearance and layout of the Game Page are presented in Figure 4.

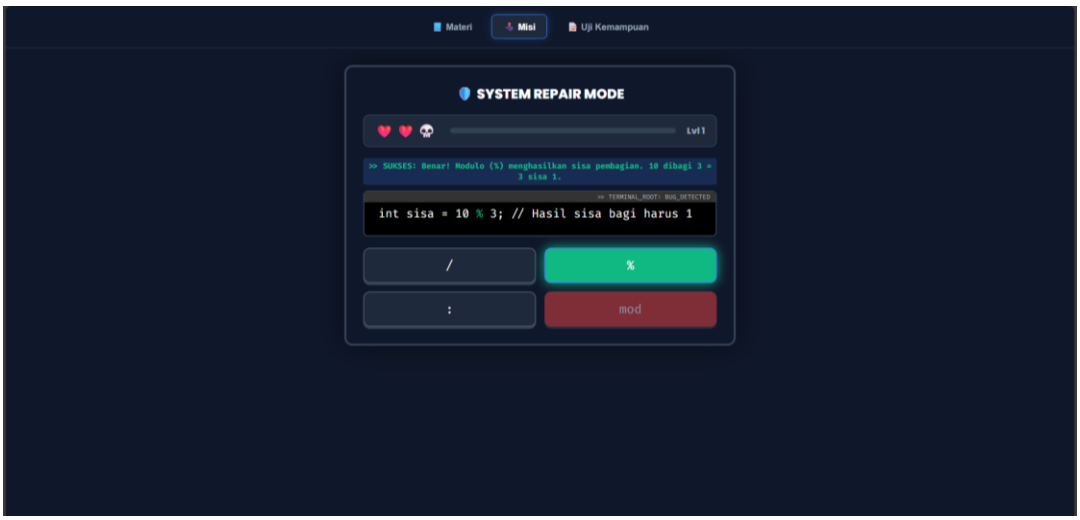


Fig 4. Game Page of the Interactive Website-Based Learning Media

The last page of the Interactive Website-Based Learning Media is the Quiz Page. The Quiz Page is designed as an evaluation component to measure students' understanding of C++ operators after interacting with the learning materials and game-based activities. This page functions as a formative and summative assessment tool, allowing students to reflect on their learning outcomes while providing structured feedback on their performance. The Quiz Page presents a set of ten multiple-choice questions organized in a clean and structured layout. Each question is displayed within an individual question card, ensuring readability and minimizing distraction. After submitting the quiz, students receive an immediate score summary along with detailed feedback for each question. The feedback highlights whether the student's answer is correct or incorrect and provides concise explanations to reinforce learning and correct misconceptions. The visual appearance and layout of the Quiz Page are presented in Figure 5.

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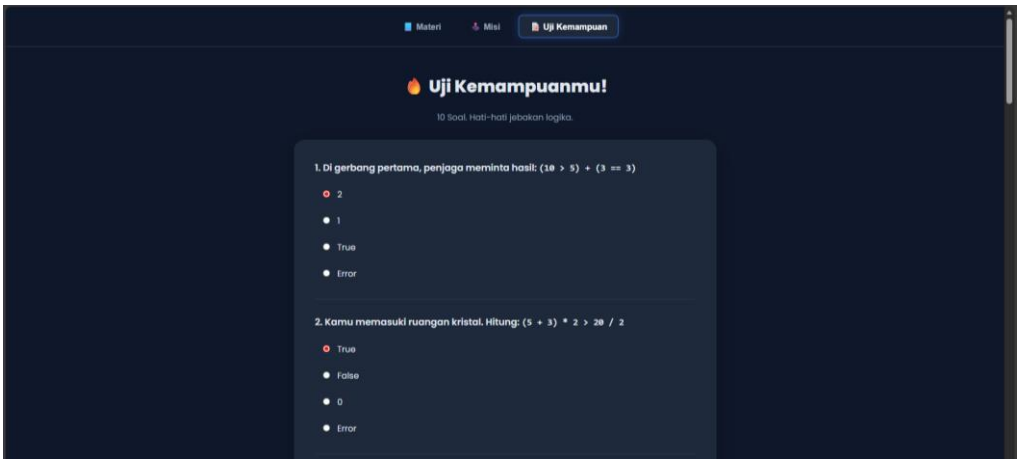


Fig 5. Quiz Page of the Interactive Website-Based Learning Media

The evaluation stage aims to determine the effectiveness of the developed interactive website The evaluation stage aims to determine the effectiveness of the developed interactive website-based learning media by analyzing students' learning outcomes through pretest and posttest assessments. The evaluation focuses on measuring the improvement in students' understanding of C++ operators and computational thinking skills after using the learning media. The effectiveness of the learning media is evaluated using the Normalized Gain (N-Gain) method, which measures the proportion of students' score improvement relative to the maximum possible improvement. Compared with the absolute gain, the N-Gain method provides a more meaningful representation of learning improvement because it considers students' initial achievement levels. In this study, the N-Gain values are classified into three categories: low ($g < 0.30$), medium ($0.30 \leq g \leq 0.70$), and high ($g > 0.70$) [14]. The results of the N-Gain analysis for each student are presented in Table 1, which includes pretest scores, posttest scores, absolute gain, normalized gain values, and the corresponding N-Gain criteria for each participant.

Table 1. *Results of N-Gain Analysis*

Student	Pretest	Posttest	Gain	N-Gain	N-Gain Criteria
S1	0.00	60.00	60.00	0.60	Medium
S2	10.00	30.00	20.00	0.22	Low
S3	20.00	50.00	30.00	0.38	Medium
S4	40.00	40.00	0.00	0.00	Low
S5	10.00	40.00	30.00	0.33	Medium
S6	30.00	60.00	30.00	0.43	Medium
S7	20.00	60.00	40.00	0.50	Medium
S8	40.00	70.00	30.00	0.50	Medium
S9	20.00	70.00	50.00	0.63	Medium
S10	20.00	30.00	10.00	0.13	Low
Mean	21.00	51.00	30.00	0.37	Medium

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Based on Table 1, the average N-Gain value obtained was 0.37, which falls within the medium improvement category. This finding indicates that the interactive website-based learning media contributed to a moderate improvement in students' understanding of C++ operators and computational thinking skills. Most students achieved medium learning gains, while several students demonstrated low improvement. Individual differences were observed across participants. For example, students S2 and S10 obtained low N-Gain values (0.22 and 0.13), suggesting that they experienced only limited improvement after the learning intervention. In addition, S4 showed no improvement (N-Gain = 0.00) because the pretest and posttest scores remained unchanged. These variations may be influenced by differences in prior programming knowledge, learning motivation, engagement during the learning activities, or individual learning pace. Conversely, students with lower initial performance, such as S1 (N-Gain = 0.60) and S9 (N-Gain = 0.63), demonstrated relatively higher learning gains, indicating that the interactive learning media was particularly beneficial for students who initially had limited understanding of the material.

To provide a clearer visualization of students' learning improvement, Figure 6 presents a bar chart comparing the pretest and posttest scores of each participant. The figure illustrates that posttest scores are generally higher than pretest scores for nearly all students, which is consistent with the N-Gain analysis and further demonstrates the positive contribution of the interactive website-based learning media to students' learning outcomes.

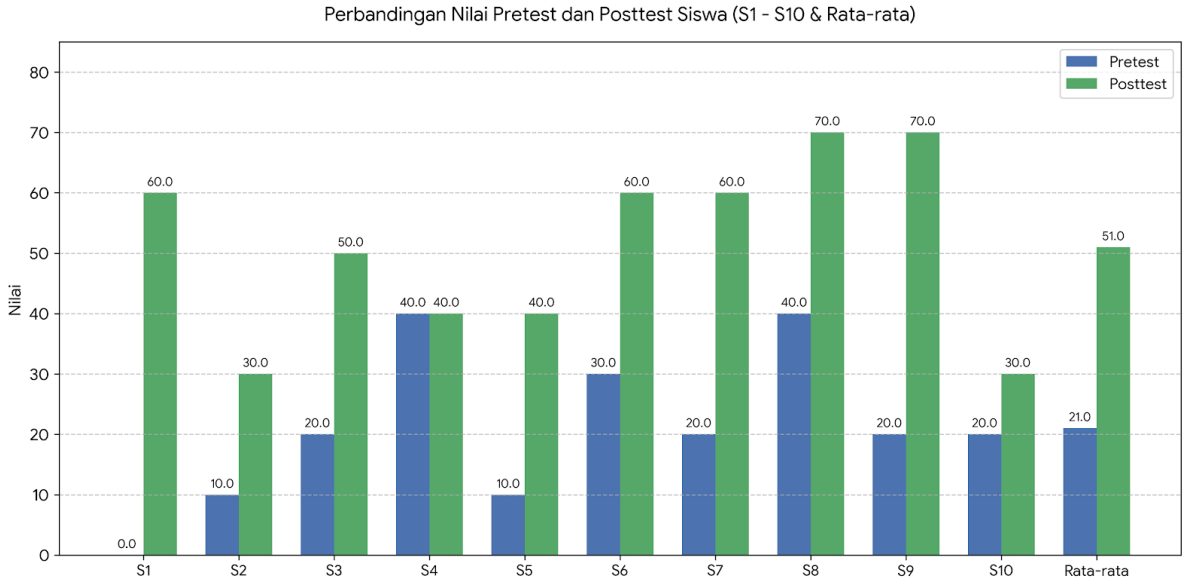


Figure 6. Result Of Students' Learning Improvement Outcomes

Discussion

This study aimed to develop an interactive website-based learning media for C++ operator topics and evaluate its effectiveness in improving students' learning outcomes. Overall, the findings support the primary hypothesis that the developed learning media contributed to improving students' understanding of C++ operators. The average N-Gain of 0.37, which falls within the medium category, indicates that the learning activities embedded in the website facilitated gradual conceptual improvement through structured learning materials, interactive exercises, and immediate feedback.

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When compared with previous studies, the findings both confirm and extend existing research on web-based learning media. Kuswanto [5] demonstrated that web-based learning media are feasible for supporting software engineering instruction using the ADDIE development model. While the study primarily emphasized media feasibility through expert validation and user acceptance, the present study complements these findings by providing evidence of learning improvement through students' pretest and posttest performance. This suggests that, beyond being technically feasible, web-based learning media can also contribute to measurable learning gains when combined with appropriate instructional activities.

The findings are also consistent with Nur et al. [6], who integrated gamification into web-based learning for CSS and reported high material and media validity. Similar to their approach, the interactive website developed in this study incorporates gamified elements through challenge-based activities, instant feedback, and quizzes that encourage active learner participation. These features likely explain the medium N-Gain obtained, as students were required to actively apply programming concepts rather than passively read instructional content. However, unlike Nur et al., whose evaluation focused primarily on media validity, this study further demonstrates the instructional impact of the media through learning outcome improvement.

Furthermore, the present findings support Fitri et al. [7], who reported that the absence of web-based learning media contributed to students' limited understanding of ICT subjects. The improvement observed in this study reinforces the importance of providing interactive learning media for programming education. Nevertheless, while Fitri et al. developed a general web-based learning application for ICT, this research specifically targets C++ operator concepts that require logical reasoning and computational thinking. Consequently, the contribution of this study lies not only in developing a web-based learning medium but also in demonstrating its application for strengthening students' understanding of fundamental programming concepts.

The variation in students' learning gains also supports the conclusions reported by Sipahutar et al. [8], who emphasized that the effectiveness of web-based learning media is determined not only by HTML and JavaScript technologies but also by the quality of instructional design and the implementation context. Although all students used the same interactive website, differences in individual N-Gain values indicate that learner characteristics, including prior knowledge, motivation, and readiness for self-directed learning, may influence learning outcomes. Therefore, the results suggest that interactive technology alone is insufficient to ensure optimal learning improvement without considering pedagogical design and learner diversity.

Several limitations should be acknowledged when interpreting these findings. First, the sample size was relatively small, limiting the generalizability of the results. Second, learning outcomes were evaluated using pretest and posttest scores, which mainly measured students' understanding of C++ operators and may not fully represent broader computational thinking abilities or long-term knowledge retention. Third, differences in students' prior knowledge and learning motivation were not controlled, which may explain the variation in individual learning gains. Future studies should involve larger and more diverse samples, investigate additional factors influencing learning improvement, and examine the long-term effectiveness of interactive website-based learning media in programming education. Despite these limitations, this study provides practical evidence that integrating structured instructional content,

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interactive exercises, and immediate feedback within a website-based learning environment can support meaningful improvements in students' programming learning outcomes.

4. CONCLUSION

This study developed an interactive website-based learning media for C++ operator topics and evaluated its effectiveness in supporting students' learning. The developed media integrates structured learning materials, interactive coding challenges, and quizzes within a website environment to encourage active learning and strengthen students' understanding of fundamental programming concepts. The evaluation results indicate that the learning media effectively improved students' learning outcomes, as reflected by an average N-Gain of 0.37, which is categorized as medium improvement. These findings suggest that the developed learning media provides meaningful support for learning C++ operators while promoting computational thinking through interactive problem-solving activities.

The primary contribution of this study lies in demonstrating that interactive website-based learning media can serve as an effective instructional tool for introductory programming education. By integrating pedagogically structured content with gamified learning activities and immediate feedback, the developed media offers an engaging learning experience that supports both classroom instruction and independent learning. This study also contributes empirical evidence regarding the practical application of interactive web technologies in programming education, particularly for teaching fundamental C++ operator concepts at the senior high school level.

Despite these contributions, the findings should be interpreted in light of several limitations, including the relatively small number of participants and the short-term implementation of the learning intervention. Future research is therefore recommended to involve larger and more diverse participant groups, investigate the long-term effects of the learning media on computational thinking development, and incorporate adaptive or personalized learning features to better accommodate differences in students' prior knowledge and learning pace. Such improvements are expected to further enhance the effectiveness and broader applicability of interactive website-based learning media in informatics education.

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