Gamifying Human Circulatory System: A Game-Based Learning Application to Enhance Students' Understanding and Retention of Human Body Concepts For Grade 6 Students

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Abstract

This thesis developed a gamified mobile learning application designed to enhance Grade 6 students' understanding of circulatory system concepts namedGamifying Human Circulatory System . Acknowledging the rising significance of games in fostering children's engagement in educational pursuits, this research capitalized on the trend by developing a mobile game that not only captures students' interest but also facilitates the comprehension of complex anatomical concepts. Utilizing a pretest-posttest design with paired t-tests for analysis and survey questionnaires based on the ISO 25010 standards , the study reveals a highly significant positive impact on students' knowledge scores. The Gamifying Human Circulatory System application successfully engaged students, transforming the learning of fundamental circulatory system principles into an enjoyable and effective educational experience. These findings underscored the potential of gamified approaches to create an immersive and entertaining educational environment for Grade 6 students. This study provided valuable insights into science education, emphasizing the practical application of gamification to enhance both engagement and comprehension. Focused on the circulatory system, the study supported the idea that gamified learning tools, particularly in the form of mobile games, can positively influence how young learners interact with scientific concepts. The study's outcome demonstrated that incorporating gamified elements into educational tools holds promise in significantly improving students' understanding, making the learning process both informative and enjoyable in the Grade 6 Science curriculum.

1. Introduction

The rapid advancement of technology has significantly transformed various aspects of life, particularly education. The COVID-19 pandemic accelerated this dependence, prompting schools to adopt technology to bridge gaps in learning (Daniel, 2020; Pokhrel & Chhetri, 2021). As students grow up in a digital era, they are adept at using technology daily, but challenges like lack of motivation and engagement persist in digital classrooms (Chang et al., 2019; Admiraal, 2022). Gamification, defined as the application of game elements in non-game settings (Dicheva et al., 2019), has proven effective in addressing these challenges by enhancing engagement and comprehension (Sailor & Homer, 2020; Crisol-Moya et al., 2020). While the concept of gamification dates back to the Soviet era, its widespread use began after 2010 (Heindrich, 2023; Monteiro & Bartiel, 2021).

Gamification is now applied in fields like education, marketing, and wellness. Platforms such as Khan Academy and Duolingo effectively utilize game elements like badges to motivate users (Shortt et al., 2021; Zecri et al., 2021). In education, games scaffold learning by combining challenge, skills, and immersion, fostering deep engagement and skill development (Koivisto & Hamari, 2019; Gounaridou et al., 2021). However, existing circulatory system applications primarily rely on 3D models and basic explanations, lacking interactivity and engagement.

This study introduces an adventure-based gamified mobile application to teach the circulatory system to Grade 6 students at Letran-Calamba. Inspired by the success of augmented reality and gamified approaches in enhancing learning experiences (Lamorpropoulos, 2021), this research aims to create an immersive and engaging tool that fosters comprehension of complex scientific concepts, providing a meaningful and enjoyable learning experience for students.

The general problem addressed in this study is the difficulty students, especially Grade 6 learners, face in understanding the circulatory system, a complex subject that is often new to them. Specific problems include finding ways to make circulatory system lessons more interactive and engaging, creating an effective method to assess knowledge through reflective post-tests after game-based learning, and improving students' low attention spans during the learning process. Additionally, the study aims to explore how students can better retain information while learning about the circulatory system and how the gamified learning application adheres to the ISO 25010 standards for software quality.

1.1 Literature Review

This chapter presents a review of relevant literature related to the subject of the study. By examining existing research, theories, and findings, this review established a strong foundation and context for the current investigation. The insights gained from the esteemed scholars' works highlighted the gaps and opportunities for further exploration, contributing to the advancement of knowledge in the field.

1) Circulatory System

The Circulatory System, also known as the Cardiovascular System, is a body system that is responsible for transporting the oxygenated blood through the arteries (Cleveland Clinic, 2021). The Circulatory system carries hormones to the cells and is responsible for removing body waste (Hirsch, 2018). The circulatory system has connection to the different body systems, mainly to the respiratory system with its role to deliver blood to the lungs (U.S Dept of health, 2022) and also to the role of circulatory system is crucial in process digestive system which its role absorb nutrients that comes from the food and delivers them throughout body (YawandWossen, 2020).

2) Gaming in Education

The rapid evolution of technology in recent decades has also driven advancements in the gaming industry, making games a common diversion for children (Tapingka et al., 2020). Educational literature increasingly explores using games and game elements as teaching tools, noting their potential to enhance students' interest, motivation, and group collaboration. While evidence remains limited, games may also improve knowledge retention. Sailer and Homer (2020) highlighted the growing attention to gamification in education, where game design elements are used to engage and reward learners (Tapingka et al., 2020). Studies suggest that incorporating game-like activities in traditional educational settings boosts student engagement and focus (Koivisto & Hamari, 2019; Bai et al., 2020; Yu et al., 2020). Additionally, Natsis et al. (2022) reviewed literature on game-based learning for teaching anatomy, finding promising educational outcomes through platforms like PubMed and other scholarly databases.

3) Effects of Gamification on Education

The use of game mechanics and design elements in education has gained significant attention for enhancing learning and engagement. ÖZTÜRK (2019) highlights that gamification can boost student motivation, engagement, learning outcomes, and retention. Elements like badges and leaderboards foster competition and collaboration, as supported by Junttila et al. (2022). Kormaz (2019) and Stuart et al. (2020) further emphasize gamification's role in improving retention and recall, with immediate feedback and rewards maintaining motivation (Howard & Bevins, 2019; Li et al., 2022). Personalized learning through adaptive algorithms also enhances student achievement and reduces gaps (Chen et al., 2020).

Hill and Nassrallah (2018) demonstrated gamification in anatomy education, where students engaging in game-based exercises showed improved test scores compared to traditional methods. Similarly, Antonio and Tamban (2022) studied gamification in Math education during the COVID-19 pandemic in the Philippines. While both traditional and gamified teaching improved student attitudes, the gamified group showed notable progress in Math 8 performance, indicating its potential educational benefits.

4) ISO 25010

The ISO 25010 is an international standard that provides a framework for evaluating the quality of software products and systems. It's part of the ISO/IEC 25000 series, which covers software product quality requirements and evaluation. ISO 25010 specifically focuses on the quality characteristics of software products. It defines a set of quality characteristics and sub characteristics that can be used to assess the quality of software in various dimensions. (Purtbarati & Krisnawaty 2023) In the development and assessment of the Android game Gamifying Human Circulatory System, adherence to ISO 25010 standards is essential for ensuring its quality and effectiveness. ISO 25010 offers a structured approach to evaluating software attributes such as functionality, reliability, usability, efficiency, maintainability, and portability. By applying ISO 25010 criteria throughout the development lifecycle, we aim to deliver a polished and reliable gaming experience for Android users. This involves meticulous testing and optimization to enhance the game's performance, usability, and overall enjoyment. By prioritizing ISO 25010 standards, "Gamifying Human Circulatory System" strives to stand out in the competitive landscape of Android gaming, offering users a seamless and engaging experience while maintaining high standards of quality and reliability.

5) Synthesis

The circulatory system, or cardiovascular system, is vital for transporting oxygen, nutrients, and hormones while removing waste, connecting closely with other bodily systems like respiratory and digestive systems to maintain balance. Gamification in education, leveraging gaming elements, has emerged as a transformative approach, enhancing student engagement, motivation, and retention. Studies show its effectiveness in fostering interactive and immersive learning experiences.

This proposed study focuses on creating a gamified adventure game about the circulatory system for Grade 6 students, adhering to ISO 25010 standards. By addressing specific cognitive needs, it distinguishes itself from broader gamification applications, aiming for a deeper understanding of this scientific concept. While aligned with prior research on gamification's benefits, this study uniquely centers on the circulatory system, offering targeted insights into its learning impact.

The study highlights the potential of gamification to combine entertainment and education effectively, enhancing student comprehension and engagement with the circulatory system in a meaningful and innovative way.

6) Research Gap

Numerous studies have examined gamification's role in education, yet gaps remain in understanding its long-term impact on students' retention of human anatomy principles and their application in clinical settings. Prior research has emphasized short-term outcomes, but further investigation is needed to determine gamification's influence on motivation, participation, and academic performance, as well as its potential to enhance clinical skills. Additionally, exploring the optimal design and implementation of game-based learning in anatomy education is essential. This includes identifying effective game elements, addressing challenges in adoption, and developing evidence-based strategies to enhance learning outcomes and skill acquisition. Closing these research gaps is vital for improving anatomy education's effectiveness and preparing students for practical applications.

7) Theoretical Framework

Figure 1: Lander's Gamification Learning Theory (2014)

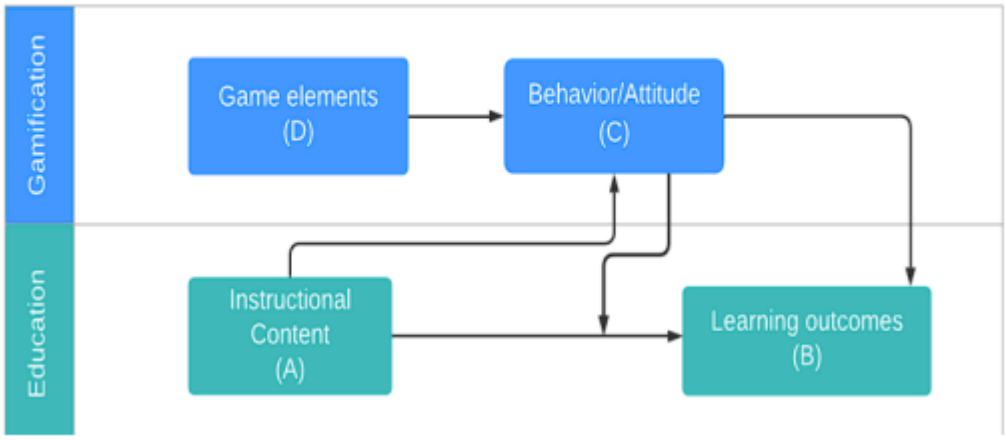

Fig. 1 Lander's Gamification Learning Theory (2014)

The researchers applied the Gamified Learning Theory (GLT) by Lander, which uses game elements in non-gaming contexts to influence behaviors and attitudes related to learning. These game attributes, derived from serious games, aim to evoke game-like mental states and behaviors that impact the learning process.

GLT emphasizes that gamification does not directly affect learning but instead stimulates learning-related behaviors, acting as a mediator or moderator. As a mediator, gamification promotes specific behaviors or attitudes that enhance the learning experience, with these behaviors bridging the connection between game elements and learning outcomes.

8) Conceptual Framework

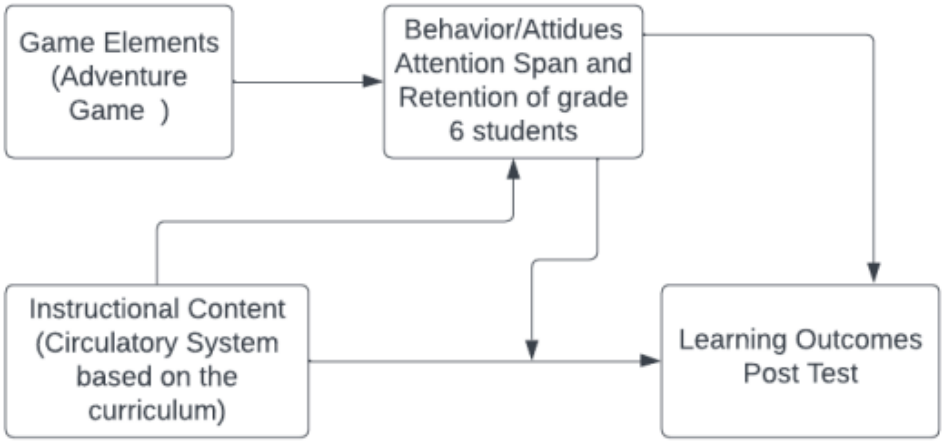

Fig. 2 Conceptual Framework Based on GFT

The researchers utilized Landers' Gamified Learning Theory (GLT) from 2014 for the study. The GLT defines gamification as the deliberate use of game elements in non-gaming contexts, which precisely reflects the research's intent in designing a game-based learning application. The study aligns with GLT's core concept that gamification does not directly impact learning but rather functions as a mediator. In this context, the game-like elements (Adventure) within the application are aimed at stimulating and cultivating specific behaviors and attitudes (Retention and attention) related to learning of the Grade 6 students. Through this mediating process, the researchers investigated how the game-based learning approach enhances students' comprehension and retention (Post Test) of complex human body concepts, particularly those associated with the circulatory system (Instructional content) . This research employs Landers' theory to explore the potential of gamification in enhancing the educational experience for young learners studying human biology.

2. Research Methods

The researchers used quantitative research method design in collection data for the proposed game application. The researchers conducted a Pre-test and Post-test to determine the effectiveness of gamifying the circulatory system in Grade 6 students of Colegio San Juan De Letran - Calamba.

I. Population of the study

The sample from this study were the Grade 6 students of Colegio de San Juan de Letran Calamba - Basic Education in accordance with the modern curriculum that the circulatory system first introduced to the grade 6 pupils. A total of 51 students participated in the study. The objective of the study was to ascertain how well a game based learning application may help the students in comprehending and remembering human body ideas, particularly those related to the circulatory system.

II. Sampling Design

The researchers utilized convenience sampling design, a non-probability sampling method, to select the participants for their study. The respondents consisted of Grade 6 students of Colegio de San Juan de Letran-Calamba who were deemed the most suitable for the research due to the proximity of the samples together with the accordance of the new curriculum.

III. Data Collection Method

The researchers gathered qualitative data through structured interviews with the Science teachers and faculty members in designing the concept of the game application. Additionally, the researchers conducted surveys by distributing questionnaires to the respondents. Data was analyzed to identify patterns and trends within the collected information. The survey questionnaire utilized Likert Scale format. It included closed-ended questions to obtain specific, predetermined responses from the participants to validate the quantitative data obtained The objective of the survey was to gather feedback on the Gamifying Human Circulatory System application. It consisted of seven questions that assessed the participants' level of engagement, improvement in understanding and retention of human body concepts, and the application's effectiveness in explaining complex concepts related to the human circulatory system. This questionnaire for the pretest and post-test quiz was designed to evaluate the impact and effectiveness of the application in enhancing users' understanding of the human body and its intricate circulatory system.

IV. Software Development Life Cycle (SDLC)

The gamifying circulatory system application utilized the Agile Software Development Life Cycle (SDLC) in accordance with the standard set by ISO 26511. The use of Agile SDLC places significant emphasis on collaborative decision-making and development, executed through a series of cycles or sprints. These cycles encompass six distinct phases, which include: requirement gathering, design, development, testing, deployment, and review. The subsequent description elaborates on the specific processes applied during each of these phases

3. Result and Discussion

The researchers conducted a test in determining how the gamifying mobile game enhances the students' information retention . Before using the app Gamifying Human Circulatory System , the students take the pre-test quiz. Then after completing the game, students receive a link to a post-test on Google Forms. This test assesses the effectiveness of game-based learning experience in enhancing their understanding of the circulatory system. Both the pre-test and post-test quiz questions are directly aligned with the content covered in the game . Results from the pre-test and post-test are then visually presented in a bar graph, offering a concise overview of student performance. The content of questionnaires (Post-Test and Pre - test) are the same in the study ,data-driven analysis contributes valuable insights to the broader discussion on the educational impact of game-based learning. The design of the post test is similar to the pre-test which has 10 questions and multiple choice quiz questions based on the information included in the game. Here is the interface of the developed game. The game will be evaluated using ISO 26511 standards.

Fig. 3 Main Screen Interface

Upon launching the application, users are greeted with an initial interface featuring options such as "New Game," "Load Game," "Settings," and "Quit Game." Background music (BGM) automatically plays to create an immersive atmosphere. This interface has been carefully designed to ensure user-friendly navigation and provide an engaging introduction to the game.

Following the post-test, 51 Grade 6 students participated in a survey aimed at evaluating the effectiveness of game-based learning. To ensure a meticulous system development and testing process, researchers adhered to ISO 25010 standards. This comprehensive approach included thorough unit and integration testing during the game evaluation phase, aligning with ISO 25010's criteria for functionality, reliability, usability, efficiency and portability. The utilization of these standards reflected the commitment to a rigorous and standardized methodology, enhancing the reliability and validity of the assessment of game-based learning effectiveness.

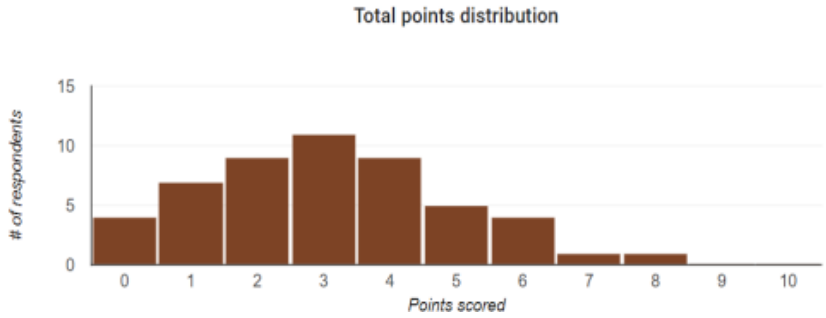

Fig. 4 Pre-Test Result

In the context of a pre-test quiz with a maximum score of 10 points, the study indicated an average performance of 3.1 points, suggesting a subpar level of achievement. The median score, situated at 3 out of 10 points, reflected an uneven distribution of scores among the cohort members, indicative of an overall lack of success. Notably, individual student scores ranged from 0 to 8 points, highlighting the performances within the constrained scale of the 10-item quiz. This 46 insightful information provided a nuanced comprehension of the class's overall performance, revealing a range of achievements among the students.

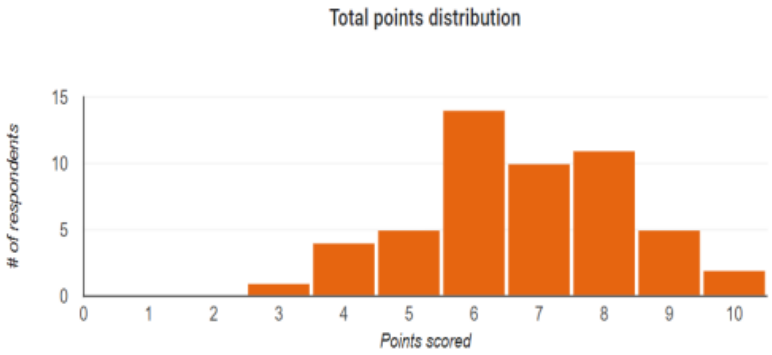

Fig. 5 Post Test Result

In the context of the post-test quiz, wherein students could attain a maximum of 10 points, the study revealed an average performance of 6.75 points, pointing to a moderately successful achievement level. The median score, positioned at 7 out of 10 points, signified a well balanced distribution of scores within the cohort. Notably, the individual student scores demonstrated a range spanning from 3 to 10 points, showcasing a diverse spectrum of performances within the limited scale of the quiz, which encompassed a total of 10 items. This insightful information contributed to a nuanced understanding of the overall class performance, shedding light on a spectrum of achievements among the students.

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4. Conclusions

Based on the test and survey results provided, it is evident that integrating gamification into the Gamifying Human Circulatory System mobile application for teaching basic circulatory system concepts can significantly enhance students' understanding. The paired samples t-test conducted to evaluate the impact of gamified learning interventions on Grade 6 students' comprehension of human circulatory system concepts revealed a statistically significant mean difference between pre-test and post-test scores additionally, the survey, conducted using ISO 25010 standard-based questionnaires, showed a positive response from the Grade 6 students of Letran Calamba, indicating favorable perceptions and experiences with the Gamifying Human Circulatory System . This indicates that the games effectively address the needs and preferences of the Grade 6 students, highlighting their engagement and satisfaction with the interactive content provided. Overall, these findings demonstrate the efficacy of gamification in achieving educational objectives, fostering student engagement, and improving satisfaction with interactive learning content among the target population

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