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SPARK: Simplified Practices, Analogies, and Resources for Knowing C++ Functions

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***Abstract*— The teaching and learning of programming languages, especially C++, have often been cited as challenging for both instructors and students, leading to persistently high failure rates. This paper introduces SPARK C++, an acronym for Simplified Practices with Analogy and Resources for Knowing C++. SPARK is an innovative web-based teaching tool developed in response to identified difficulties, with the aim of enhancing the learning experience. By leveraging a mix of multimedia elements, it offers a dynamic and interactive learning experience. This innovative educational tool enables students to proficiently grasp essential modular programming ideas through the utilization of real-world analogies. The incorporation of relatable analogies is one of the notable features of SPARK which serves to clarify complex programming ideas, thereby facilitating the intuitive comprehension and long-term recall of the material. Moreover, SPARK integrates practice quizzes, equipped with immediate feedback mechanisms, which serve to promote ongoing student engagement and strengthen the process of acquiring knowledge. The teaching tool is also equipped with pre-test and post-test questions that are specifically designed to evaluate students' comprehension and assess the success of the tool in assisting their acquisition of the C++ modular programming. The efficacy of SPARK is assessed by analyzing the pre-test and post-test scores and calculating the N-Gain formula. The computation indicates that the mean score is 0.6336, falling within the range of modest improvements. This finding is noteworthy as it demonstrates a substantial contribution to enhanced comprehension. In conclusion, SPARK has the ability to significantly improve students' comprehension of programming concepts, such as the complex field of C++ functions, while also lowering the failure rate for programming students.**

Keywords*— *C++ functions, normalized gain, educational technology, multimedia, computer science education

I. INTRODUCTION

The study of C++ programming presents difficulties for numerous university students, particularly those enrolled at Universiti Teknologi MARA Pasir Gudang Campus. This institution requires the inclusion of C++ programming as a mandatory component within the diploma curriculum for mechanical and civil engineering disciplines. Recent assessments have identified student difficulties in understanding the topic of C++ functions. Therefore, the primary aim of this project is to develop an e-content application that is specifically tailored to enhance comprehension of C++ functions.

However, there is currently a shortage of research on the e-content application in programming education, particularly when it comes to incorporating interactive multimedia, analogies, and practice. As a result, there is a lack of thorough information about the extent to which this integration might effectively enhance student engagement in the learning process. Hence, it is imperative to evaluate the application to ascertain its effectiveness.

The produced e-content application is referred to as SPARK C++, an acronym for Simplified Practices with Analogy and Resources for Knowing C++. It integrates multimedia elements with analogies and interactive quizzes. The development of the application is based on ADDIE model, a five-step educational framework: analysis, design, development, implementation, and evaluation. The objective of ADDIE is to enhance the efficacy of multimedia learning aids in fostering students' engagement with programming.

II. MATERIALS

The growing popularity of e-learning has led to an increased demand for advanced authoring tools. Prominent entities in this domain encompass Adobe Captivate, Articulate Storyline, and iSpring, all of which provide specific features for the purpose of content generation. Adobe Captivate is known for its VR capabilities, responsive design, and software simulations. Its use in developing e-learning materials is evident in studies like those [1] and [2]. Articulate Storyline boasts an intuitive interface, facilitating complex interactions and animations. It excels in software training due to its task mimicry feature and offers consistent user experiences across devices [3], [4]. iSpring Suite, which integrates with PowerPoint, stands out for its user-friendly design, ideal for educators transitioning to online teaching. It supports quizzes, simulations, and screencasts. iSpring's application in language classes has shown notable advantages over traditional methods [5]. Moreover, in scientific disciplines, such as chemistry and computer science, iSpring has clarified complex concepts and enhanced student engagement [6], [7]. Conclusively, iSpring has demonstrated significant value in education, fostering comprehension and engagement. As the educational paradigm shifts, iSpring emerges as a vital tool, and is the chosen medium for this study's teaching of C++ functions.

In the educational landscape, alongside technological tools, the efficacy of teaching strategies holds equal importance. A widely accepted method for gauging the impact of instructional interventions is the pre-test and post-test approach. Through the comparison of these test outcomes, researchers are able to evaluate the efficacy of different educational strategies. For instance, Neureiter et al. [8] applied the online gaming platform Kahoot! in conjunction with traditional histopathology sessions. Using the Mann-Whitney U-test, often referred to as the Student's t-test, they observed heightened student engagement during pathology instruction. Similarly, Anwar et al. [9] aimed to amplify engagement in mathematics through iSpring Presenter. After deploying the N-Gain test, they noted a high N-Gain value of 0.704, pointing to increased student interest in mathematics. In another study, Yunus & Hua [10] used Quizizz to teach irregular English verbs. Their findings, based on the Mann-Whitney U test, confirmed an augmentation in student engagement and proficiency in understanding irregular verbs. These research pieces collectively highlight the transformative potential of digital tools and gamification in enhancing student engagement across subjects.

Recent studies underscore the transformative power of digital platforms like iSpring, Kahoot!, and Quizizz in student motivation across varied disciplines. Supported by rigorous efficacy analyses, this has the potential to greatly enhance the quality of programming teaching, particularly in relation to complex topics such as C++ functions.

III. METHODS

The project utilizes the ADDIE model, a widely recognized instructional design framework for crafting impactful educational experiences. The teaching tool was developed using the ADDIE approach, which encompasses five stages: Analysis, Design, Development, Implementation, and Evaluation.

A. Analysis

Our investigation during the Analysis stage of the ADDIE model included three main procedures: (i) problem identification, (ii) subtopic identification, and (iii) technical considerations. The problem identified was the assessment results from a sample of 69 students that shows the score distribution for the topic of C++ function. These assessment outcomes pinpointed gaps in students' knowledge, guiding which subtopics should be addressed and where analogies would be most effective. Observations revealed that traditional teaching methods, like PowerPoint presentations, aren't adequately addressing theoretical concepts of functions.

B. Design

The design step encompasses three crucial components, namely the development of an analogy (narrative), incorporation of digital multimedia elements, and establishing practice-related questions. The completion of the entire design process typically requires a duration of approximately two weeks.

C. Development

The development of teaching tools involves two essential procedures: (i) the creation of the teaching tool and its assessment, and (ii) the review and testing of the prototype. The application software used in the development are Microsoft PowerPoint with iSpring add-in, iSpring Cam Pro, Wondershare Filmora, iSpring QuizMaker and Microsoft Form.

D. Implementation

In this phase, the iSpring software is employed to convert PowerPoint presentations into HTML5 format, facilitating the integration of the educational tool on the itch.io website and ensuring its compatibility with mobile browsers for enhanced accessibility. The desired result can be achieved by entering the URL provided: https://cppspark.itch.io/functions/.

E. Evaluation

Analysis is done in Microsoft Excel using pre- and post-test results. A normalised gain (N-gain) test scored pre- and post-test questions to compare student C++ Function performance. The normalized gain, often known as ⟨g⟩, is often represented as:

$$\langle g \rangle = \frac{\text{PostAvg} - \text{PreAvg}}{28 - PreAvg} \qquad (1)$$

IV. RESULTS AND FINDINGS

A group comprising 33 students undertook a pre-assessment prior to their involvement in the study of the topic of C++ functions. After gaining a comprehensive understanding of the topic, the students proceed to provide their responses to the post-assessment. The N-Gain Score approach is utilized to calculate the scores achieved by students. The calculated mean N-Gain score for the entire student population was 0.6336. The examination of the findings revealed that a significant percentage of pupils demonstrated N-Gain scores falling within the moderate gains range (0.3 to 0.7).

Based on the statistics provided in Table 1, it is apparent that a proportion of 27.3% of students successfully fulfilled the criteria for high gain, but a majority of 72.7% attained moderate gain. It is worth noting that there were no students who fell into the category of poor gain. The efficacy of implementing the instructional tool has been demonstrated by a rise in the scores of the pretest and post-test. Hake (1999) claims that a score beyond 0.7 is indicative of a substantial increase, whilst a score falling below 0.3 is suggestive of a minimal gain. The results of the study suggest that students' comprehension of C++ functions saw a moderate positive impact, as evidenced by an average N-Gain score of 0.6336, which falls within the range of medium gains. The results indicate that there was an encouraging increase in students' levels of knowledge following the implementation of the tool, as demonstrated by the average improvement seen from their initial baseline.

Table 1. The result of N-Gain criteria

Score Range	***No of Students***	***Percentage***	***Criteria***
g > 0.7	9	27.3	High
g > 0.3, g <= 0.7	24	72.7	Moderate
g <= 0.3	0	0	Low

V. CONCLUSIONS

The N-Gain study yielded statistically significant enhancements in comprehension of C++ functions, underscoring the efficacy of individualized learning approaches. The advancement discussed herein holds significant educational implications, since it empowers students with the necessary skills to excel in the field of computer programming. According to our research findings, the combination of multimedia, analogy and practices questions has the potential to significantly enhance comprehension levels, particularly in subjects such as C++ functions. Although the study shows promise, its limited application may be attributed to the specific circumstances in which it was conducted and the very small sample size. However, the results of our study provide insights into novel pedagogical approaches in the digital age, presenting a guide for instructors in the field of computer science and emphasizing the possibilities of contemporary educational resources.

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