The Effectiveness of Interactive Learning in Enhancing Programming Skills Among Computer Science Students in Form 4 at a Secondary School.

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Abstract- This study focuses on the main challenges in enhancing programming skills among Form 4 students who take Computer Science as a subject, which is a crucial topic in the subject. The main objective of this study is to assess the effectiveness of interactive learning in implementing a module that uses web-based learning, specifically W3School, to improve understanding and mastery of programming concepts based on the Standard Curriculum and Assessment Document (DSKP) for the Form 4 Computer Science subject. This study is academically and practically significant because the provided module offers a technology-based approach that supports self-directed learning and makes the teaching and learning process more effective at the secondary school level. A mixed-methods research design was used, involving data collection through pre- and post-tests as well as questionnaires. The main findings from the pre- and post-tests showed a significant improvement in the understanding of control structures after using the module that applied interactive learning. Meanwhile, the qualitative analysis from the questionnaire revealed the effectiveness of the W3School platform in enhancing both theoretical and practical programming skills. This study contributes to filling a gap in the literature by demonstrating how interactive learning platforms in today's educational world can be integrated into formal education to improve programming learning outcomes. The implication is that teachers can adapt interactive learning technologies by using web-based learning platforms like W3School and others as teaching tools to enhance students' teaching and learning experience in programming topics in the Computer Science subject.

Keywords- Programming, control structures, interactive learning, computer science.

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I. INTRODUCTION

The Fourth Industrial Revolution (IR 4.0) has had a significant impact on various fields, including education, as it forms the foundation for preparing the workforce of the future. In this era, interactive and engaging learning systems must be expanded at all levels of education, from primary schools to higher education institutions, to ensure that the teaching and learning process can increase students' interest and contribute to their academic achievements. Programming skills have become increasingly important in shaping a tech-literate generation. In this context, students need to understand fundamental concepts such as control structures, which are crucial in programming. However, many students face difficulties in understanding these concepts due to their abstract and complex nature. By using a more interactive and effective approach, these challenges can be overcome. This not only supports the educational objectives of the digital age but also helps produce graduates who are better prepared to compete in the rapidly changing technological world.

According to Cetinkaya, Baykan, and Kırgız (2023), in the rapidly evolving digital world, students should be given opportunities to learn computer algorithms, create applications, and understand the basics of the internet. Previous studies have shown that interactive learning approaches can enhance students' engagement and understanding of programming concepts. W3Schools, a self-learning platform, has been identified as an effective tool because it offers a step-by-step approach and live coding features that are relevant to the Form 4 Computer Science syllabus in Malaysia. Although there are many interactive learning platforms, studies examining the effectiveness of using W3Schools in the context of secondary education in Malaysia remain limited. This study aims to fill this gap by assessing how W3Schools can help improve students' understanding of control structures and comparing its effectiveness with traditional teaching methods.

This study aims to assess the effectiveness of interactive learning using the W3Schools platform in enhancing Form 4 students' programming skills. The focus is on control structures, one of the key topics in the Form 4 Computer Science Standard Curriculum and Assessment Document (DSKP), which often presents challenges for students. Additionally, the study compares the achievement of students before and after the implementation of the module. The primary research question to be answered in this study is how effective is the interactive web-based learning module in improving the programming skills of Form 4 Computer Science students? The second research question is what are the students' perceptions of the interactive web-based learning module in terms of its effectiveness, satisfaction, and ease of use? By addressing these questions, this study aims to provide guidance to educators in selecting more effective approaches to teaching programming, particularly in the context of secondary education in Malaysia.

This article is divided into several main sections. The first section discusses the literature review related to the effectiveness of interactive learning and the use of W3Schools in programming education. The second section explains the research methodology, including the research design, sample, instruments, and data collection procedures. The third section presents the research findings, followed by an in-depth discussion of the implications of these findings for programming education. Finally, the article concludes with a summary and recommendations for future research.

Through a systematic and evidence-based approach, this study aims to contribute to a deeper understanding of the potential of interactive learning in enhancing students' programming skills, thus supporting efforts to prepare the younger generation for the challenges of the digital world.

II. LITERATURE REVIEW

Web-based learning approaches have proven effective and are one of the most efficient ways to increase student engagement in the teaching and learning process. In the context of programming, various platforms such as W3Schools, Code.org, Scratch, and others offer practical exercises that allow students to write and test code directly, thereby helping to improve their programming skills. According to Gutierrez Beltran and Martinez Arias (2021), their study found that interactive learning tools using visual elements and avatars have helped students better understand fundamental concepts. This shows that web-based learning platforms like W3Schools provide a flexible learning environment and allow students to learn at their own pace, with the ability to access learning resources at any time.

The main advantage of this approach is the active involvement of students, which is a key element in improving conceptual understanding and practical skills. According to the ICAP (Interactive, Constructive, Active, Passive) framework, interactive engagement through conversation or discussion can significantly improve learning outcomes (Hobert, 2022). In a study by Aung et al. (2024), it was stated that using interactive learning techniques in teaching can increase student engagement and facilitate understanding of complex concepts, thus enhancing programming skills. Based on research findings showing that innovative pedagogy significantly improves academic achievement and student ability in computer programming, Omeh and Olelewe (2021) concluded that more creative, student-centered teaching approaches can promote active involvement and help students develop the skills necessary to face the challenges of the workforce. Therefore, this foundational theory underpins the study of using W3Schools as an interactive learning tool.

A study by Sumayyah Dzulkifly et al. (2021) on game-based learning found that this method could increase students' motivation to actively engage in the learning process. Furthermore, in support of technology-based learning, Rousouliotis and Marios (2023) discovered that the use of underwater vehicles in learning not only enhanced students' technical knowledge but also motivated them to explore further in this field, positively changing their views on the subject. Specifically, using innovative learning platforms like EDUV has been shown to improve students' perceptions of programming and robotics using the Python programming language. A study by Lappi et al. (2020) showed that programming syntax is often a major barrier for students; however, this issue can be overcome by using interactive learning tools that exist in today’s technological world. In the study by Ling and Chiang (2022), the authors discuss the effectiveness of an adaptive learning system designed to enhance student motivation and learning outcomes in programming courses. They found that learning tailored to students' needs can help overcome challenges faced in programming education, thus improving student performance. These findings support the argument that interactive learning, including adaptive learning elements, has the potential to enhance programming skills among Computer Science students.

"Programming is becoming a new form of literacy worldwide, and programming education is now offered in elementary schools as part of the development of computational thinking," is a statement by Oka et al. (2024) in their study, which shows that interactive programming education can improve programming skills among Computer Science students by providing a solid foundation in computational thinking. Kinari et al. (2024) emphasized that the interactive learning systems developed not only serve as tools to support independent learning and complement classroom teaching but also enhance student engagement through the use of user interface screenshots, helping them visualize the expected output and understand the relationship between the code and interface changes. This enables beginner students to effectively solve code modification problems in the CMP (Code Modification Program).

III. METHOD

A. Sampling

This study uses a quasi-experimental quantitative research design, which is a suitable approach to assess the effectiveness of interactive learning using the I-Code Module in enhancing the programming skills of Form 4 Computer Science students. The methodology of this study includes an explanation of the population and sample, research instruments, data collection procedures, and the data analysis methods used to achieve the research objectives.

B. Data Collection

Data collection consists of the I-Code Module, pre-test and post-test, as well as a questionnaire form:

1. **I-Code Module**: This module is developed based on the Form 4 Computer Science DSKP content and focuses on topics related to control structures such as if-else, for loops, and while loops. The module includes concept explanations, code examples, and programming exercises delivered through an interactive approach using a web platform.
2. **Pre-test and Post-test**:
    - **Pre-test** is conducted before the intervention to assess the students' initial understanding.
    - **Post-test** is carried out after the intervention to evaluate the improvement in students' skills.
    - The test questions cover both theoretical and practical aspects to assess students' understanding of concepts as well as their ability to write code.
3. **Questionnaire Form**: The questionnaire is used to gather student feedback on the I-Code Module, their learning experience, and factors influencing the module's effectiveness. The questionnaire includes demographic questions, perceptions of the module content, and aspects of satisfaction.

C. Data Collection Procedure

The data collection process is carried out in four main phases:

1. **Pre-test**: Before the intervention, a pre-test is administered to assess students' existing skills in control structures. This test is conducted within a 30-minute timeframe.
2. **Intervention**: The intervention is conducted over four weeks, with sessions lasting two hours each week. During this period, students use the I-Code Module, which emphasizes interactive activities such as writing code directly, answering online quizzes, and receiving immediate feedback through the platform.
3. **Post-test**: After four weeks, a post-test is administered to evaluate the improvement in students' programming knowledge and skills. The format and duration of the test are the same as the pre-test.
4. **Questionnaire**: After the post-test, students are asked to complete a questionnaire to provide their views on the effectiveness of the I-Code Module. The questionnaire includes questions about student demographics, perceptions of the module content, and satisfaction with the learning experience, using a five-point Likert scale.

D. Data Analysis Methods

The data obtained is analyzed using both quantitative and descriptive methods:

1. **Quantitative Analysis**:
    - The comparison between pre-test and post-test scores is analyzed using a paired T-test to determine the effectiveness of the I-Code Module intervention.
    - The mean score differences are used to quantitatively assess the improvement in students' skills.
2. **Descriptive Analysis**:
    - Data from the questionnaire is analyzed to identify patterns in student feedback regarding their learning experience, factors influencing effectiveness, and their satisfaction with the I-Code Module.
    - The results of this analysis support the quantitative findings and provide a more comprehensive view of the effectiveness of interactive learning.

This study is designed systematically to ensure the results contribute to the improvement of programming teaching methods in secondary schools. With a comprehensive approach, the findings of the study are expected to assist educators in enhancing the effectiveness of Computer Science.

IV. RESEARCH FINDINGS

This study aims to assess the impact of using the I-CODES module in improving Form 4 students' understanding of programming, particularly in grasping control structure concepts such as conditional statements and loops. Descriptive analysis and statistical tests are used to evaluate the effectiveness of the module and student satisfaction with the learning experience provided by this module.
The findings will focus on:

- **Improvement in Programming Skills**: The comparison of pre-test and post-test results will highlight any significant progress in students' ability to understand and apply control structures.
- **Student Satisfaction**: The results from the questionnaire will shed light on students' perceptions of the module's content, their learning experience, and their overall satisfaction with the interactive learning approach.

This section will present these findings in detail, offering insights into how the I-CODES module contributes to enhancing students' programming skills and their learning experience.

A. Quantitative Analysis

Table 1

Descriptive Statistical Analysis through Score Change Analysis Test

Item	N	Minimum	Maximum	Mean
Pre Test	18	40	77	56.44
Post Test	18	60	87	73.94
Different Score	18	.00	35.00	17.5000
Valid N(listwise)	18			

The descriptive statistical analysis shows that most of the students involved in this study demonstrated an improvement in their test scores between the pre-test and post-test. The average score for the pre-test was 56.44, with a standard deviation of 9.538, while the average score for the post-test increased to 73.94, with a standard deviation of 8.250. The average score difference between the pre-test and post-test is 17.50 points, indicating a significant improvement in students' understanding after using the I-CODES module. The lower standard deviation in the post-test indicates that students' scores were more consistent after using this module.
These results highlight the effectiveness of the I-CODES module in enhancing students' understanding and application of programming concepts, particularly in control structures such as conditional statements and loops.

Table 2

Paired Sample Correlation Analysis

Item	N	Colleration	Sig.
Pre Test- Post Test	18	.625	.006

The correlation analysis results indicate a moderate positive relationship between the pre-test and post-test scores, with a correlation value of r = 0.625. The p-value of 0.006 ($p < 0.05$) shows that this correlation is statistically significant. This means that there is a significant connection between students' performance before and after the intervention through the implementation of the I-CODES module, which utilizes interactive learning. Students who scored higher in the pre-test tended to score higher in the post-test as well.
This finding reinforces the effectiveness of the I-CODES module in improving students' understanding and skills in programming, particularly in the area of control structures. The moderate correlation suggests that students' initial knowledge is positively associated with the improvements made after the interactive learning intervention.

Table 3

Paired Sample Test (Paired Differences)

				95% confidence interval of the difference				
Pair	Mean	Std.Deviation	Std.Error Mean	Lower	Upper	t	df	Sig(2-tailed)
Pre Test-Post Test	-17.500	7.786	1.835	-21.372	-13.628	-9.536	17	<0.001

The results of the t-test indicate a statistically significant difference between the pre-test and post-test scores ($t(17) = -9.536$, $p < 0.001$). The mean difference between the two tests is -17.50, with a 95% confidence interval ranging from -21.372 to -13.628. This result demonstrates that the intervention had a significant impact on improving student performance, with higher scores observed in the post-test compared to the pre-test.
The negative mean difference of -17.50 suggests that the post-test scores were consistently higher than the pre-test scores, confirming that the use of the I-CODES module, which involves interactive learning, contributed to a notable improvement in the students' understanding and skills in programming. The 95% confidence interval provides further support for the robustness of this finding, indicating that the observed improvement is highly likely to be a true effect rather than a random occurrence.

B. Descriptive Analysis

Experience Using the Module

The results of the study show that the I-CODES module is designed with clear and structured steps, making it easy for students to follow the activities without encountering difficulties. The majority of students (88.9%) agreed that the instructions in the module were easy to understand, while 61.1% did not experience any difficulties in starting the activities. These findings reflect the structure of the module, which supports usability among students with varying skill levels, proving its effectiveness as an interactive programming learning tool.

Regarding the time taken to complete the activities, the majority of students (55.6%) completed the activities within 15 to 30 minutes, while 44.4% took less than 15 minutes. No students reported taking more than 30 minutes, indicating that the difficulty level of the module was moderate and challenging. This allows students to gradually reinforce their programming skills while ensuring a balanced learning experience.

In terms of understanding control structure concepts, the module proved to be highly effective. A total of 72.2% of students agreed that the module helped them understand conditional statements (if-else) and loops, while 27.8% strongly agreed. Furthermore, 88.9% of students believed that the exercises provided in the module were sufficient, with clear code examples, which 11.1% of students acknowledged as being very helpful. These findings indicate that the I-CODES module successfully links theory with practical application, enhancing students' understanding of key programming concepts.

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Satisfaction and Effectiveness of the Module

Based on the findings of the study, the use of the I-CODES module showed a high level of satisfaction among students. A total of 88.9% of students agreed that the module enhanced their understanding of writing programming code, while 100% of students were satisfied with the quality of the module's content. All students also reported that the module helped them understand programming topics better than traditional teaching methods and was suitable for self-learning.

The study also showed that the module successfully connected theory with practical applications, with 100% of students agreeing that it helped them understand the relationship between theory and application. Additionally, 94.4% of students stated that the module enhanced their understanding of control structure topics such as conditional statements (if-else) and loops. Furthermore, all students agreed that they found it easier to solve programming problems after using the module and were willing to recommend the module to their peers.

These findings align with the statement that the use of the I-CODES module not only helps students understand theoretical concepts but also provides opportunities to apply them in real-life situations. The module also provided space for students to experiment and explore solutions to various programming problems, which further enhanced their critical thinking skills. This high level of satisfaction is also supported by 100% of students who reported being satisfied with the technical support and guidance provided by the teacher throughout the use of the module, ensuring a comprehensive learning experience.

V. DISCUSSION

In this study, the discussion on the effectiveness of interactive learning through the W3Schools platform in enhancing programming skills of Form 4 students was carried out by analyzing the findings from the collected data. The results of the study provide various implications, particularly in the context of Information and Communication Technology (ICT) education at the secondary school level.

Summary of Findings

The findings of the study show that the use of interactive learning through the W3Schools platform has had a significant impact on improving students' programming skills. Students who used this platform demonstrated better performance in understanding programming concepts compared to before using the W3Schools platform to grasp programming concepts. Skills such as understanding control structures (e.g., if-else statements and for-loop structures), basic functions, and variables were notably improved among the experimental group students. This indicates that the use of learning tools that provide interactive and practical content can strengthen students' understanding of complex programming concepts.

Additionally, the ease of use and high level of student satisfaction with the module confirm its effectiveness as an interactive approach to learning programming. This conclusion supports the study's objectives and answers the research questions by demonstrating the effectiveness of interactive approaches like I-CODES, aligned with the goal of enhancing students' understanding and performance in the topic of control structures.

However, the study also highlighted some limitations. For example, students who were less proficient in using computers required more time to adjust to the platform. This posed a challenge for teachers to provide additional support to these students, especially in classes with students of varying skill levels.

Implications of the Study

Implications for Teaching and Learning

This study presents significant implications for teaching and learning strategies, particularly in the field of Computer Science. Teachers need to consider more technology-based approaches to help students understand abstract and technical topics. The use of

W3Schools as an interactive learning tool has shown that students can grasp programming concepts more effectively through hands-on practice and self-exploration. A study by Krusche and Berrezueta-Guzman (2023) demonstrates that interactive learning in programming courses for first-year Computer Science students can enhance academic performance and encourage knowledge sharing among students. This approach has the potential to be expanded into a broader curriculum in Computer Science, emphasizing more practical and collaborative learning methods. These findings suggest that using interactive strategies can strengthen students' understanding of fundamental programming concepts, providing a solid foundation for further learning.

Furthermore, the platform offers flexible learning resources that can be accessed anytime. This allows students to learn at their own pace, which is crucial for ensuring effective learning. However, teachers need to play an active role in guiding students, particularly in integrating interactive exercises into their lesson plans. Nariman (2020) found that using interactive e-learning instructions improves the effectiveness of programming courses, with a positive impact on students' cognitive and affective learning outcomes. This study emphasizes that interactive learning methods not only enhance the understanding of programming concepts but also contribute to students' motivation and satisfaction throughout the learning process. These findings support the integration of interactive technology in programming courses as an effective pedagogical tool.

Implications for Students

From the students' perspective, the findings of the study indicate that interactive learning methods can enhance their programming skills more effectively than traditional methods. This is because platforms like W3Schools provide an interactive learning environment where students can try out their own code and see the results instantly. This not only helps them understand programming concepts but also builds their confidence to explore problem-solving creatively.

However, the study also shows that students who are less skilled in technology require more guidance. Therefore, it is important to provide additional support, such as individual or small group mentoring sessions, to ensure no student is left behind. These findings suggest that using interactive strategies can strengthen the understanding of basic programming concepts, providing a solid foundation for further learning.

Furthermore, the platform provides flexible learning resources that can be accessed at any time. This allows students to learn at their own pace, which is crucial for ensuring effective learning. However, teachers must play an active role in guiding students, especially in integrating interactive exercises into their lesson plans. Nariman (2020) found that the use of interactive e-learning instructions enhances the effectiveness of programming courses, positively impacting students' cognitive and affective learning outcomes. This study emphasizes that interactive learning methods not only improve the understanding of programming concepts but also contribute to students' motivation and satisfaction throughout the learning process. These findings support the integration of interactive technology in programming courses as an effective pedagogical tool.

Implications for Curriculum Development

In the context of curriculum development, this study highlights the need to incorporate more interactive learning elements into the Computer Science subject. The current curriculum should emphasize the use of relevant and up-to-date technological tools, such as W3Schools, to help students better master programming skills. The curriculum should also allow students to engage in self-directed projects using such learning tools. This would provide them with a deeper practical experience, thereby enhancing their problem-solving skills and critical thinking abilities.

Limitations of the Study

Although this study provides positive findings, there are several limitations to consider. First, the study sample only involved students from a single secondary school, which may not represent the broader student population. As such, the results of this study may not be generalizable to all secondary school students.

Second, this study relied on the W3Schools platform as an interactive learning tool. While this platform proved effective, there is a possibility that the results could differ if other platforms were used. This highlights the need for further studies using a variety of learning platforms to ensure the effectiveness of this method in a broader context.

Third, this study only assessed the effectiveness of learning over a limited period. Therefore, a long-term study is needed to determine whether the effectiveness of this interactive learning approach can be sustained over a longer period.
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Recommendation for Future Research

Based on the identified limitations, several suggestions can be made for future studies. First, research should involve a larger and more diverse sample to enhance the reliability and generalizability of the findings. This includes involving students from various backgrounds, such as urban, rural, and students with differing academic achievements.

Second, future research should evaluate the effectiveness of other learning platforms to determine the most suitable methods for enhancing students' programming skills. Comparing various platforms can provide a clearer picture of the strengths and weaknesses of each learning tool.

Third, long-term studies should be conducted to assess whether the improvement in students' programming skills through interactive learning can be maintained over an extended period. This would provide more accurate information on the long-term effectiveness of interactive learning as a better teaching method.

VI. CONCLUSION

Overall, the discussion of this study indicates that the use of interactive learning through the W3Schools platform has a positive impact on students' programming skills. Despite certain limitations, the findings of this study have important implications for teaching, students, and curriculum development. By addressing the identified limitations and implementing the suggested recommendations, interactive learning methods can become an effective tool for enhancing the effectiveness of Computer Science education at the secondary school level.

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