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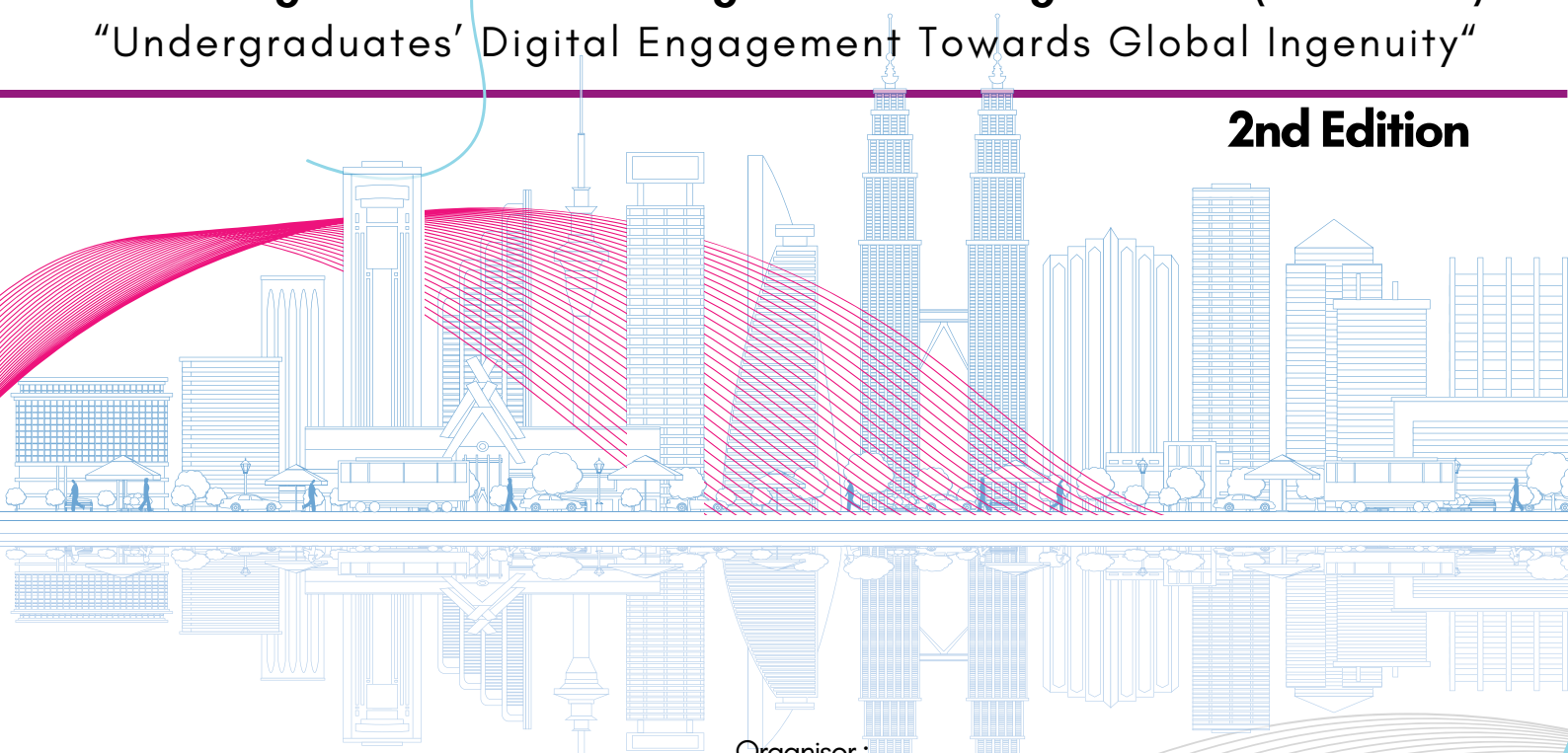
"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition



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ENHANCING PROGRAMMING LANGUAGE LEARNING WITH 3D GAME-BASED PROGRAMMING FOR MSU STUDENTS: CODADVENTURE

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Abstract
This study focuses on innovative approaches to enhance the learning experiences of programming languages, focusing on developing 3D game-based programming for students at Management & Science University (MSU). The study thoroughly examines the difficulties encountered in conventional programming education and emphasizes the potential advantages of utilizing immersive gamified techniques. The students face challenges while learning programming languages and memorizing programming concepts. The research emphasizes individuals' syntax, debugging, and algorithmic writing difficulties. Conventional face-to-face learning methods result in a relatively low average score of 3.50 in understanding syntax. The instructor's methodology also guides the students in teaching and learning programming language using the Logic Learning method in the game. The project's objective is to reduce the common difficulties MSU students face in learning programming languages. This was achieved by creating a 3D game-based programming platform called Codadventure. The game's development implemented Unity3D to create a platform that enhances the memorization of programming concepts. Furthermore, the research provides educators with efficient techniques for improving students' learning in acquiring programming languages using the Logic Learning method integrated into the game. The project uses the Game Development Life Cycle (GDLC) to facilitate methodical development. The approach involves doing a Pearson correlation coefficient heatmap analysis, specifically examining factors such as Enhancement, Gameplay, Familiarity, and Engagement. Utilizing data analysis and student feedback allows for significant insights into the effects of the 3D game-based method on the adoption of programming languages. In the future, the project has the potential to include an adaptive learning path that customizes the educational experience on the individual student's progress, abilities, and areas that need to be developed.

Keywords: *Education Game, Pearson Correlation, Logic Learning, Game Learning, Programming Language*

1. INTRODUCTION

In the Merriam-Webster dictionary (Merriam Webster, n.d.), a game is an organized activity engaged for amusement or enjoyment and occasionally utilized for educational purposes. Games need players to make choices and effectively allocate resources to accomplish predetermined objectives. Games may provide a dual purpose for students, serving as a means of entertainment and learning. They provide incentives and milestones that increase engagement and motivation. Programming is the foundation for several technical activities that students encounter daily, such as buying groceries or utilizing speech recognition. Programming language is widely helpful and frequently seen as intricate and daunting. Beginner students sometimes need help understanding many concepts, like functions, loops, and variables.

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Howard Gardner, a professor at Harvard University, emphasizes that conventional educational institutions frequently depend on standardized measures to evaluate learning, which may only adequately address the individual requirements of some students (Gardner, n.d.). This study utilizes game-based learning approaches to instruct programming utilizing logical problem-solving and improving memorization and practical application.

Students need help memorizing programming constructs such as functions, loops, and variables, which impairs their ability to learn efficiently (Islam et al., 2019). Students have significant hurdles in writing and debugging programs due to syntax issues, such as missing commas or misspelt words (Piteira & Costa, 2013). Conventional teaching methods did not frequently engage students or effectively elucidate programming concepts, impacting their interest and comprehension (Abuaiadah et al., 2019; Kadar et al., 2021). This study aims to solve these challenges by pursuing creating a programming tool based on Unity3D that utilizes 3D game elements to aid in the retention of programming concepts, incorporating game-based learning techniques that improve comprehension of syntax through logical problem-solving, and establishing efficient instructional approaches for teaching programming by integrating logic learning within the game. The research aims to create a game-based learning platform incorporating logical learning methods.

Additionally, the research will provide instructional strategies for teaching programming using the developed game. This project aims to improve the educational experience of tertiary programming students at Management and Science University by creating a 3D game-based learning tool. The study aims to enhance students' comprehension and memory of programming ideas using logical learning strategies in the game. This approach aims to tackle the difficulties associated with conventional teaching methods.

2. MATERIALS AND METHODS

This research used Unity3D, PlayFab, and PHP to construct a 3D game-based programming learning. Unity3D was used for game development, PlayFab for database management, and PHP for API integration. The immersive learning experience is mostly created using Unity3D, with PlayFab handling data storage and retrieval, and PHP facilitating communication between the game and the database. The students are required to complete a Playtesting survey while playing the game, and data collection is conducted using Google Forms. This survey provides significant insights into the students' preferences, experiences, and challenges that they face during gameplay. The qualitative comprehension of the impact of the 3D game-based approach on programming language learning is provided by the collected data. The data is analysed using a software-based approach, with the Matplotlib library in Python generating graphical representations of the data, enabling a visual interpretation of a variety of study aspects. Graphical representations of the accumulated data are generated by the MATLAB library (Matplotlib). The data was represented via the use of line charts, scatter plots, and bar graphs to illustrate patterns, trends, and connections (Hassan Sial et al., 2021). This approach is used to demonstrate the progression of student results, the distribution of responses, or variations in engagement levels over time. The analysis of the obtained data utilizes a heatmap that is particularly tailored to showcase Pearson correlation coefficients between the major variables: Enhancement, Gameplay, Familiarity, and Engagement. This statistical study provides a graphical depiction of the correlations between various variables, therefore offering insights into their interactions and mutual influences. The Pearson correlation coefficients quantify the intensity and direction of these relationships, thereby facilitating the assessment of the efficacy of the game-based learning approach.

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The methodology of the project to develop the game used Game Development Life Cycle (GDLC). In this study, GDLC has all the requirements necessary to build games since other methodologies do not provide phases such as designing games, storyboarding, and developing characters. The first phase of this methodology required several stages which are initial project, pre-production, production, post-production, game testing, beta release and release of the game. The project methodology follows the GDLC to systematically develop the 3D game-based programming platform, Codadventure. In the Concept Phase, the project conceptualizes goals, research, and analysis of the requirement. The Pre-Production phase involves designing game mechanics, prototyping features, and selecting technologies such as Unity3D, PlayFab, and PHP. The Production Phase sees the actual implementation of the game, integrating PlayFab for database management and using PHP for API creation. In the Testing Phase, playtesting, and bug fixing refine the game's functionality and user experience. The Deployment Phase releases the final version, including finalization, distribution, and documentation. Finally, the Post-Production Phase analyses user feedback, evaluates Codadventure's impact, and plans updates based on insights gained.

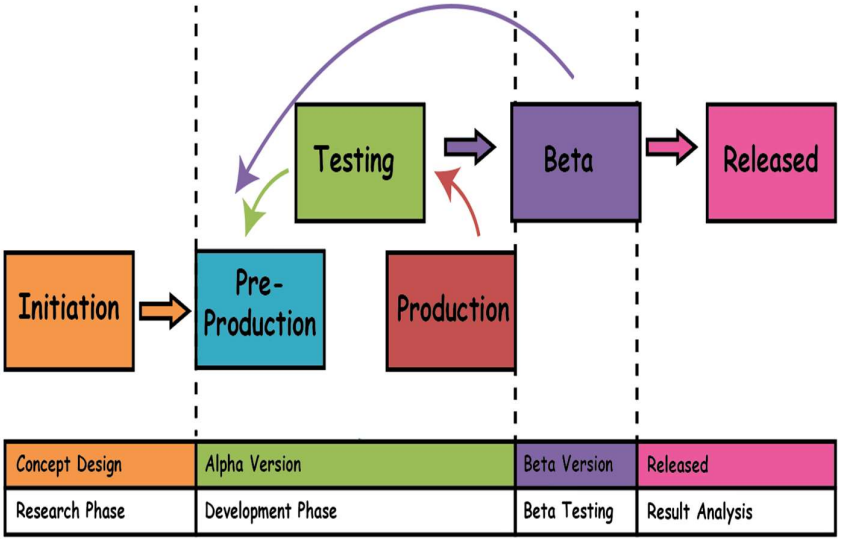

Figure 1. Game Development Life Cycle Process.

3. RESULTS AND DISCUSSION

The Pearson correlation heatmap illustrates the correlation coefficients between several content categories, namely Enhancement, Gameplay, Familiarity, and Engagement, using the respondent data supplied. The heatmap exhibits correlation coefficient values for each cell ranging from -1 to 1. A positive coefficient suggests a direct relationship, whereas a negative coefficient signifies an inverse relationship. A coefficient close to 1 or -1 implies a high connection, whereas a value close to 0 shows a weak or nonexistent link (Marques et al., 2020). The Pearson correlation coefficient formula calculates the coefficient for each pair of variables presented in the heatmap. The correlation coefficient is a numerical value from -1 to 1. A value of -1 signifies a complete negative correlation, while 1 signifies a complete positive correlation. A value of 0 shows no correlation between the variables.

The p-value corresponding to each correlation coefficient is usually obtained by statistical testing. Within the framework of Pearson correlation, this examines the null hypothesis that there is no correlation between the variables. A smaller p-value indicates stronger evidence against the null hypothesis.

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The Pearson correlation coefficient (r) is computed using the below formula:

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \cdot \sum (Y_i - \bar{Y})^2}}$$

Where:

a) Xi and Yi are individuals' data points in the two variables.
b) X and Y are the means of the two variables, respectively.

The formula calculates the covariance of the two variables, divided by the product of their standard deviations. Figure 2 depicts Pearson correlation coefficients revealing insightful relationships among different dimensions of the 3D game-based programming platform, Codadventure.

In summary, the research supports the continuing study and incorporation of 3D game-based learning with programming learning. From Figure 2, the assessment of Pearson correlation coefficients reveals significant correlations among key dimensions, including Engagement, Familiarity, Gameplay, and Enhancement. The moderately strong positive correlation between Enhancement and Gameplay (r = 0.29) indicates that user engagement with gameplay tends to increase as they experience platform enhancements, highlighting the positive impact of interactive features on user participation. The weak positive correlation between Enhancement and Familiarity (r = 0.18) suggests that platform improvements may contribute marginally to increased user familiarity with programming concepts. Additionally, the moderately positive correlation between Enhancement and Engagement (r = 0.38) underscores the critical role of platform enhancements in promoting user engagement, as greater enhancements are associated with increased user engagement. These findings suggest that targeted improvements in game-based learning platforms can significantly enhance the educational outcomes for students learning programming.

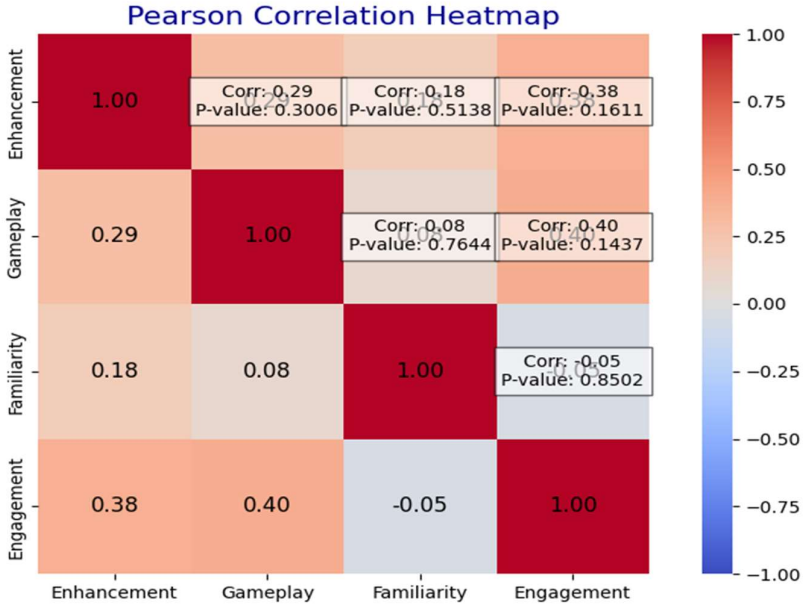

Figure 2. Pearson Correlation Coefficient Heatmap of Codadventure Review

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4. CONCLUSION

In summary, the research supports the continuing study and incorporation of 3D game-based learning into programming education. These concepts establish a foundation for the advancement of technology-enhanced learning and the improvement of educational game design. In future, the project has the potential to develop adaptive learning paths that customize the educational experience to unique strengths, progress, and areas that require the development of each student. The initiative provides that every student will have a learning experience that is both efficient and personalized.

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