Journal of Artificial Intelligence and Technology, 2024, 4, 200-207
https://doi.org/10.37965/jait.2024.0421

RESEARCH ARTICLE

Matching Game Genre with Lesson Content – A Development of Blood Circulation Racing Game

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(Received 10 July 2023; Revised 14 August 2023; Accepted 16 August 2023; Published online 21 February 2024)

Abstract: It has been demonstrated that students pay more attention during game-based learning, which in turn leads to greater levels of learning among students. In addition, the success of students in their academic endeavors is increased when the learning styles or learning objectives of the children are matched with the appropriate game type. This paper describes the development of a digital game for learning blood circulation that maps to a "racing" game genre. The lesson's objective was for the students to be able to understand how blood flows, and a racing game genre was chosen to match the lesson content. Racing game assets such as racetrack, race path, race car, and obstacles are mapped to lesson-embedded designs such as simplified blood circuit, blood direction, blood cells, and cholesterol lumps. Multiple cues are inserted into the game to help players with content recollections. Common challenges for racing games, such as time limits, energy meters, and obstacles, are tailored to the theme of blood circulation. Usability testing was conducted to measure the ease of use of this game using System Usability Scale (SUS). Five 15-year-old participants took part in the testing at a secondary school in Melaka. Participants were chosen using convenience sampling, and none of the participants had ever played the game before. A SUS standard score of 78 was obtained, which is considered "Good" under the Adjective Ratings when measured against the SUS Score Graph.

Keywords: game-based learning; game design; game genre; usability testing

I. INTRODUCTION

Digital games as a tool to support teaching have been enthusiastically embraced by academicians and researchers in the education field since the first release of commercial games. When personal computers became affordable and more widely available, titles such as Math Blaster and Oregon Trail appeared [1], and they helped in making learning exciting and engaging for students.

Lesson-based games share the characteristics of employing the many elements of the platform's medium to capture students' attention: audio, video, animation, and images, together with games' elements such as objectives, progression, points, time pressure, and levels [2]. Newer games are also able to benefit from new game hardware, including haptic feedback, virtual-reality headsets, mobile devices supported by augmented reality, and multiple custom accessories like steering wheels, dance pads, and sporting gadgets, among others [3].

A research interest in game-based learning is the effort of matching the design of the game, most specifically its genre, to match lessons. This effort is motivated by the belief that such synchronization may support a better understanding of content. Studies on matching genre to lessons in game-based learning include role-playing as an Indonesian warrior character in Battle of Surabaya [4], solving a murder case at the backstage of a New Orleans jazz club to experience and learn jazz and Afro-American music concepts [5].

This paper highlights the development effort of an educational game with this characteristic. It is a game meant to help visualize the journey of human blood circulation and is designed to be played like circuit racing. The scope of this game is the topic of blood circulation as delivered in the syllabus of Malaysian schools, with the Biology textbook referred as the primary source.

In the design and development of this game, several challenges and considerations had to be overcome. The first challenge was balancing realism and accuracy versus appealing visuals. This game represents the complex process of blood circulation; therefore, easily identified components of the circulatory system are expected. However, the game must also incorporate elements of fun in the design of its graphics and gameplay. The second dilemma was determining the missions that should be designed in the game in addition to the obligatory steering and maneuvering of a racing game. The missions and obstacles should add elements of entertainment to the game while also being relevant to the theme of blood circulation. The third challenge was determining which mobile platform feedback, including audio, visual, and haptic, should be mapped to which design cues of the game. All these three design challenges and decisions made to address them are documented in this paper.

The merits of this research lie in the innovative decision to match the game genre and gameplay of a racing game to teach the lesson of blood circulation. This decision, while seemingly simple, brought about multiple harmonious alignments between elements

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of this game and the topic in focus. The game documented in this paper is significantly different and better than the more widely adopted game-based learning platforms such as Kahoot and Quizziz because of the difference in gameplay. The two platforms are played in the form of gamifying quizzes. They assume students have existing knowledge of the topic in focus and, as such, unfairly penalize students who answer wrongly or take time to answer. In contrast, our game allows students to intuitively learn about blood circulation while playing a fun racing game.

This paper is arranged in several sections. The first section is Introduction, explaining the motivation, scope, challenges, and merits of this research. The second section is Literature Review, summarizing topics of Game-based Learning and the interesting more recent efforts of matching syllabus, content, and learning styles to game genres. The third section is Game Design and Development, documenting the design referrals, decisions, and creative executions that resulted in the finished development of the game prototype. The fourth section is Usability Testing, which documents the testing process involving students chosen to play and gives feedback on the game, and the analysis of the session. The fifth and sixth sections are Conclusion and Acknowledgment, which concludes and summarizes the research effort.

II. LITERATURE REVIEW

A. GAME-BASED LEARNING

Game-based learning is the activity of gameplay with defined learning outcomes (Shaffer, Halverson, Squire, and Gee), as cited by [6]. The interest in game-based learning is a natural consequence of understanding the [impo]rtance of play in learning [7]. Game-based learning environments have been proven to increase attention and result in increased learning, among others [8].

B. GAME GENRE

Various game genres exist within the gaming industry, including strategy, puzzle, role-playing, action-adventure, sports, simulation, shooter, fighter, and many others [9]. Among the different genres, simulation is the most popular genre to date [10]. Different game genres may lead to different computational thinking development [11]. Scholars believe that ga[mes]are beneficial in encouraging engagement in learning. Designing educational games that are both engaging and effective in achieving learning objectives is difficult. One of the biggest hurdles in educational game design is creating a balance between gameplay and learning objectives [12]. Toward this, there have been efforts to match game genres with educational games and consider how different types of games suit different learning objectives [13].

With the increasing integration of technology in education, research has been conducted to investigate how the principles of Bloom's taxonomy can be applied to educational technologies. This effort includes investigating how the taxonomy can be blended into Google Classroom LMS [14], research on amalgamating Bloom's taxonomy with Artificial Intelligence for remote learning [15], and discussion on how a WebQuests prototype that stimulates higher levels of Bloom's taxonomy can be developed [16]. More relevant to this research are the efforts to match Bloom's taxonomy educational objectives into game genres, such as the works by Sherry [9,13] and [17]. In their publication, a game genre such as first-person shooter may be mapped to all levels of Bloom's hierarchy from Knowledge to Evaluation, but the quiz-type genre is suitable only for the lowest level of Bloom's hierarchy, the Knowledge level, which focuses on the skills of rote memory [9].

There are also works with the interest of matching children's learning styles with game genres to increase students' learning success and works that propose possible game styles with learning content as promoted by [18] and [19]. For example, Prensky, as cited by Rapeepisarn et al. [18], suggested process-type content such as auditing is taught via strategy and adventure games, while procedure content, as found in the legal syllabus, is taught via timed or reflex games.

These endeavors highlight the importance of choosing a game genre to suit the learning objective, style, or content. With this motivation in mind, this paper describes the development efforts of a digital game titled +Ma Circuit to teach blood circulation mapped to the "racing" game genre.

III. GAME DESIGN AND DEVELOPMENT

The content of +Ma Circuit is based on the syllabus of Malaysian Education, more specifically on the topic of "Transport in Humans and Animals" and the subtopic of "Circulatory System of Humans" of Form Four Biology subject [20].

A. LESSON OBJECTIVE AND GAME GENRE

The lesson objective chosen for this game is to describe the human circulatory system, which includes understanding how blood flows in the system and becomes oxygenated and deoxygenated. The source and depth of content in this game's design are from the textbook on this subject [20].

To align with the educational objectives and intended learning outcomes of the human circulatory system topic, a deliberate decision was made to select the racing genre for this particular game. The rationale behind choosing this genre stems from the belief that its gameplay mechanics, centered around maneuvering a vehicle through a meticulously crafted circuit [21], can effectively mirror students' conceptualization of the blood cell's trajectory. Therefore, it is of the opinion that this game may support a better understanding of the blood circulation topic.

B. DESIGNING A BLOOD CIRCULATION RACING GAME

This game is made up of several interrelated components that collectively contribute to its instructional efficacy. One fundamental element is the racetrack, crafted to resemble a simplified representation of the intricate blood circulatory system. This deliberate visual resemblance serves as a metaphorical framework, enabling students to establish connections between the gameplay experience and the underlying physiological processes of the human circulatory system. Moreover, the racing direction within the game aligns with the actual flow of blood within the body, reinforcing the association between the virtual racing experience and the anatomical pathways through which blood traverses.

An integral aspect of this educational game is the incorporation of a blood-cell-shaped car as the protagonist. The visual representation of the car in the form of a blood cell may help to enhance students' immersion in the game world [22] and further solidify the connection between the gameplay mechanics and the lesson's content. Complementing this visual design, obstacles within the game are designed to mimic the appearance of cholesterol and simulate their impact on blood cells within the veins. This approach to representing obstacles not only reinforces students' understanding of the adverse effects of cholesterol but also prompts them to strategize and make decisions within the game to successfully navigate through challenges.

Furthermore, the game utilizes a combination of animation, audio, and haptic cues to facilitate the recollection of the blood cell's path and the organs it encounters along the way. Multimodality is beneficial in increasing comprehension [22]; therefore, by integrating these multimodal cues, the game engages multiple sensory channels, enhances the players' cognitive processing, and aids in retaining vital information related to the lesson's content. These designs of game elements collectively contribute to a comprehensive and immersive learning experience, promoting a deeper understanding of the mechanisms of the human circulatory system.

Table I shows the assets of this game and how their designs are expected to assist in understanding the lesson's content.

1) BLOOD CIRCULATION RACETRACK AND PATH. Considerable effort was dedicated to the design of the racetrack within the educational game, "+Ma Circuit," with the goal of emulating the simplified representation of the blood circulatory system. This deliberate design choice serves a twofold purpose. First, it aligns with the visual depictions of the blood circuit commonly found in educational resources, effectively reinforcing the game's role as a supplementary tool for enhancing instruction on this topic. A game map that reflects actual content can increase coherence in the learning experience [23]. By closely mirroring the familiar blood circuit images used in educational materials, the racetrack bolsters students' comprehension and facilitates the seamless integration of the game into the broader curriculum.

Second, the racetrack's layout and configuration were also designed to optimize students' gameplay experience. By predominantly featuring a straight road throughout the circuit, the game ensures a smoother and more streamlined user experience. This deliberate decision to minimize sharp turns and complex track structures aims to enhance players' engagement and immersion, enabling them to focus on the core gameplay mechanics and the underlying educational content without unnecessary distractions. If gamers do not like the game style or controls of a game, they would have a reduced engagement and be less immersed in it [23]. Therefore, by offering a more straightforward and intuitive gameplay environment, the racetrack design facilitates a seamless alignment between the game's educational objectives and the users' gaming experience.

The selection of the racing genre for the educational game is driven by the goal of aligning with the intended learning outcome of comprehending the dynamics of human blood flow within the body. Blood circulation in the human body begins when the heart's right ventricles pump blood into the lungs, getting the blood oxygenated. This bloodstream then enters the heart again via the left atrium and, from there, gets pumped with enough pressure, exiting via the left atrium to bring blood cells containing oxygen throughout the whole body [20].

Figure 1 shows a simplified blood circuit diagram used as a reference [24] for the entire racetrack from the game.

Similarly, in this game, the path that the player must take is consistent with the actual process, the player's race car enters the right side of the heart, exits to reach the lungs for oxygenation, re-enters the heart from the left side, and subsequently exits the heart to embark on a long journey throughout the body before ultimately returning to the starting point.

By immersing players in a virtual racing experience replicating the intricate blood flow path, the educational game offers an engaging and experiential platform for learners to reinforce their understanding of human blood circulation. The parallel between the gameplay and the physiological processes creates a comprehensive understanding of the subject matter, enabling students to visualize the complex nature of blood flow in an interactive manner.

2) AUDIO, VISUAL, AND HAPTIC CUES. To support players' recollection, the educational game incorporates several cues embedded throughout the gameplay. These cues serve to enhance players' engagement and facilitate the recall of relevant lesson content.

Table II provides an overview of the various cues that have been integrated into the racetrack design, offering players a dynamic and immersive experience during gameplay.

The inclusion of a mini-map in the game serves as a navigational aid for players and might be especially helpful for new players [23], allowing them to locate the current position of their race car within the racetrack. This feature not only provides players with a sense of spatial awareness but also enhances their overall comprehension of the game's mechanics and objectives. By offering a visual representation of the race car's location, the mini-map complements and contextualizes other cues players will encounter throughout their gameplay experience.

For example, before entering the lungs, the barrier wall is blue, signifying the blood cell is deoxygenated and turns red after

Table I. +Ma Circuit game assets

Asset	Lesson embedded design
Racetrack	Simplified blood circuit
Race path	The direction of blood cell path in the body
Race car	Blood cell with wheels
Obstacles	Cholesterol lumps that slowdown race car

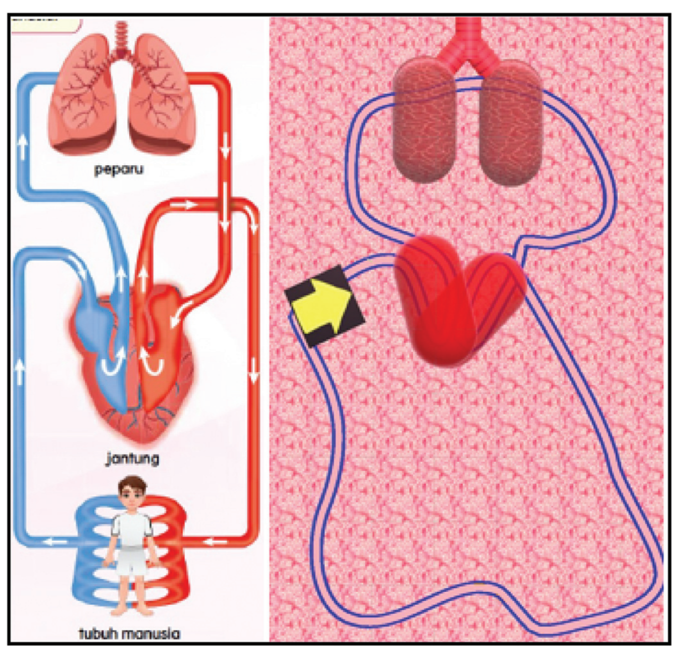

Fig. 1. Simplified blood diagram (L) and game racetrack (R).

Table II. Lesson-related game cues of +Ma Circuit

Cue	Type	Trigger
Mini-map	Visual	Always on
Destination announcement	Audio	Entering organs
Vibration	Haptic	Entering organs
Signboards	Visual	Entering organs
Heartbeat sound	Audio	Entering heart
Bubble sound	Audio	Entering lungs
Blue barrier wall	Visual	Right side of body
Red barrier wall	Visual	Left side of body
Oxygen on race car	Visual	After entering lungs
Warning sign	Visual	Before encountering cholesterol

entering the lungs, showing that the cell is now oxygenated. The blue and red colorings are based on the simplified diagram from Fig. 1 and are also standard color markings used by other blood diagrams in science books. Figure 2 shows the in-game pictures with the mini-map, signboard, and visible blue and red barrier walls.

In addition to visual cues, players are also presented with auditory and haptic cues as they progress through different organs. Upon entering organs, players encounter signboards that provide additional information, audio announcements that serve as aural cues, and haptic feedback in the form of vibrations on the mobile devices they are using. Furthermore, players are immersed in a multisensory experience while inside the heart and lungs. They hear unique sounds, such as a simulated heartbeat within the heart and bubbling sounds within the lungs, reinforcing the contextual significance of these vital organs within the human blood circulation system.

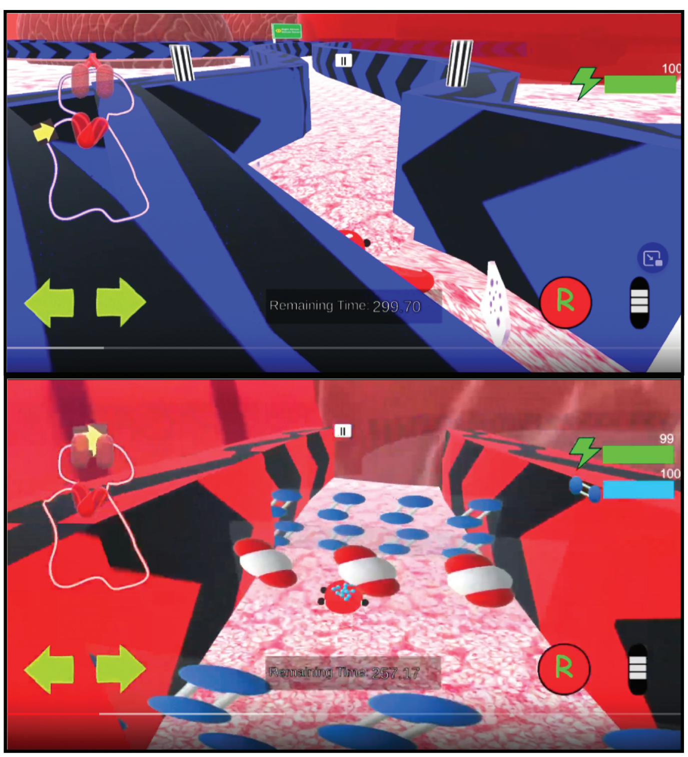

Fig. 2. Before entering lung (T) and oxygenated after entering lung (B).

By strategically placing cues within the racetrack environment, players are provided with visual, auditory, and haptic stimuli that prompt the recollection of key concepts and information. These cues serve as contextual reminders, linking the gameplay experience to the underlying educational content. For instance, visual cues may include symbolic representations of anatomical structures or physiological processes, while auditory cues can encompass relevant sound effects or narrations that reinforce specific concepts. Haptic cues, such as subtle vibrations or force feedback, further immerse players in the game and increase their cognitive engagement. Using various types of cues in combination may enhance participants' performance and increase the effectiveness of the instructional material [25].

3) BLOOD CELL AS RACE CAR. The design of the race car is modeled on a blood cell likeness with wheels attached. The race car features empty craters on its surface, which will be filled with oxygen molecules upon entering the lungs. This visual transformation of the race car serves as an evident representation of the oxygenation process within the game.

In addition to the race car that can be controlled by the player, there are also other Non-Playable Characters (NPC) in the form of other race cars that race in the same circuit as the player. The visuals of these cars are all derivations from blood cells, with only slight changes in how they look.

The intentional design of the race car, with its blood cell likeness and the incorporation of empty craters to represent oxygen absorption, effectively translates complex physiological concepts into a visually comprehensible and engaging form. The inclusion of NPC race cars further enhances the game's educational value, providing players with opportunities for observation of blood cell-derived entities, meant as competitors in the same racing session.

Figure 3 shows the transformation of the race car visual.

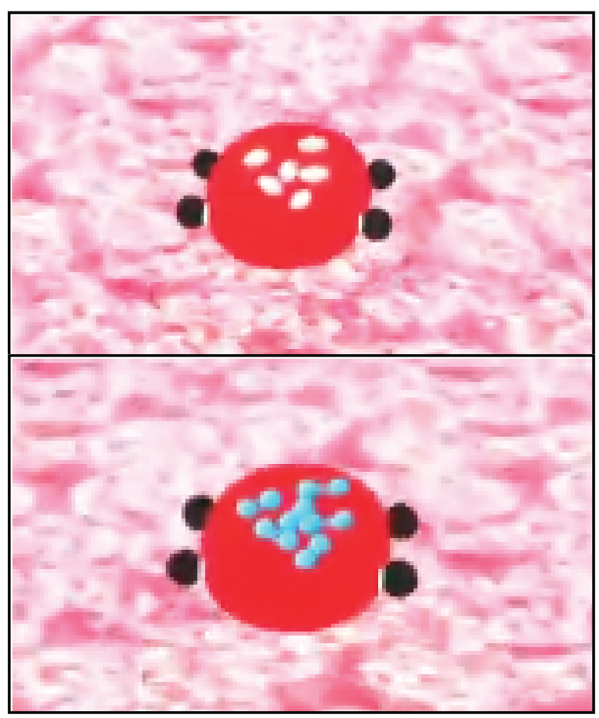

Fig. 3. Blood cell race car deoxygenated (T) and oxygenated after entering lung (B).

4) CHALLENGES. The incorporation of challenges is a fundamental aspect of game design, often characterized as puzzles or tasks that demand effort and problem-solving skills [26]. In alignment with this principle, +Ma Circuit integrates familiar racing game elements while customizing them to align with the theme of blood circulation. This adaptation ensures that the challenges presented within the game remain relevant to the educational objectives. Table III provides an overview of the specific challenges that have been incorporated into the game, tailored to enhance the players' understanding of the circulatory system. By combining time limits, energy meters, and obstacles, the game creates a dynamic and engaging experience while maintaining a connection to the theme of blood circulation. These challenges not only add excitement and difficulty to the gameplay but also help reinforce key concepts related to the circulatory system.

• METERS. There are two types of meters included in this game: the energy meter and the oxygen meter. The energy meter serves as a measure of the race car's endurance and starts at full capacity when the race begins. Throughout the course of the race, the energy meter gradually depletes over time or when the player encounters collisions with obstacles or walls. Once the energy meter is completely exhausted, the blood cell race car becomes immobilized, resulting in a failed game attempt.

The second meter, the oxygen meter, introduces an additional layer of gameplay dynamics related to the theme of blood circulation. At the start of the race, the oxygen meter is empty. However, as the blood cell race car enters the lungs within the racetrack, the oxygen meter gradually fills up, signifying the oxygenation process of the blood cell. Collisions with walls and obstacles also cause a reduction in the oxygen meter's level. The oxygen meter's status at the end of the race becomes a crucial factor in determining the player's overall score. A higher level of oxygen in the meter indicates successful navigation and avoidance of obstacles, resulting in a higher achievable score.

• TIME LIMIT. In this game, a timer is incorporated to add an extra layer of excitement and challenge for the player. As the game begins, the player is granted a generous time limit of 300 seconds to successfully navigate through the captivating circuit. Interestingly, this timer does not have a direct correlation with any specific lesson content or subject matter within the game. Instead, it is an independent challenge, intensifying the overall gameplay experience.

Should the player fail to complete a full circuit within the allocated time frame, the consequence is a game over, amplifying the sense of urgency and encouraging strategic decision-making throughout the course. Moreover, the remaining time left on the clock significantly influences the player's overall score, providing a further incentive to optimize their performance. By skillfully managing their time and making swift yet calculated moves, players can not only avoid the dreaded game over but also enhance their chances of achieving a higher score, further elevating their satisfaction and motivation in the game.

• OBSTACLE. For this game, in addition to the challenge of maneuvering the blood cell race car along the racetrack, players also run the risk of colliding with obstacles designed in the shape of cholesterol lumps. These cholesterols must be avoided as running into the lumps reduces the speed of the car.

This design of cause and effect in this game may allow students to explore the consequences of actions and decisions within a controlled environment (Chen et al., 2019). These cholesterol lumps are found in the walls of the racetrack. This imitates how cholesterols are found in blood vessels, obstructing the path of a blood cell. Figure 4 shows the warning sign, cholesterol lumps obstacles, and the finishing screen with the score.

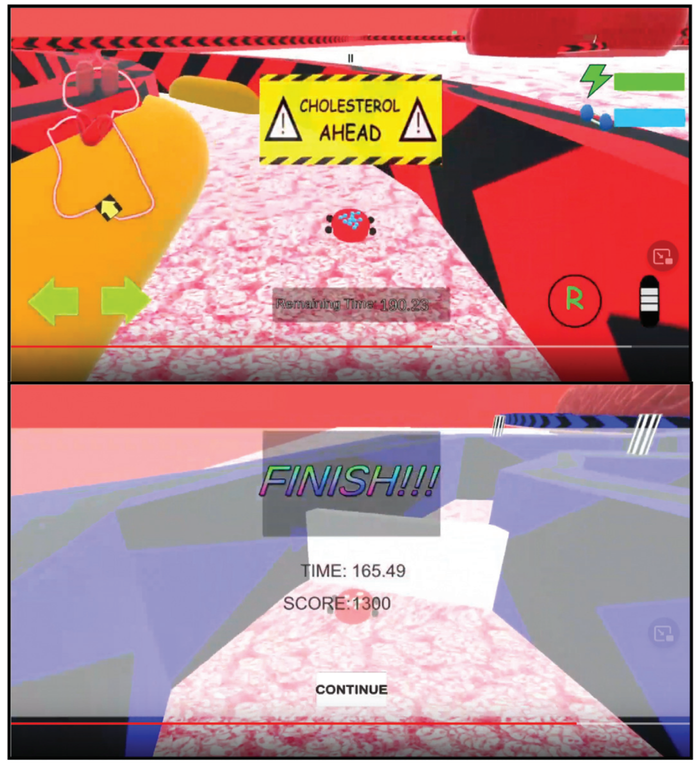

Fig. 4. Cholesterol lumps as obstacles (T) and race finish screen with score (B).

Table III. Challenges in +Ma Circuit racing game

Challenge	Type	Mechanism
Energy	Meter	Reduced over time, player crash
Oxygen	Meter	Reduced when hitting obstacles
Timer	Time limit	The game is over when time runs out
Cholesterol Lumps	Obstacle	Slow the car down when it collided

5) NAVIGATION. This game offers three different navigation options for players: steering, buttons, or tilt controls. Players can choose which control option they are most comfortable with.

IV. USABILITY TESTING

After the development effort was finished, usability testing was conducted to measure the ease of use of this game. This is important because the game is intended to supplement the materials in the classroom; therefore, it should not be difficult or confusing to use. Testing was conducted at a secondary school in Melaka involving five participants aged 15 years. Convenience sampling was used in participant selections. None of the participants had any experience with using the game before.

While larger sample sizes are often preferred for statistical reliability, there is evidence suggesting that a smaller sample size may be sufficient for usability testing, with research claiming that four or five participants will allow practitioners to discover 80% of a product's usability issues [27,28]. The number of five participants is also understood as a golden, simple number sufficient for finding usability problems, as advocated by usability scholars, including UX guru Jakob Nielsen [29,30]. This study chose to adhere to the suggested sample of five participants for convenience, cost, and time-saving factors.

A brief explanation about the game was given before all participants took a turn in playing the game. They were allowed to play the game at their own pace without any restrictions. Once they were done playing the game, they were then asked to answer a usability testing questionnaire about their experience in playing the game.

The usability testing used in this project is System Usability Scale (SUS). This instrument involves 10 items, as shown in Table IV, and participants are asked to respond with five options from Strongly Agree to Strongly Disagree [31].

The participants are labeled P1 to P5, and their answers are numbered from 1 – Strongly Agree, through 5 – Strongly Disagree for all 10 items of SUS. These findings were then calculated to get the SUS score of the usability testing.

The results of this session meanwhile are shown in Table V. Table V also shows the SUS score for each participant using the SUS calculation formula. Scores from odd-numbered questions are summed up and are deducted with five as X, while scores from even-numbered questions are summed up, and this value is deducted from 25 marked as Y. The sum of X and Y is then multiplied by 2.5 to get a score over a range of 0 to 100.

This calculation is more concisely represented through the following equation by Lewis [32]:

$$\begin{aligned}\text{SUS} &= 2.5 * \Big[20 + \text{SUM}\big(\text{SUS01}, \text{SUS03}, \text{SUS05}, \text{SUS07}, \text{SUS09}\big) \\ &\quad - \text{SUM}\big(\text{SUS02}, \text{SUS04}, \text{SUS06}, \text{SUS08}, \text{SUS10}\big)\Big]\end{aligned}$$

The mean SUS score obtained from this session amounted to an impressive 78, while the median score stood at 77.5. These scores surpassed the benchmark of 68, indicating an "above average" usability rating according to the established criteria [33].

Table IV. System Usability Scale items

No.	SUS item
01	I think that I would like to use this system frequently.
02	I found the system unnecessarily complex.
03	I thought the system was easy to use.
04	I think that I would need the support of a technical person to be able to use this system.
05	I found the various functions in this system were well integrated.
06	I thought there was too much inconsistency in this system.
07	I would imagine that most people would learn to use this system very quickly.
08	I found the system very cumbersome to use.
09	I felt very confident using the system.
10	I needed to learn a lot of things before I could get going with this system.

Table V. Results of usability testing for +Ma game

SUS	P1	P2	P3	P4	P5
01	4	5	4	4	4
02	2	1	3	2	1
03	5	5	5	5	4
04	3	1	1	3	2
05	3	5	2	4	3
06	2	1	4	3	2
07	5	5	3	5	5
08	1	1	2	1	1
09	4	5	4	4	3
10	2	4	2	2	1
Score	75	92.5	65	77.5	80

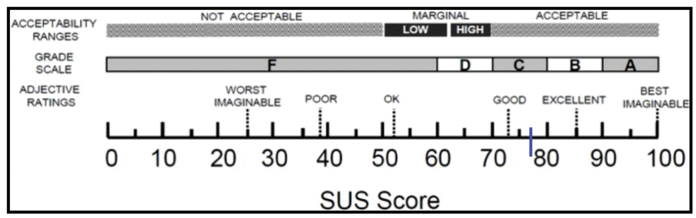

Fig. 5. Score of 78 compared against adjective ratings.

To gain further insight into the usability assessment, the SUS Score Graph, as presented in Fig. 5 and outlined by Bangor et al. [34], was consulted. The graph provides a visual representation of the SUS scores and corresponding adjective ratings. Remarkably, the obtained score of 78 falls within the "Good" range, as indicated by the adjective ratings on the graph, further affirming the positive usability evaluation of the system.

These encouraging findings from the participants' SUS scores highlight the system's effectiveness and user satisfaction, surpassing the established benchmark and aligning with the "Good" rating on the SUS Score Graph. Such outcomes indicate that the system demonstrates strong usability and is a testament to the successful design and implementation of user-friendly features.

A detailed analysis of each SUS item shows an inconsistency in the responses received for Items 5, 6, and 10, where responses received were within the agree and disagree region. For Item 5, one participant disagreed that the various functions in this system were well integrated, while the remaining two felt neutral about it and the remaining two participants agreed with the statement. For Item 6, only one participant agreed that there was too much inconsistency in this system, and the remaining four responses ranged from neutral to disagree. For Item 10, only one participant agreed that many things need to be learned before he can get going with this system, and the remaining four participants disagreed with this statement. Although the inconsistency of the responses may suggest that the system could have been improved further, this is considered a minor issue as only one participant had a different opinion on the respective item.

Upon further analysis of the participants' responses, it is apparent that participant P3 exhibited inconsistencies in their answers. Notable discrepancies can be observed in their ratings for Item 2 (unnecessarily complex) and Item 6 (too much inconsistency). Participant P3 provided a neutral rating for Item 2, indicating a lack of agreement with the statement, while simultaneously agreeing with Item 6, which suggests there is too much inconsistency in the system. This contradiction in ratings suggests an inconsistency in participant P3's perception of the system's complexity and inconsistency. In contrast, participants P1, P2, P4, and P5 demonstrated relatively consistent responses across the SUS items, with their ratings aligning more consistently with their overall SUS scores. Their ratings for items related to complexity, inconsistency, and learning curve were generally consistent with their overall perception of system usability.

V. CONCLUSION

This paper explained the design and development of a digital game titled +Ma Circuit, which was mapped to a "racing" game genre. Understanding blood circulation lesson was chosen as the lesson objective of this game, and the lesson content and expected lesson outcome were matched to a racing game genre. The gameplay of this genre involves controlling a vehicle through a specifically designed circuit that resembles the path of the blood flow. Several components or assets of a racing car game were designed to reflect a simplified blood circulatory system. Cues consisting of visual, audio, and haptic feedback were also added to the game to help players with content recollections. Common racing game challenges such as time limit, energy meter, and obstacles were included and tailored to the theme of blood circulation. The SUS was used in usability testing to assess the game's ease of use. Five 15-year-olds took part in the testing at Melaka secondary school. Participants were chosen using convenience sampling, and none had previously played the game. When measured against the SUS Score Graph, a SUS standard score of 78 was obtained, which is considered "Good" under the adjective ratings. Although a detailed analysis shows an inconsistency in the responses, this, however, can be seen as a small concern, given that only one participant disagrees with the respective item. Therefore, it is of the opinion that this game may support a better understanding of the blood circulation topic.

There are many possibilities and directions for future extensions for this project. The game circuit can be expanded, and more organs can be added to the blood cell journey. More levels with different circulation systems which entail different "race cars" may also be added to the game, with human digestion and respiratory system showing the same potential of game design. Usability testing may also be improved by having control groups, which may include students with experience playing racing games to see if they may give a different insight into the gameplay. The authors are confident that further work on this project may reveal more opportunities in game design and research.

ACKNOWLEDGMENTS

The data collection of this research has been approved by the Branch Ethics Review Committee of Universiti Teknologi MARA with the referral number BERC/MLK/056/2022.

CONFLICT OF INTEREST STATEMENT

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

[1] L. Peters and S. Gagliano, "19 '90s computer games that made learning unbelievably fun," *Bustle*, 2021. Available: https://www.bustle.com/life/90s-computer-games-that-made-learning-unbelievably-fun.

[2] A. M. Toda et al., "A taxonomy of game elements for gamification in educational contexts: proposal and evaluation," *2019 IEEE 19th Int. Conf. Adv. Learn. Technol. (ICALT)*, vol. 2161, pp. 84–88, 2019.

[3] D. Sanchez-crespo and D. S. C. Dalmau, *Core Techniques and Algorithms in Game Programming*: New Riders, Indianapolis, IN, 2004.

[4] R. E. Rinaldi, M. T. Wihartono, R. E. Dharmalim, and S. Suharjito, "Serious game application development for learning battle of Surabaya," in *2022 Int. Conf. ICT Smart Soc. (ICISS)*, 2022, pp. 1–6. DOI: 10.1109/ICISS55894.2022.9915076.

[5] M. Babazadeh, L. Botturi, and G. Reggiani, "Let's Jazz: a case study on teaching music with educational escape rooms," *Eur. Conf. Games Based Learn.*, vol. 16, no. 1, 656–665, 2022. DOI: 10.34190/ecgbl.16.1.854.

[6] J. L. Plass, B. D. Homer, and C. K. Kinzer, "Foundations of game-based learning," *Educ. Psychol.*, vol. 50, no. 4, 258–283, 2015.

[7] J. Kessel, "Let our children play: the importance of play in early childhood education," *Univ. Montana J. Early Childhood Scholarship Innovat. Pract.*, vol. 2, no. 1, p. 5, 2018.

[8] J. L. Sabourin and J. C. Lester, "Affect and engagement in game-based learning environments," *IEEE Trans. Affect. Comput.*, vol. 5, no. 1, pp. 45–56, 2013.

[9] J. L. Sherry, "Matching computer game genres to educational outcomes," in *Teaching and Learning with Technology* (C. M. Stewart, C. C. Schifter, M. E. Markaridian Selverian (eds.)). Routledge, New York, 2010, pp. 234–246.

[10] K. Fu, Y. Yuan, E. L. -C. Mai, and J. He, "A systematic literature review to identify empirical evidence on the game design framework and model of games-based learning," in *Proc. 13th Eur. Conf. Game Based Learn.*, 2020. DOI: 10.34190/GBL.20.038.

[11] G. M. Troiano, et al. "Exploring how game genre in student-designed games influences computational thinking development," in *Proc. 2020 CHI Conf. Hum. Fact. Comput. Syst.*, 2020, pp. 1–17. DOI: 10.1145/3313831.3376755.

[12] A. Soska, J. Mottok, and C. Wolff, "Pattern oriented card game development: SOFTTY – A card game for academic learning of software testing," In *IEEE Global Eng. Educ. Conf., EDUCON*, 2017. DOI: 10.1109/EDUCON.2017.7942996.

[13] L. Buchanan, F. Wolanczyk, and F. Zinghini, "Blending bloom's taxonomy and serious game design," in *Proc. Int. Conf. Secur. Manag. (SAM)*, CSREA Press, Las Vegas, Nevada, 2011, p. 1.

[14] N. Ayyanathan, "Learning analytics model and bloom's taxonomy based evaluation framework for the post graduate students' project assessment – a blended project based learning management system with rubric referenced predictors," *Shanlax Int. J. Educ.*, vol. 10, no. 3, 2022. DOI: 10.34293/education.v10i3.4766.

[15] A. Abalkheel, "Amalgamating bloom's taxonomy and artificial intelligence to face the challenges of online EFL learning amid post-covid-19 in Saudi Arabia," *Int. J. Engl. Lang. Literat. Stud.*, vol. 11, no. 1, 2021. DOI: 10.18488/5019.v11i1.4409.

[16] S. S. S. Filho and R. Bonacin, "Best practices in WebQuest design: stimulating the higher levels of Bloom's taxonomy," in *Proc. – IEEE 16th Int. Conf. Adv. Learn. Technol., ICALT 2016*, pp. 391–395, 2016. DOI: 10.1109/ICALT.2016.29.

[17] V. Pelser-Carstens, "Game based learning: a tabletop game approach to knowledge application and pervasive skill acquisition," *EdMedia + Innovate Learning*, pp. 1148–1161, 2019.
[18] K. Rapeepisarn, K. W. Wong, C. C. Fung, and M. S. Khine, "The relationship between game genres, learning techniques and learning styles in educational computer games," *Int. Conf. Tech. E-Learn. Digital Enter.*, pp. 497–508, 2008.
[19] S. Dubreil, "Using games for language learning in the age of social distancing," *Foreign Lang. Ann.*, vol. 53, no. 2, pp. 250–259, 2020. DOI: 10.1111/flan.12465.
[20] G. W. Yeat, M. Haziq, N. Teoh, and C. K. Wei, *BIOLOGY FORM 4* (H. bin Hashim, S. F. binti M. Kamil, N. Teoh, T. W. Ling, C. K. Wei, and L. P. Kuan (eds.)). Must Read Sdn. Bhd, 2019.
[21] C. Pacheco, L. Tokarchuk, and D. Pérez-Liébana, "Studying believability assessment in racing games," in *Proc. 13th Int. Conf. Foundat. Digital Games*, 2018, pp. 1–10.
[22] T. M. Herder and M. Rau, "The role of representational competencies for students' learning from an educational video game for astronomy," *Front. Educ.*, 2022. DOI: 10.3389/feduc.2022.919645.
[23] L. A. Annetta, The "I's" have it: a framework for serious educational game design," *Rev. Gener. Psychol.*, 2010. DOI: 10.1037/a0018985.
[24] S. R. Abd Karim, M. R. Anwar, and S. Jalaludin, *Sains Tahun 5 Sekolah Kebangsaan*: Dewan Bahasa dan Pustaka, 2020.
[25] K. Qi, D. Borland, E. Brunsen, J. Minogue, and T. C. Peck, *The Impact of Prior Knowledge on the Effectiveness of Haptic and Visual Modalities for Teaching Forces*, Association for Computing Machinery, New York, NY, 2021. DOI: 10.1145/3462244.3479915.
[26] A. L. dos Santos, R. de A. Maurício, M. Dayrell, and E. Figueiredo, "Exploring game elements in learning programming: an empirical evaluation," in *2018 IEEE Front. Educ. Conf. (FIE)*, 2018, pp. 1–9.
[27] L. Faulkner, "Beyond the five-user assumption: benefits of increased sample sizes in usability testing," *Behav. Res. Methods Instrum. Comput.*, 2003. DOI: 10.3758/bf03195514.
[28] J. D. Lewis, "Sample sizes for usability studies: additional considerations," *Hum. Factors J. Hum. Factors Ergonom. Soc.*, 1994. DOI: 10.1177/001872089403600215.
[29] J. Nielsen, *How Many Test Users in a Usability Study?*: Nielsen Norman Group, 2012. Available: https://www.nngroup.com/articles/how-many-test-users/.
[30] C. W. Turner, J. R. Lewis, and J. Nielsen, "Determining usability test sample size," *Int. Encycloped. Ergonom. Hum. Factors*, vol. 3, no. 2, pp. 3084–3088, 2006.
[31] J. Brooke, "SUS-A quick and dirty usability scale," *Usabil. Eval. Ind.*, vol. 189, no. 194, pp. 4–7, 1996.
[32] J. R. Lewis, "The system usability scale: past, present, and future," *Int. J. Hum.–Comput. Interact.*, vol. 34, no. 7, pp. 577–590, 2018.
[33] J. Sauro, "Measuring usability with the System Usability Scale (SUS)," *Meas. U.*, 2011. Available: https://measuringu.com/sus/
[34] A. Bangor, P. Kortum, and J. Miller, "Determining what individual SUS scores mean: adding an adjective rating scale," *J. Usabil. Studies*, vol. 4, no. 3, pp. 114–123, 2009.