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Virtual Reality Learning Kit for Road Crossing Safety

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Abstract

The Virtual Reality Learning Kit for Road Crossing Safety project commenced with the factors contributing to pedestrian vulnerability. This analysis guided the design of the Virtual Reality (VR) Learning Kit, which combined immersive VR technology, interactive scenarios, and gamified learning elements to simulate real-life road-crossing situations. The VR kit aims to enhance road crossing skills and promote safer behaviour. 11 participants took part in a test run of the VR kit and gave satisfying feedback on the reliability and road safety educability of the VR kit evaluation survey. Performance analysis shows that the VR kit can perform well with an average framerate of 23 FPS. In conclusion, the VR Learning Kit for Road Crossing Safety project successfully developed a comprehensive VR solution that offers an immersive and engaging learning experience.

1. Introduction

According to statistics from 2019 until now, a total of 6,000 deaths were recorded in road accidents, and of that number, 1,000 deaths involved children [1]. Road Safety Education (PKJR) is a long-term initiative that starts from childhood to produce a new generation of road users who practice a culture of safety, civility, prudence, and caution on the road. One of the initiatives from PKJR carried out in road safety education at the primary school level is to hold practical crossing of the road. It is a good initiative for learning, but there is much to compare with real situations full of out-of-control situations. For example, when a motorcycle does not obey the traffic lights and crosses an intersection in a dangerous situation, the students who cross the road without detecting the danger are at risk of an accident with the motorcycle [2].

Fig. 1 *Concept of the project*

The purpose of this project is to create a road-crossing simulation kit with interaction situations that are more similar to real situations that could happen for users to experience these situations themselves while reducing the risk of injury by using virtual reality (VR) technology. Virtual Reality (VR) is a computer-generated environment with scenes and objects that appear real, making the user feel immersed in their surroundings [3]. As shown in Fig. 1, virtual reality is ideal for training to develop skills required in environments that are complex to reproduce, remote, or involve a certain degree of danger [4].

1.1 Problem Statement

Learning in theory alone is not enough to understand the real situation, and they need to be exposed to the situation face to face because the experience is easier to remember, especially for students who have difficulties in learning. However, there is a limit in the real-world simulation. For example, the vehicle used in the simulation crossing the road does not interact like a real dangerous situation, such as a vehicle driven at high speed. However, this can't be implemented in real life because it can cause injury.

1.2 Literature Review

This project draws inspiration and insight from several preceding VR initiatives focused on road safety education. Examining projects like "Evaluation of an Immersive Virtual Reality Safety Training Used to Teach Pedestrian Skills to Children with Autism Spectrum Disorder" [5] highlights the potential of VR in creating safe and engaging learning environments for vulnerable populations. Similarly, "Investigating Pedestrian Crossing Decision with Autonomous Cars in Virtual Reality" [6] underscores the importance of simulated crossing experiences in shaping pedestrian behaviour. Finally, "Usability and Feasibility of an Internet-based Virtual Pedestrian Environment to Teach Children to Cross Streets Safely" [7] demonstrates the value of accessible and interactive VR tools for widespread safety education.

By gleaning valuable lessons from these past undertakings, our project can leverage existing successes, incorporate proven innovations, and anticipate potential challenges, ultimately leading to a more impactful and well-rounded VR experience for its target audience.

2. Research Methodology

This project aims to develop a VR simulation teaching road safety to young audiences. Firstly, the interface is designed with students and facilitators in mind, aiming for a smooth learning journey for everyone involved. Secondly, the simulation immerses students in realistic road-crossing scenarios, allowing them to develop safe responses in a controlled virtual environment. Unlike real-world situations, this controlled environment provides a safe space for experimentation and learning. Finally, the project is not just about creating an immersive experience; it also includes assessments to measure the impact on students' understanding of traffic rules and safe practices. By combining user-friendly design, realistic scenarios, and measurable outcomes, this VR simulation strives to be engaging and effective in promoting pedestrian safety knowledge.

The project utilizes the Unity engine and targets primary school students. It incorporates various scenarios and traffic complexities, preparing them for real-world encounters. Smartphone VR headsets ensure accessibility and cost-effectiveness. This impactful and user-friendly VR simulation empowers young learners with crucial road safety knowledge, potentially impacting their understanding and promoting safe behaviour on the road.

It is required to design and develop an educational game application based on virtual reality (VR) using Google Cardboard so that this simulation wouldn't cost much money [8]. The flow of the gameplay, developed using Unity for Google Cardboard, challenges players to traverse a busy road across three progressively difficult levels. Fig. 2 shows the gameplay flow and the levels of flow subroutines. As shown in the beginning of the flowchart in Fig. 2(a), the game opens with a Main Menu interface where the user can interact with it to start the game.

Following the tutorial, players embark on three levels of different road-crossing scenarios, each simulating progressively complex obstacles. As shown in the subroutine flowcharts in Fig. 2(b), each level starts by placing the player at a designated starting point with their destination visible. Between these points, a dynamic environment with realistic obstacles unfolds, including roads, traffic vehicles, traffic lights, and zebra crossings.

Throughout the level, a floating window presents players with actions representing safe behaviours in that specific scenario. Choosing the correct action based on traffic rules and situational awareness advances the player towards the destination. Any misstep behaviour results in a "retry" option, allowing players to learn from their mistakes and reattempt the level. Successfully navigating the obstacles and reaching the destination signifies mastery of that level's challenges. The player then progresses to the next level, encountering more complex situations that test their understanding of safe road-crossing practices.

Upon completing all three levels, the players can choose to replay the game from the beginning to improve their performances or end the simulation altogether. This VR simulation offers a unique and engaging platform for developing essential road safety skills. By immersing players in realistic scenarios and requiring them to make

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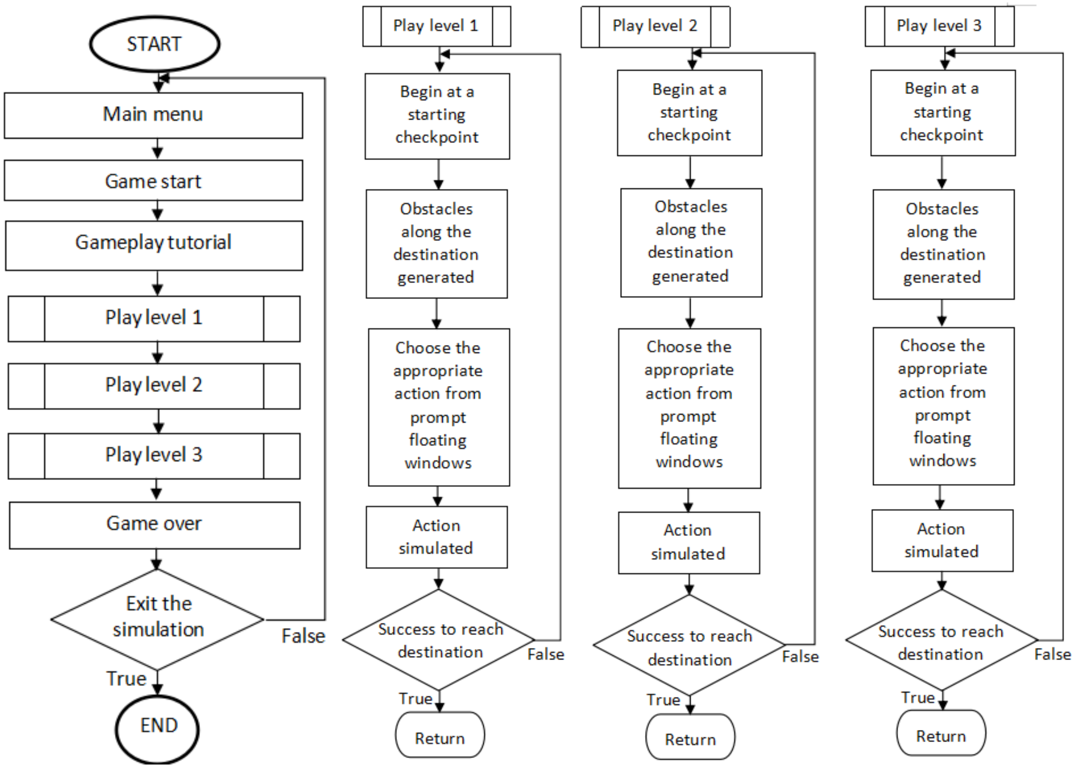
critical decisions in real-time, the game fosters an active learning experience that transcends traditional pedagogical methods.



(a) (b)

Fig. 2 *Flowcharts (a) Gameplay flow (b) Levels flow subroutine*

3. Results and Discussion

In making a VR program, several processes must be followed to determine what kind of VR program to produce [9]. Having a 3D-modelling design, as in Fig. 3, is frequently where VR creation begins. A ton of time can be saved by downloading pre-made objects, backgrounds, or textures, which frequently enhance your creation without requiring additional work.

(a) (b)

Fig. 3 *3D-modellings (a) 3D infrastructures; (b) 3D objects*

The Unity engines can be heavily customized via Application Programming Interfaces (API), are accessible (at least to a point), and are easily integrated with VR platform-specific Software Development Kits (SDK), as shown in Fig. 4. The initial SDK is chosen for any development project to build your experience around it. It comprises resources, content, and methods tailored specifically for each device's native experience on each engine and platform.

Animation breathes life into characters and environment, facilitates interactions, enhances storytelling, and contributes to smooth and enjoyable VR experiences. In this project, Fig. 5 shows the animation used for making obstacles like cars moving around as required and as the action the player will perform after a particular interaction is triggered.

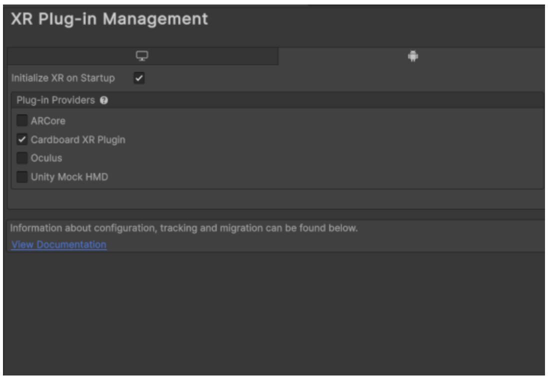


Fig. 4 *SDK setup for Google Cardboard*

Interactive UI buttons, as shown in Fig. 6, are essential for crafting intuitive and engaging VR experiences in Unity. Buttons can trigger various events or actions within the game world, such as activating mechanisms or interacting with the characters.

Fig. 5 *Car animations*

Repeatability is a cornerstone of reliable performance evaluation in game development. By conducting standardized tests and carefully documenting results, as shown in Table 1, developers can make informed decisions about optimization strategies and ensure a consistent gameplay experience across various devices.

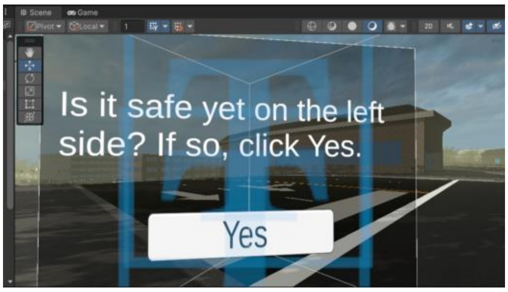


Fig. 6 *Player mechanism trigger UI button*

Table 1 *Repeatability performances*

Trial	*First*	*Second*	*Third*
Framerate (Average)	28 FPS	22 FPS	20 FPS
Framerate (Minimum)	25 FPS	16 FPS	14 FPS
Battery Consumption (per minute)	2%	2%	3%
Level Loading Times (Level 1)	1 seconds	3 seconds	4 seconds
Level Loading Times (Level 2)	2 seconds	6 seconds	4 seconds
Level Loading Times (Level 3)	2 seconds	4 seconds	6 seconds

To demonstrate the dependability and significance of this simulation, 11 public audiences were allowed to test the VR simulation. The testers were required to answer several Google Form surveys to rate their satisfaction on several aspects: the dependability, consisting of the realism of the road crossing scenarios in Fig. 7 and the ease of control of the player in Fig. 8, and its significance, consisting of button pressing reasoning in Fig. 9 and the feedback of incorrect decision in Fig. 10. These are their feedback from the survey:

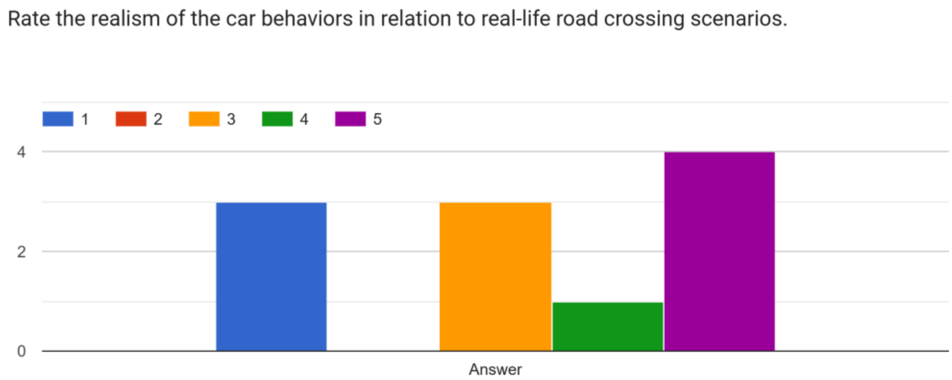


Fig. 7 *Survey rates on the realism of road crossing scenario*

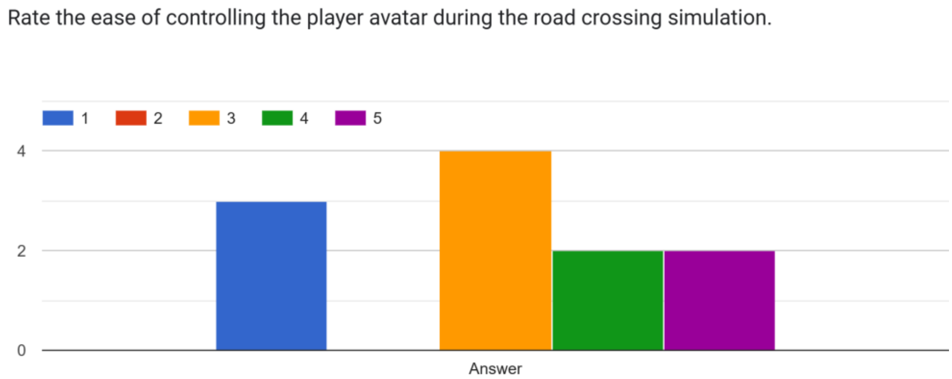


Fig. 8 *Survey rates on the ease of controlling the player*

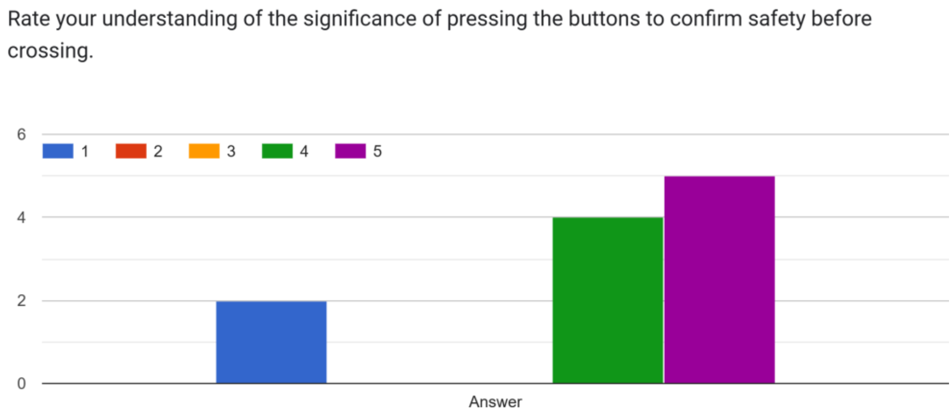


Fig. 9 *Survey rates on the buttons pressing reasoning*

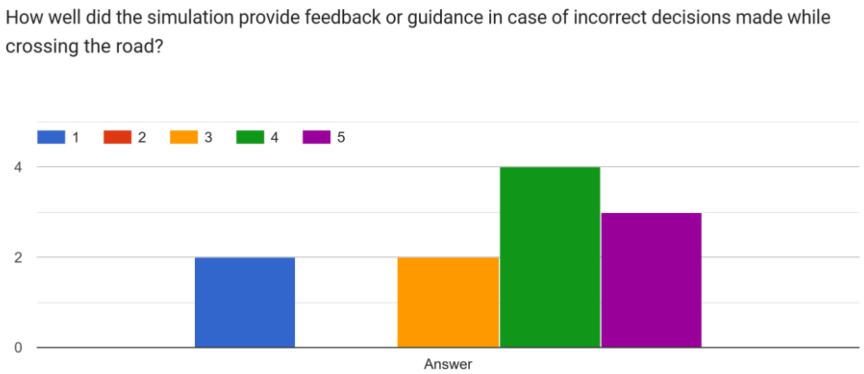


Fig. 10 *Survey rates on the feedback of incorrect decisions*

Concerning the realism of car behaviours in road crossing scenarios in Fig. 7, four participants gave the highest rating, affirming its authenticity. The result shows that realistic portrayals of car behaviour significantly influence pedestrians' crossing decisions in the VR environment [10].

The ease of controlling the avatar during road crossing received mixed reviews, as shown in Fig. 8, with participants split between lower and moderate ratings. This suggests potential usability issues that require further investigation and refinement.

The importance of the buttons pressing as the significance of looking both ways before crossing in Fig. 9 received positive ratings, as did the significance of pressing safety buttons. This highlights the effectiveness of the VR simulation in conveying fundamental pedestrian safety principles.

Regarding feedback for incorrect decisions during the crossing in Fig. 10, a balanced response was observed, with participants spread across different satisfaction levels. This suggests potential areas for refining feedback mechanisms to resonate better with diverse learning styles.

Many challenges were encountered while making VR simulations, primarily technical issues. Making cars move realistically took work, with both AI and animation having drawbacks. This problem settled on animation for control, even though it limits car movement options. Getting the simulator to work on different devices (like Oculus and Google Cardboard) was also challenging, but using a template from another game helped. Finally, even though we fixed some problems with building the app, it still crashes on phones.

4. Conclusion

In conclusion, the project has achieved its objectives by designing a user-friendly interface, implementing realistic road crossing scenarios, and effectively educating users on road safety knowledge through the VR simulation. However, ongoing improvements and updates may further enhance the simulation's impact, ensuring its continued effectiveness in educating users about road safety practices.

Recommendations for future works: refine the game's visuals and soundscapes to replicate real-life road crossings, heightening user engagement. Also, implement real-time feedback mechanisms such as scorekeeping or safety tips to enrich the educational aspect of the simulation. Finally, consider integrating the VR simulation into educational programs or public awareness campaigns to broaden its impact.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design:*** *Fahmi;* ***data collection:*** *Fahmi;* ***analysis and interpretation of results:*** *Fahmi;* ***draft manuscript preparation:*** *Fahmi, Shamsul, Mahadzir. All authors reviewed the results and approved the final version of the manuscript.*

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