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Tales of C++ Worlds: C++ Programming Language Game-Based Learning

Nur Amalin Mohd Nazri, Nur Izzati Hasanah Zainal, Wan Haziqah Liyana Wan Abdul Aziz, Zuraida Ibrahim*

Department of Information Technology, Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Higher Education Hub, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author: zuraidai@uthm.edu.my

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Abstract

C++ is considered fundamental for many programming languages and is highly important in computer science and information technology. However, it is often seen as challenging, especially for programming beginners. C++ expertise is in demand in various professional roles, including software developers, game developers, C++ analysts, and backend developers. Game-based learning, which uses games to improve education, has shown potential in making learning more engaging for students. The main goals of the study are to develop a game-based learning app for C++ and evaluate its effectiveness in helping students learn the language. The study will create an interactive game that covers essential C++ principles, primarily targeting teenagers. The research and development will follow the ADDIE model, including five stages: analysis, design, development, implementation, and evaluation. The study used Unity game engine to create a game-based learning app for Android smartphones. The team designed 2D character sprite sheets and game components using Pixel Studio and Adobe Illustrator. Adobe After Effects was used for animating cut scenes. The app's design matched the learning objectives and the target audience. It was made available on the Google Play Store for Android users. The game-based learning programmed was put through beta testing, and user feedback was mixed. Some users liked the interactive and visual learning experience; however, they had suggested for enhancements to the user interface and character design. The C++ learning software demonstrated the ability to engage pupils. User input identified two areas for enhancement: the interface and character design. Future research should address these concerns and assess its usefulness in accomplishing learning objectives. Continuous feedback-based changes are critical for improving the learning experience and app value.

1. Introduction

C++ is widely regarded as a foundation language for many other languages. It is one of the most important languages to master if you want to work in computer science or information technology. There is a very good possibility that every other successful programmer and software developer is familiar with the ideas and principles of C++. There are several occupations that call for the C++ language. Its versatility keeps specialists like

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software developers, game developers, C++ analyzers, and backend developers, among others, in great demand [1]. C++ is frequently regarded as one of the most difficult programming languages to master when compared to other popular languages such as Python and Java. C++ is a difficult language to learn because it derives from the C language's economy of expression, which newbies frequently find puzzling.

Furthermore, being an object-oriented language, the frequent usage of classes and templates poses a tremendous challenge to individuals who have previously thought in such terms [2]. C++ programming is a fundamental language that all students should be familiar with. As a result, most Malaysian schools and universities require this language to be taught. C++ is a powerful programming language that supports many different types of programs, including procedural, object-oriented, and functional. Furthermore, this language is a general-purpose programming language that can be used to create an operating system, games, and other applications.

As a result, large enterprises rely on C++ to achieve fast performance while utilizing fewer resources. C++ is an important language that all students should be familiar with, and most Malaysian schools and organizations require it to be taught. Consequently, game-based learning is a teaching method that uses the power of games to define and support learning outcomes [3]. A game-based learning environment achieves this through educational games that have elements such as engagement, immediate rewards, and healthy competition. All so that while students play, they stay motivated to learn.

2. Problem Statement

There are many additional languages that are thought to have their roots in C++. Moreover, when involved studying in information technology or computer science, one of the most crucial languages to understand is C++. Every other successful programmer and software developer is probably acquainted with the concepts and tenets of C++. Currently, most students believe that the C++ language is difficult to grasp, particularly for students from backgrounds other than the computer science course [5]. According to the failure to write the programs was due to a lack of comprehension of basic principles and techniques [6]. Over a decade, the C++ language has also been modified and enhanced as a contemporary language. Therefore, students must study differently compared to the previous technique over the decade [7]. Moreover, students struggle to comprehend the ideas and conclude that the programming course is not engaging enough. As a result, individuals get demotivated and less interested in learning the language from time to time. In addition, instructors must ensure that students grasp the core principles of the C++ programming language to keep students interested as the language's concepts get increasingly complicated over time.

3. Literature Review

Game-based learning provides a highly effective method for fostering young learners' creativity, critical thinking, and problem-solving ability. It relies on the use of one's imagination. Instructors can build creative thinking abilities in students by involving them in in-game scenarios. This learner-cantered approach allows students to think outside the box and express their creative ideas, thus increasing their level of creativity. Because it is an intermediate language, C++ is commonly utilized in embedded systems. C++ contains both high-level and low-level language capabilities, giving it an advantage over other languages since it can directly access the hardware component without compromising the high-level part.

3.1 C++ Programming Language

C++ is a general-purpose programming language that was developed as an extension of the C programming language in the early 1980s. It is defined as a high-level structured language that supports object-oriented programming, generic programming, and procedural programming paradigms. C++ is an object-oriented, multi-paradigm language that supports procedural, functional, and generic programming styles [8]. It is also extremely portable and may be used on a wide range of platforms, including desktop computers, mobile devices, and embedded systems.

All students should be conversant with the core programming language C++, and most Malaysian schools and higher institutions require the teaching of this language as a mandatory subject. [7]. C++ is used in various areas such as game development, software engineering, data structures, and database management.

3.2 Game-based Learning

Game-based learning is an approach that applies gaming principles to real-life settings to engage learners in a playful and dynamic way, incrementally introducing concepts toward an end goal. It involves designing learning activities that incorporate competition, points, incentives, and feedback loops. This approach has gained popularity in higher education and libraries to foster student engagement in learning [9]. By leveraging game-based learning strategies, educators can create more engaging and effective learning experiences for students.

Playful learning approaches encourage the development of playful learners not just by using toys and games but through the development of fundamental playful values.

4. Methodology

The process for developing multimedia-based educational material served as the foundation for the development of game-based learning (GBL) for the C++ programming language. The study employed the research and development methodology of the ADDIE model. The analysis, design, development, implementation, and evaluation phases make up this model's five stages. The output of each working phase was evaluated formatively and revised in accordance with the ADDIE paradigm. Prior to the deployment phase, the GBL will be evaluated for quality and validity [10]. This project was aimed at those who need help in learning C++ computer language as well as this project was created for educational games and multimedia participated to help in their revision for the examination.

Our aim for this project is the idea behind the game will encourage players to interact and include others. As a result, it will turn an uninteresting task into one that is enjoyable. This type of instruction is not novel, but the incorporation of games into the curriculum relies on the developers' originality to make learning more enjoyable [10]. This course concentrated on learning the basics of C++ programming. As in the preliminary study, an iterative approach methodology has been adopted to construct this project. To capitalize on the pedagogical and design components of the educational game, this research method incorporates five-layered phases of the ADDIE model to develop a Game-based learning application [10]. Fig. 1 illustrates the five phases of this iterative approach: analysis, design, development, implementation, and evaluation. Below is short brief explore how the output of each phase is evaluated and revised within the ADDIE methodology in this project:

4.1 Analysis

Hence, prior to designing the game plots and quizzes for the GBL C++ programming language, extensive research and analysis were conducted to fulfil the requirements of this project. Additionally, we had valuable resources at our disposal, including reliable open-source research materials and assistance from W3Schools. This website provided easily understandable explanations and examples that we could modify as needed while developing applications. In addition to the specific subjects addressed in this project, we also included general information that students can learn, as our primary focus is comprehension. Therefore, topics such as variables, data types, conditions, for-loops, switches, arrays, and functions were covered. We constructed grammar for these concepts and utilized it in both fictional and real-world scenarios.

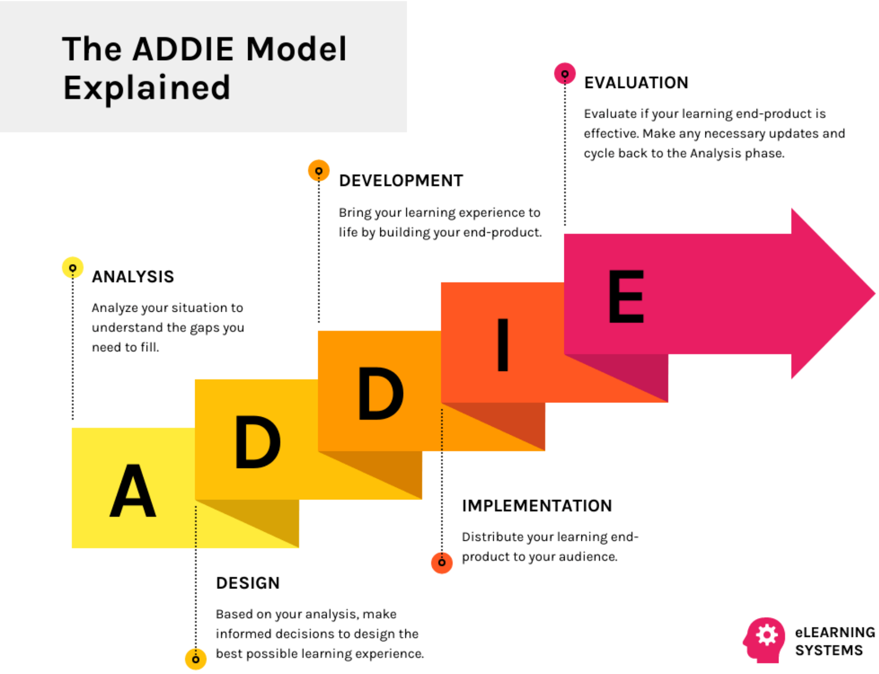
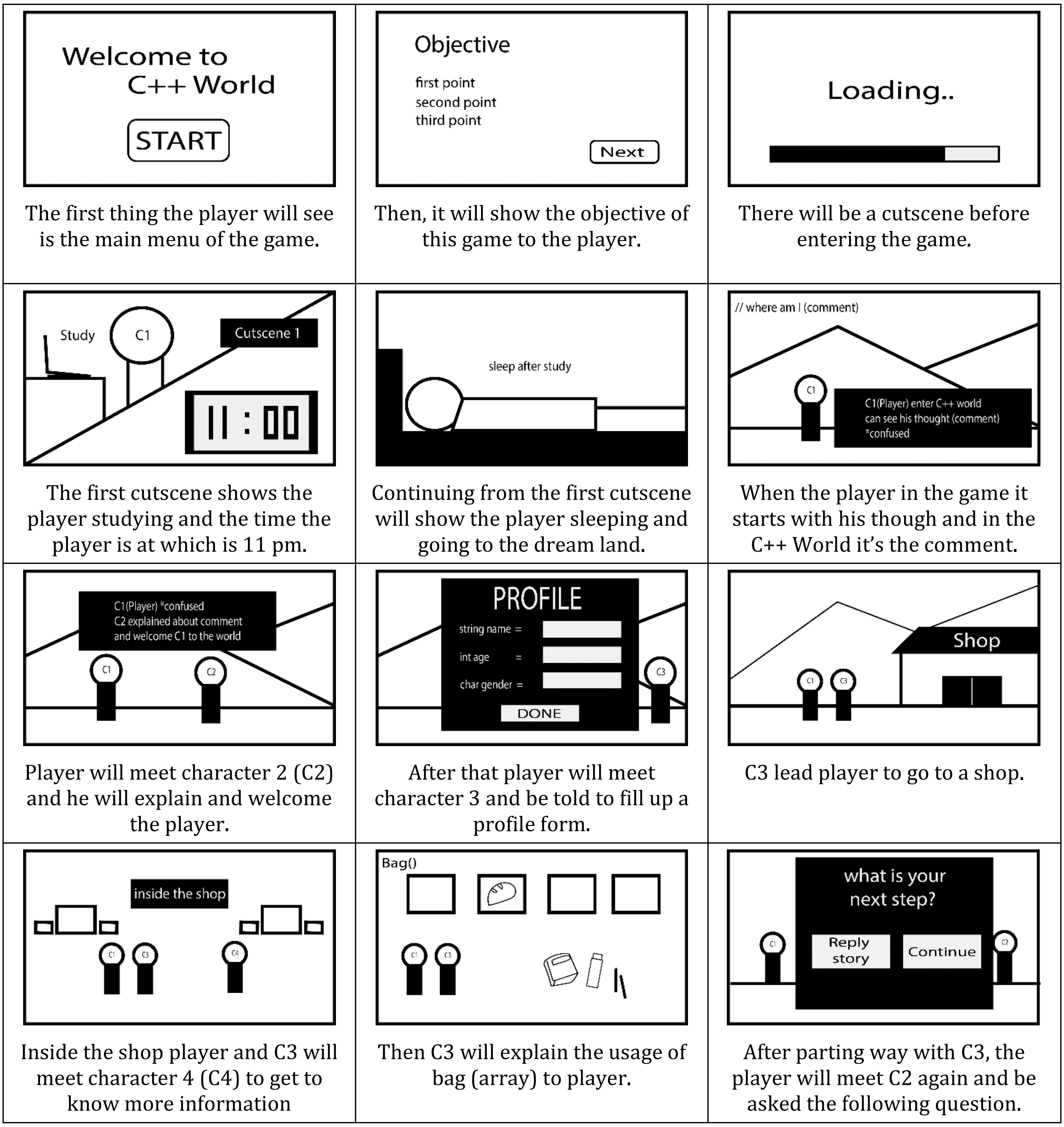

The ADDIE Model Explained
EVALUATION
Evaluate if your learning end-product is effective. Make any necessary updates and cycle back to the Analysis phase.
DEVELOPMENT
Bring your learning experience to life by building your end-product.
ANALYSIS
Analyze your situation to understand the gaps you need to fill.
A
D
D
I
E
IMPLEMENTATION
Distribute your learning end-product to your audience.
DESIGN
Based on your analysis, make informed decisions to design the best possible learning experience.
eLEARNING SYSTEMS

Fig. 1 *ADDIE model*

During the Analysis phase, various aspects such as learning objectives, target audience, and project requirements are identified, leveraging article papers as a key source of information. This phase involves a meticulous examination of relevant scholarly articles to gather insights and knowledge that can inform the design and development of the project. By delving into the articles, the research team gains a deeper understanding of the subject matter, identifies the specific learning objectives to be addressed, and determines the target audience for the project. Furthermore, the project requirements are delineated based on the findings from the literature review, ensuring that the subsequent stages of the project align with the identified objectives and cater to the needs of the intended audience. By leveraging article papers as a source, the Analysis phase establishes a solid foundation for the project, guiding subsequent decisions and actions to create an effective and targeted learning experience.

4.2 Design

In the design phase, the instructional and visual design of the game-based learning experience is established [11]. The output of this phase, such as storyboards, storyline, concept art, and prototypes, is evaluated formatively to assess the alignment with the learning objectives and target audience needs which our main attention to use this apps is among teenagers. Feedback obtained during the evaluation informs revisions and improvements to the design, ensuring it effectively supports the desired learning outcomes. Fig. 2 shows our storyboard.



The first thing the player will see is the main menu of the game.

Then, it will show the objective of this game to the player.

There will be a cutscene before entering the game.

The first cutscene shows the player studying and the time the player is at which is 11 pm.

Continuing from the first cutscene will show the player sleeping and going to the dream land.

When the player in the game it starts with his though and in the C++ World it's the comment.

Player will meet character 2 (C2) and he will explain and welcome the player.

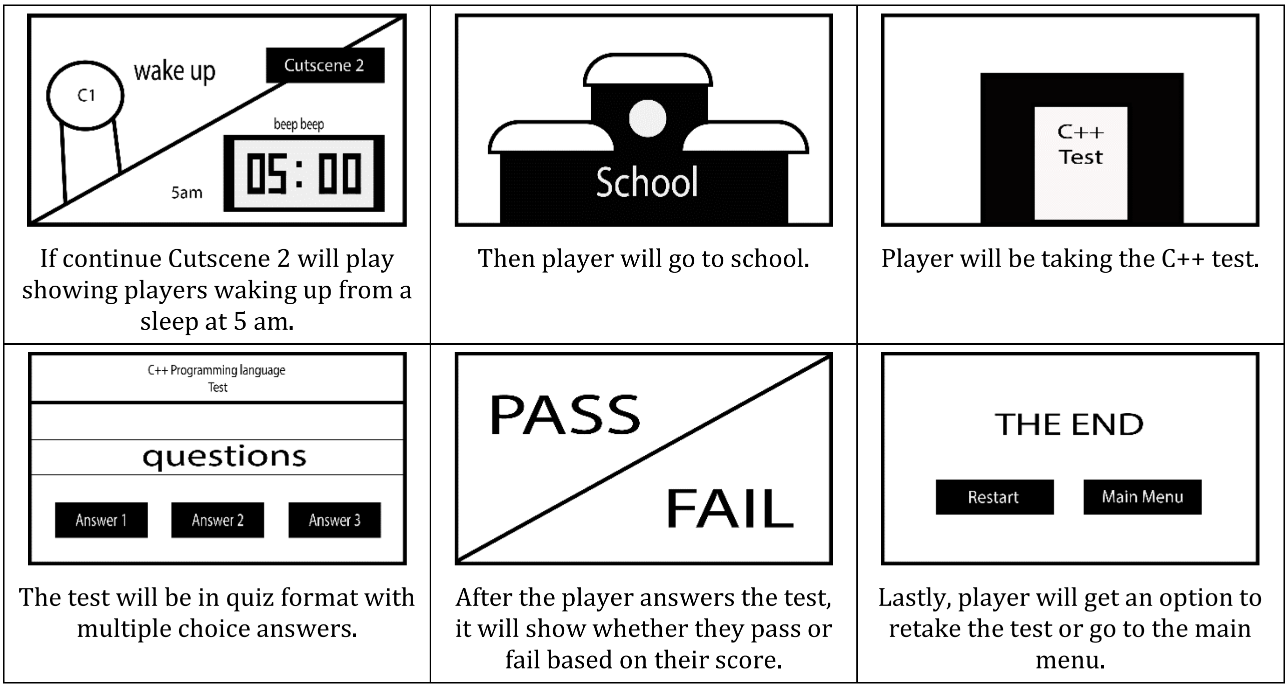
After that player will meet character 3 and be told to fill up a profile form.

C3 lead player to go to a shop.

Inside the shop player and C3 will meet character 4 (C4) to get to know more information

Then C3 will explain the usage of bag (array) to player.

After parting way with C3, the player will meet C2 again and be asked the following question.



If continue Cutscene 2 will play showing players waking up from a sleep at 5 am.

Then player will go to school.

Player will be taking the C++ test.

The test will be in quiz format with multiple choice answers.

After the player answers the test, it will show whether they pass or fail based on their score.

Lastly, player will get an option to retake the test or go to the main menu.

Fig. 2 *Storyboard*

4.3 Development

The development of game-based learning using C++ was carried out by following the specifications established during the design phase. The Unity game engine was utilized as the software tool during the development process.

The first picture in Fig. 3 shows the process of creating the 2D character sprite sheet in game using the Pixel Studio application. Then, the second picture shows the process of creating the real look of the player outside the gameplay using Adobe Illustrator, for example it will be used during dialog conversation. Continuing to the second to last picture, show the development design for the cutscene in Adobe Illustrator also. Lastly, the cutscene design from Illustrator will be imported to Adobe After Affect to be animated.

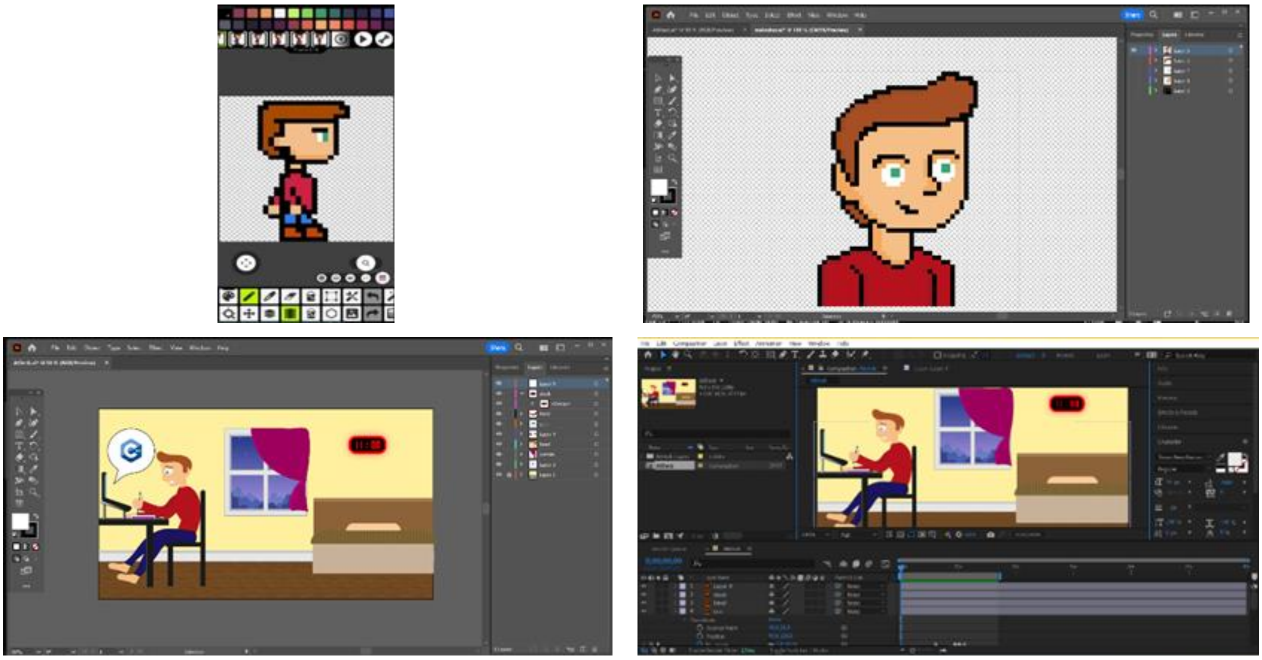
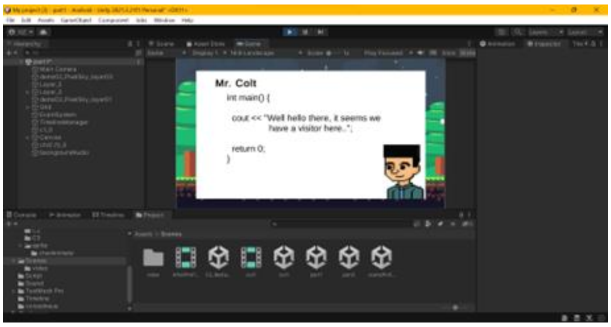


Fig. 3 *Character development and scene creation at Adobe Illustrator and Pixel Studio application and animation development at Adobe After Affect*

Fig. 4 shows the development of the game in the unity software, all design created had been imported in unity to be used as asset in the game and to create the scene based on the storyboard.



Mr. Colt

```
int main() {

  cout << "Well hello there, it seems we
           have a visitor here..";

  return 0;
}
```

Fig. 4 *Game development in Unity*

Fig. 5 shows the development process of C++ Programming Language Game-Based Learning application on Android device (tablet).

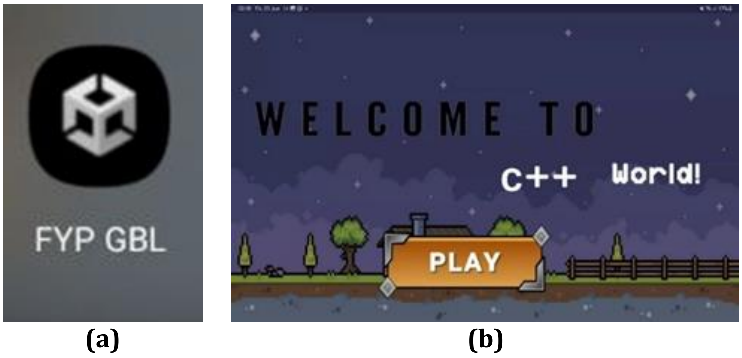


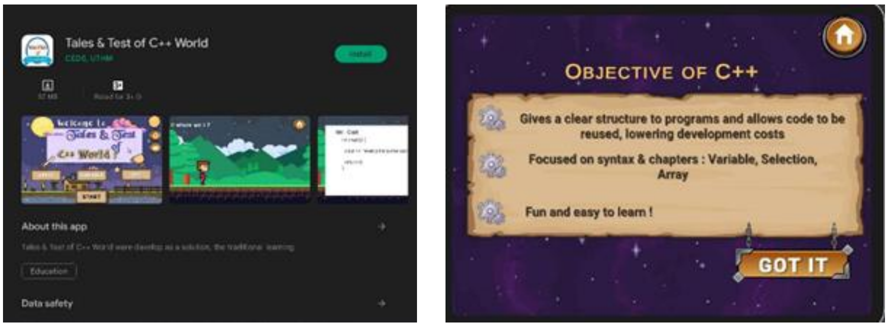
Fig. 5 *The development process on Android tablet (a) app icon; (b) app homepage after start-up*

4.4 Implementation

The game-based learning experience is delivered and made accessible to learners through the Google Play Store during the implementation phase. Downloading it to a phone or tablet makes it more accessible, liberating, and convenient for the learner. At this step, the evaluation concentrates on determining how well the implementation process works, considering elements like accessibility, usability, and technological compatibility [10]. This gives customers the freedom to learn whenever and wherever they want by allowing them to access the apps on their tablets or smartphones. This convenience may be especially useful to those who enjoy learning on the road or have limited access to traditional educational resources [12]. In addition, this project intends to include user accessibility. Android consumers are our primary target market because they can easily locate, download, and install C++ Programming Language Game-Based Learning on the Play Store, a widely used platform, Android users are our primary target audience. By making instructional games more widely available, this ease of use increases the audience's access to them [6].

Before releasing this app for public review, we tested it and sought feedback from the supervisor at our weekly meetings to show the supervisor and friends who were considering using our app the development's progress. As users of our program, we consider these replies seriously before deciding whether to make this application available to the whole public. Our project's goal is to find the game to be educational, reflecting how they preferred interactive, visual learning sources to textbooks. The improvements we make include adding more free navigation buttons for users in front of our app page and every scene of storyline in the game as well as smoother animation in every character during the game's storyline. Additionally, any problems or faults discovered during the assessment are fixed during the implementation phase to ensure the smooth and successful development of our program into an APK file. This process of implementation was carried out to ensure that every user had access to a variety of material on learning the C++ programming language and did not lose the opportunity to learn about this topic in several contexts, such as in this application.

Fig. 6 shows the Tales and Test of C++ World application and one of the interfaces in our application that has been successfully entered into the Google Play Store as well as evidence of how many users have downloaded our application.


Tales & Test of C++ World
CEDS, UTHM
Install
About this app
Tales & Test of C++ World were develop as a solution, the traditional learning
Education
Data safety
OBJECTIVE OF C++
GOT IT

Gives a clear structure to programs and allows code to be reused, lowering development costs

Focused on syntax & chapters : Variable, Selection, Array

Fun and easy to learn !

Fig. 6 *The Tales and Test of C++ World application that has been successfully uploaded into the Google Play Store and one of the interfaces in this application*

4.5 Evaluation

The Evaluation phase aims to assess the overall effectiveness of the game-based learning experience in achieving its desired outcomes which is as an aid for students to learn C++ programming language. Both formative and summative evaluation techniques are employed to gather data and measure the impact of the learning experience. Usually, it involves providing supervisor and friends with detailed feedback on both performance and material for our project. Summative evaluation describes the evaluation of the project participants with an emphasis on application outcomes from users [13]. At the end of implementation phase, we collect the data from user to see as feedback, such as the storyline, design, attraction, understanding, skill development, and academic accomplishment as summative evaluations are used to evaluate students' learning from C++ programming language application. The feedback obtained from evaluation is used to inform revisions and improvements to the game, instructional materials, or the overall learning approach, ensuring continuous enhancement of the learning experience [13].

The ADDIE method follows an iterative approach, meaning that the output of each phase is evaluated and revised based on feedback and evaluation data, leading to refinements and improvements throughout the development process [10]. This iterative feedback loop helps ensure that the game-based learning experience is continuously optimized to meet the specific needs of the learners and effectively facilitate C++ programming language learning.

5. Results and Discussion

The Results and Discussion section analyses the findings from the beta testing phase, focusing on the performance, usability, and user feedback of the tested product or service. Evaluate how well the product met user expectations. The discussion critically evaluates the results, identifies strengths and weaknesses, and suggests potential improvements. This section provides valuable insights for further development and refinement, enabling informed decisions based on user experiences.

5.1 Results

The result of testing was conducted via beta testing. Beta testing is an opportunity for users to use a product in a production environment to uncover any bugs or issues before a general release. There are various opinions and results found. This includes the perception of learning, the effectiveness of the application after using it, the appearance of the user interface, and the character design and the implementation of multimedia elements like video, music, and sound. A total of 22 people is involved in beta testing, among them are 3 lecturers, 5 students from different courses, and 12 students from the information technology course. Overall, user input shows that the project still needs to be improved to make it more appealing to users.

5.2 Discussions

Several tests have been done to ensure that the project or game works properly. During the development phase, several errors, mistakes, and shortcomings were encountered.

5.2.1 User Interaction (UI)

During testing our tester and observer commented that our button element seems dull and not interesting. Which means that our button element like its colour needs to be changed. Also, the font used in our game at first were not consistent, so we ended up using the default font from unity trough out our game since it seems suitable for our game and does not seem too basic. Other than that, there is an issue with our character scaling and the asset itself. Which makes our game look slightly unprofessional and not pleasing to the eye since the characters look different from one another.

5.2.2 User Experience (UX)

For the user experience, as stated above the buttons are dull, so we recommended adding animations and sound after clicking to it. Aside from that, first, our game does not have any sort of music, so for the critics we are obliged to add background music for the game. We can find royalty and copyright-free music that can be used commercially suitable for our game aesthetic. Furthermore, during the part in the game where character interacted, we advocated changing or replacing the look of the dialog box, before the replacement the dialog only filled half of the screen, and currently, the dialog box show at the centre of the screen as the main focus point during the conversation because the point of the game as pointed out by our tester was to let the user see the overall speech to learn and read the story. Overall, the look of the game is found with just an exemption from the above critics.

6. Conclusion

In conclusion, the C++ Programming Language Game-Based Learning application is a smart project that can attract more users who have more projects that are user-friendly, intelligent, and entertaining. The project will benefit in terms of comprehension because it focuses primarily on the method of learning as opposed to the traditional method, which takes more time and attracts less student interest. The application can increase the user's knowledge of various methods of learning C++ because it is not boring and always issues diverse types of questions in the form of interesting games as well as the existence of various characters and a challenging path to the next question phase in a story situation. The Unity game engine is frequently used since it provides access to many official and community information and instructional resources. By leveraging game-based learning strategies, educators can create more engaging and effective learning experiences for students. Learning C++ for C++ Programming Language Game-based Learning is a wonderful way to learn the language and develop computer software applications. Hopefully, the C++ Programming Language Game-based Learning Application can be a highly effective tool that can benefit every individual who wants to learn and understand various aspects of information technology, especially C++ programming. By incorporating game-based elements, this app not only facilitates learning but also provides a fun and stress-relieving experience for users. Hopefully, these games have the potential to be widely accepted and have a significant impact on the learning journey of many individuals in the field of information technology.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design, data collection, draft manuscript:*** *Nur Amalin Mohd Nazri, Nur Izzati Hasanah Zainal, Wan Haziqah Liyana Wan Abdul Aziz, Zuraida Ibrahim;* ***draft manuscript preparation:****Nur Amalin Mohd Nazri, Nur Izzati Hasanah Zainal, Wan Haziqah Liyana Wan Abdul Aziz, Zuraida Ibrahi. All authors reviewed the results and approved the final version of the manuscript.*

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