Universiti Teknologi MARA
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College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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EDITORS

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
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MARINE ODYSSEY: A NON-IMMERSIVE VIRTUAL REALITY GAME FOR MARINE LITTER AWARENESS

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Abstract

Marine litter, composed of plastic waste, posed a significant threat to marine environments, impacting over 40% of marine areas and endangering marine life through entanglement and ingestion. Public lacking on awareness played a central role in this issue, highlighting the need for effective educational interventions. Virtual Reality (VR) technology and game-based learning approaches was utilized, as this research focused on developing a non-immersive VR game aimed at raising awareness about marine litter and the marine litter impacts. A structured Game Development Life Cycle has been followed, including initiation, pre-production, production, testing, beta testing, and release phases, as the game aimed to engage users and give knowledge about marine litter and the marine litter impacts. Beta testing revealed a notable increase in awareness levels, indicating successful delivery of key messages.

Keywords: Marine litter; Awareness; Virtual Reality

INTRODUCTION

According to Portman and Brennan (2023), any persistent, made, or processed solid substance that was thrown away, disposed of, or abandoned in the marine and coastal environment was referred to as marine litter. Marine litter was a serious environmental issue that had received a lot of attention in recent years. According to Cabral, Fonseca, Sousa, &

Costa (2019), it was found that human activities, especially children, had an impact on every part of the environment, and at least 40% of marine areas were seriously affected by several different factors, primarily marine litter. This shows that marine litter has affected at least 40% of the marine areas. According to Barboza & Tekman (2019), marine litter was a significant worldwide environmental issue and most of this litter, ranging from 61% to 87%, consists of plastic materials. This shows that most marine litter comes from plastic materials. According to Consoli, Romeo, Angiolillo, Canese, Esposito, Salvati, & Tunesi (2019), many marine creatures like seagulls and turtles were harmed by this marine litter as itcould result to these marine creaturey getting caught in the marine litter or eating these marine litter. These marine creatures that got caught in marine litter limit their ability to move, eat, breathe, and reproduce. These marine creatures may also have confused this marine litter for food as these marine creatures may eat non-digestible marine litter and harm their well-being, leading to negative impacts on their survival (Angiolillo & Fortibuoni, 2020). This shows that if marine creatures were exposed to this marine litter, it may harm the marine creatures' survivability. According to Willis, Serra-Gonçalves, Richardson, Schuyler, Pedersen, Anderson, & Puskic (2022), a lack of awareness about the effects and impacts, with the acceptance of marine litter actions, contributed to the normalisation of marine litter behaviors especially in children.

As technology advanced, there were different ways to learn and one of them was through Game-Based Learning (GBL). According to Plass, Mayer, & Homer (2020), GBL involved creating games with clear learning goals. These games were interactive, meaning they responded to player actions and provide feedback. They follow established rules, were challenging, and often include an element of chance. According to Liu, Wang & Lee (2021), some experts argued that GBL systems in higher education settings engage learners, helping them to develop learning skills, and enhance learning effectiveness

As technologies evolved, another approach for education has been introduced which was Virtual Reality (VR). VR was used to replicate various events, a realistic and secure environment was created that enables repetition and accurate measurements while avoiding the drawbacks and difficulties of real-world training (Sermet & Demir, 2019). Furthermore, VR

technology was increasingly used as a teaching and learning aid in a variety of academic fields and it gave users the chance to interact with and experience real-time learning phenomena, which would have been very impossible in the physical world (Oyelere, Bouali, Kaliisa, Obaido, Yunusa, & Jimoh, 2020).

This research proposed a virtual reality game-based learning using Personal Computer (PC) that implement non-immersive virtual reality experience for users that were interested in marine litter issues. With this non-immersive virtual reality game-based learning, the game aimed to give awareness about issues of marine litter and its impacts to the environment.

LITERATURE REVIEW

Public Awareness and Knowledge on Marine Litter

Marine litter persisted due to a lack of public awareness regarding marine littering behaviours. According to a study by Hartley, Pahl, Veiga, Vlachogianni, Vasconcelos, Maes, Doyle, d'Arcy Metcalfe, Ö türk, Di Berardo & Thompson RC (2018), public tended to litter based on the public's own awareness and normalized behaviour. This shows that as some of the public was still lacking awareness on marine litter behaviours, the public not knowing that the normalized littering behaviours was wrong. According to Cigliano, Meyer, Ballard, Freitag, Phillips & Wasser (2015), children spent more time indoors rather than the marine environments which created a disconnectedness between the public and the marine environment, which leads to lacking awareness in marine litter. This shows that when children rarely go out to explore marine environment, the children had created a disconnection between the public and the marine environment, which leads to lower awareness on marine environment. Many people agreed that teaching individuals to take care of the marine environment should start at a young age, even before they become adults (Cigliano, 2015). This shows that raising the awareness should have start from a young age. According to Henderson & Green (2020), by increasing the public awareness on the marine litter behaviours, it could lead to changes in the public behaviour towards the marine environment.

Marine litter was also persisting because of public has limited knowledge on the marine litter impacts. According to Henderson & Green (2020), public were not aware of the impacts on marine litter to the marine environment due to the public lacking on awareness about the marine litter impacts towards the marine environment. As this happens, the public were not aware that the marine litter could bring impacts to the marine environment. According to Lusher, Hollman & Mendoza-Hill (2017), when the marine litter thrown by the public were eaten by the marine life, the marine litter could build up in the food chain and potentially disrupt the marine lives food chain as marine litter limits their ability to move, eat, breathe, and reproduce. According to Rayon-Viña, Miralles, Fernandez-Rodríguez, Dopico & Garcia-Vazquez (2019) , many studies had found that actively engaging with marine litter was an effective way to increase awareness about this issue, particularly among young adults and children. This shows that awareness on marine litter in children could be increased by active engagement on marine litter issues. According to Henderson & Green (2020), increasing the focus on giving the awareness to the public about the impacts of marine litter was essential for encouraging public to adopt sustainable lifestyles, which were often seen as steps to prevent marine environmental threats and marine habitat destruction.

Game-Based Learning Model for Marine Litter Awareness: Design and Implementation

According to Emerson (2020), GBL settings combined both game content and educational activities to enhance users' knowledge and skill development, with activities incorporating challenges and problem-solving to raise users' awareness. One of the most distinctive qualities of game-based learning environments was that their ability to offer engaging and effective learning opportunities. The GBL Design Model helps make sure the game concept and the player's skills match well, allowing them to use what they know and could do in the game. Table 1 shows the elements of GBL implemented in the project.

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Table 1: GBL Elements

Factors	**Description**
Game goals	To clean the marine environment and rescue entangled marine life to complete the game.
Game mechanism	Adventure game
Freedom	The player could roam the marine environment freely throughout the gameplay.
Game fantasy	3D game objects and the game surrounding that replicate real life marine environment.
Narrative	Text description about the situation that was happening in the game.
Interaction	Users must press corresponds button to collect the marine litter and rescue the entangled marine life.
Game value	Users were awarded with in-game rewards such as scuba diving kit when they successfully completed the level.
Challenges	Users must complete the tasks before the timer runs out.
Mystery	Users must locate the marine litter and entangled marine life in the game's environment.

The game goals of the project were to clean the marine environment and rescue entangled marine life to complete the game. The game mechanism was an adventure game. The freedom element provided was the player could roam the marine environment freely throughout the gameplay. The game fantasy were the 3D game objects and the game surrounding that replicate real life marine environment. The game uses text description about the situation that was happening in the game as the narrative elements. For interaction element, users must press corresponds button to collect the marine litter and rescue the entangled marine life. Users were awarded with in-game rewards such as scuba diving kit when they successfully completed the level as it was the game's value element. The challenge was the users must complete the tasks before the timer runs out. The mystery element was the users must locate the marine and entangled marine life in the game's environment.

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Non-Immersive Virtual Reality Implementation for Marine Litter Awareness: Design and Features

Non-immersive VR, also known as desktop VR, were widely used nowadays. According to Pallavicini, Pepe, & Minissi (2019), a non-immersive virtual reality was a simple presentation on a computer screen. A computer or video game console, a display, and input gadgets such as keyboard, mouse, or controller were required for non-immersive VR. According to Tsyktor Vasyl (2019), the primary characteristic of non-immersive VR was that users may maintain awareness and control over their immediate surroundings. This shows that the users were still on control even when using non-immersive VR.

Each immersion had its own delivery method and sense of immersion. Non-immersive has the lowest sense of immersion compared to other immersions while fully immersive has the highest sense of immersion compared to other immersions. Therefore, a non-immersive VR was suitable for the project as the project only used a simple desktop monitor and keyboard setup.

METHODOLOGY

Game Development Life Cycle (GDLC) would be used in the implementation of this project. According to Dhawale (2019), GDLC approach was more focused and could address most game developer issues and concerns rather than Software Development Life Cycle (SDLC). The advantages of adopting the GDLC method in this project was that it could be applied to any form of game development. A GDLC model with each methodological phase was presented in Figure 1.

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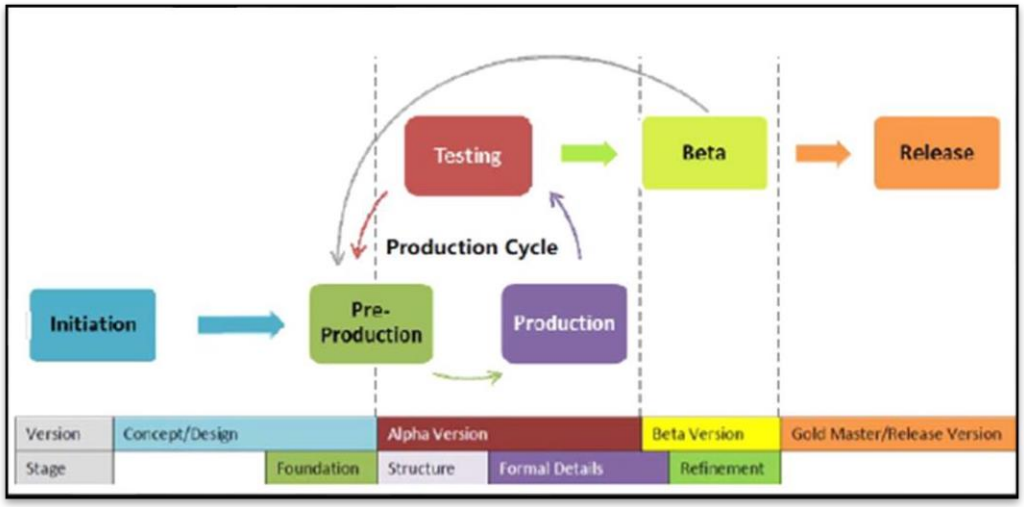

Figure 1: Game Development Life Cycle Methodology

The GDLC model comprised six stages: initiation, pre-production, production, testing, beta, and release. According to Wee (2021), in the initiation phase, the first step in game development involved producing the game concept, followed by determining the project's problem statements, objectives, scope, significance, and projected result as this initial idea was crucial. This initial idea support the game's production while in the pre-production phase. The production phase focuses on creating game assets, source codes, and integrating them while the testing phase evaluated playability and usability. This testing phase transitions into the beta phase in the GDLC model, during which the game's playability was reviewed before advancing to the release phase, which making the game available to the public. The beta phase was crucial to ensure that there were not any errors in the game before releasing the game to the public.

User Awareness Testing

This application was tested to assess user awareness by the age of 9-13 with the sample size of 33 children. User awareness of marine litter before and after playing the game was the main objective of this testing.

According to Gafoor (2012), an "instrument" in awareness testing was a tool or

technique used to evaluate an individual's level of awareness or knowledge. This tool could include surveys, questionnaires, interviews, or other forms of evaluation intended to gather information about participants' awareness. The questionnaire by Kusumawati, Setyowati, Syakti, & Fahrudin (2019), which was an adapted questionnaire from Hartley, Thompson and Pahl (2015), was selected as the tool to assess user awareness.

The user awareness evaluation used three categories of questions which were problem awareness and concern, perceived impacts, and perceived causes. Problem awareness and concern questions were used to measure children's problem awareness and concern about marine litter. The perceived impacts questions were used to measure children's perceptions about the negative impacts that marine litter had while perceived causes questions were used to measure children's perceptions about the possible different causes of marine litter. The questionnaires used a Likert scale from 1 (Not at all) to 4 (A lot). After the game has been tested, participants would rate each question based on how much they agree with the statement.

RESULT AND DISCUSSION

This evaluation testing used parametric statistical methods as it compares the mean percentages for the pre-awareness testing and the mean for post-awareness testing for each attribute. According to IBM (2021), the assumptions behind parametric statistics relate to the population distribution from which the sample was drawn. The table for comparing each attribute's mean percentages for both testing were shown in Table 2 below.

Table 2: Overall Mean Percentages Comparison

Attributes	**Pre-awareness Mean (%)**	**Post-awareness Mean (%)**	**Change in Mean (%)**
Problem awareness and concern	68.38	85.88	17.50
Perceived impacts	64.06	79.20	15.14
Perceived causes	60.15	72.63	12.48
Overall Mean	64.53	79.57	15.04

There was clear evidence of improvement in awareness across various aspects. The attribute "Problem awareness and concern" displayed a rise in mean percentage, increased from 68.38% to 85.88%, showing a positive shift of +17.50%. Similarly, the attributes "Perceived impacts" and "Perceived causes" displayed a rise in mean percentage, with mean percentages rose from 64.06% to 79.20% (+15.14%) and 60.15% to 72.63% (+12.48%), respectively. The "Overall Mean" also experienced a positive change, moving from 64.53% to 79.57%, indicating an overall increase in awareness by +15.04%. Based on the result, this shows that the awareness dissemination using the GBL elements in the game development contributed to give awareness on marine litter and the knowledge on the impacts of marine litter to the children aged 9-13 years old.

CONCLUSION

In conclusion, the results of the awareness testing of the game development showed an increment between the pre-awareness testing and post-awareness testing, thus giving awareness to children within the age group of 9-13 years old regarding marine litter and the impacts of marine litter. The observed positive changes in mean percentages across various attributes indicated increased awareness and knowledge of marine litter and its impacts among children. These findings demonstrate the effectiveness of the game as an awareness dissemination tool, effectively conveying key messages about marine litter awareness and its impacts to the targeted age group, as supported by the test results.

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