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Augmented Reality (AR) as a New Educational Medium for Children: Using Road Safety Content

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Abstract

Road accidents, often involving one or more vehicles, can result in property damage, injuries, or even fatalities. These incidents can occur due to a range of factors, including human errors, adverse weather conditions, or mechanical failures, despite precautions taken by road users. Consequently, early education on road safety is crucial, especially for children. This research focuses on assessing children's knowledge of road accidents in Malaysia and evaluating the impact of augmented reality (AR) experiences on their understanding. To support this project, we developed an AR application using the Pendidikan Keselamatan Jalan Raya (PKJR) Year 2 Guidebook as a medium for students to learn about road safety. Selected pages in the book serve as markers, enabling students to engage with AR content while using the book. The study aims to determine the effectiveness of the AR application as an educational tool for children. A group of school children participated in testing this AR application, and their experiences were assessed using an adapted Game Experience Questionnaire (GEQ) model. The results indicate that after using the AR application, the group of 8-year-old children exhibited improved awareness of the road environment. This paper also explores the emotional aspects of participant experiences as emphasized by the GEQ. These findings highlight the potential of AR as an innovative tool for educating children about road safety, challenging traditional approaches, and promoting safer road behaviors among young individuals. Furthermore, this project aligns with the strategies outlined in the Malaysian Road Safety Plan 2020-2030, particularly in reducing risks to pedestrians. In a broader context, this study contributes to the evolving landscape of technology-driven safety initiatives, underscoring the importance of adapting contemporary educational mediums to address complex societal issues like road accidents. In conclusion, we discuss the potential for future studies involving road safety education and interactive technology.

***Keywords*:** *Augmented Reality, Traffic Accident, Children*

1. Introduction

Road accidents have become increasingly prevalent on a global scale, resulting in injuries ranging from minor to fatal for those involved. According to the World Health Organization (2022), road traffic injuries stand as the primary cause of death for individuals aged 5-29 years. Vulnerable road users, including pedestrians, cyclists, and motorcyclists, constitute more than half of all road traffic deaths. Alarmingly, 93% of global road fatalities occur in low- and middle-income countries, despite these nations accounting for approximately 60% of the world's vehicles. The economic impact of road traffic crashes is significant, costing most countries around 3% of their gross domestic product (World Health Organization, 2022).

As per Insee (2020), road traffic accidents are considered preventable. While no single measure can entirely mitigate the diverse risks to children on the road, several strategies have been implemented to enhance children's safety. These strategies encompass road sign installations, law enforcement, and educational initiatives. The development of this Augmented Reality (AR) project aims to heighten children's awareness of road accidents. The AR project is designed to be accessible on multiple platforms, including smartphones, tablets, and glasses. Comprising various multimedia elements such as text, graphics, and animation, the project is tailored for young children, with content drawn from the Pendidikan Keselamatan Jalan Raya (PKJR) Year 2 Guidebook provided by the Ministry of Education, Malaysia. Subsequently, the project evaluates the effectiveness of AR in raising awareness of road accidents among children.

The project also in line with the strategies in the Malaysian Road Safety Plan 2020-2030 which is reducing risk to pedestrians (Mohamed et al., n.d.). Several researchers have explored this type of medium to see how it can improve the learning process for children. António& Guilhermina Lobato (2023) in their study found that AR had positive effects on student's learning and motivation, as well as on other variables such as visuospatial skills and student involvement in tasks. As well as Wang (2022) in his research shows that 4- to 5-year-old preschool children passively pay attention to augmented reality (AR), and they are more interested in objects with bright colors and vivid appearances.

2. Literature Review

2.1 Augmented Reality

Referring to TechTarget (2022), AR is defined as the integration of digital information with the user's environment in real-time. Unlike virtual reality (VR), which creates a completely artificial environment, AR users experience a real-world environment with generated perceptual information superimposed on it. AR also refers to technology that blends digital information or virtual content with the real world, enhancing users' perception and interaction with their environment. It overlays computer-generated graphics, audio, or other sensory enhancements onto a real-world environment in real time.

An augmented experience is typically delivered using smartphones, tablets, smart glasses, or headsets. AR systems recognize and track real-world environments through the device's cameras and sensors. With augmented reality, users are provided with contextual information, visualization, or interactive elements to enhance their perception of reality. Users can access information and receive guidance about objects or spaces that are not present in the real world.

2.2 Related Work

Some researchers have been exploring AR technology in various ways. Focusing on education, here are some examples of how AR has been used in education and the benefit from it.

2.2.1 AR in Education

The use of Augmented Reality (AR) is rapidly gaining momentum as a prominent trend, with a projected 2.4 billion Augmented Reality mobile users worldwide expected by 2021, as projected by Sinha Shweta. This marks a significant jump from just 200 million users reported in 2015, emphasizing significant improvements that require careful consideration. The focus of this article is on the integration of Augmented Reality in educational and eLearning applications. Although many individuals are familiar with Augmented Reality in the context of mobile games such as Pokémon Go and on popular social media platforms such as Snapchat, it is important to acknowledge its great potential in the field of education.

Augmented Reality has the potential to revolutionize classroom education, making it more interactive. Teachers can use AR to illustrate abstract concepts with virtual examples and incorporate gamification elements to enhance textbook materials. This approach can facilitate faster learning and improved information retention. In the current context of remote learning, maintaining student engagement during

lectures has become challenging. Consequently, developers of eLearning applications are eagerly embracing AR technology. Overall, the development of Augmented Reality is gaining prominence in the market.

AR-enabled learning applications display augmented objects on the screen, offering 3D representations of concepts for students to engage with. Additionally, computer graphics are extensively used to incorporate real-world objects into the augmented environment and provide detailed information about them. This technology enables the capture and analysis of real-world objects, integrating them into the augmented learning experience and fostering a deeper understanding of the subject matter. Creating a unique e-learning application with AR functionality is also a viable possibility.

In the educational context, students engage with learning content through augmented reality (AR) applications, enabling real-time interaction. These AR apps spark enthusiasm and draw children toward their educational experiences (Shoaib et al., 2015). When employing AR methods for learning, students not only find themselves entertained but also deeply engaged in the educational process (Ya Midak et al., 2020). This engagement leads to notable academic achievements and fosters a positive outlook toward AR-based learning materials. AR adds an element of entertainment to education, enriching the learning experience through interactive user engagement. Additionally, AR holds the potential to seamlessly integrate interactive 3D virtual visuals into the physical world, ultimately elevating students' skill development and supporting rehabilitation efforts. It's worth emphasizing that AR techniques have demonstrated their effectiveness in enhancing motivation and cultivating resilience, especially among students with disabilities in the realm of special education. In a study by Chang et al. (2011), AR learning techniques were used to teach English vocabulary, and the results demonstrated their ability to capture students' attention and make the learning process compelling.

In recent years, numerous researchers have integrated augmented reality (AR) technology into educational contexts, exploring its utility across various subjects. In the context of our current study, Safar et al. (2017) harnessed AR applications to teach the English alphabet to preschool students. They conducted a comparative analysis, pitting the AR learning method against traditional classroom-based instruction. Their findings favored the use of AR applications, recommending the incorporation of this technology into school environments. Similarly, Rambli et al. (2013) took a step further by developing an AR alphabet book and subsequently conducting an observational study to assess the efficacy of AR technology in primary school education. Their research uncovered that AR technology serves as an engaging and valuable tool for educational purposes.

2.2.2 Learning Content Understanding

Numerous publications emphasize a distinct preference for augmented reality (AR) over traditional mediums like ink and paper, computer-based systems, and video-oriented learning approaches. For example, Lindgren & Moshell (2011) conducted two separate learning sessions centered around the subject of astronomy. In the first session, a standard computer system was employed, while in the second session, AR technology was utilized, enabling direct interaction with the user. Similarly, Sin & Zaman (2010) undertook a study comparing AR-based learning with traditional book-based learning for teaching about solar systems. Their research yielded results that showcased the effectiveness of the AR technique when contrasted with the traditional book-based approach. In a novel approach to teaching human anatomy, Nischelwitzer et al. (2007) visualized 3D models of various body parts in the real world, resulting in a remarkably engaging and captivating learning experience for students.

3. Methodology

When developing an educational application, it is crucial to consider both the academic and emotional well-being of students. From a technological standpoint, the decision was made to employ augmented reality (AR) techniques for creating learning and instructional content (Sinha Shweta, 2021). AR technology fulfills all the essential educational requirements for effective learning among students. Using AR, students gain the ability to visualize educational content within their actual environment and

engage with it in real-time. Envision students using a smartphone app to view digital information such as traffic signs and cars right in their own environment. This makes learning about traffic accidents much more engaging because they can see and interact with the information. In this project, AR makes learning about staying safe in traffic enjoyable. Children can observe virtual situations, like cars stopping at a crosswalk, happening right where they are. They can even manipulate elements and observe the consequences, like a game that teaches important safety rules.

It is essential to follow an organized methodology to ensure the success of implementing an AR project. Inspired by author Jake Knapp's work at Google, Berry and his team broke down the AR creation process into five main steps (McDevitt Delaney, 2019). These steps provide a structured approach to developing an AR experience. Workplace bullying has the potential to have devastating effects on an employee's life, family, and career (Namie & Namie, 2003). Trainees are no exception, as they are also exposed to the risk of negative acts at work. Trainees with limited training and experience in facing challenges in hotel work will compromise their relationship with customers once an ill emotional state takes place. They would have to mask what they truly feel to deliver prompt and outstanding service.

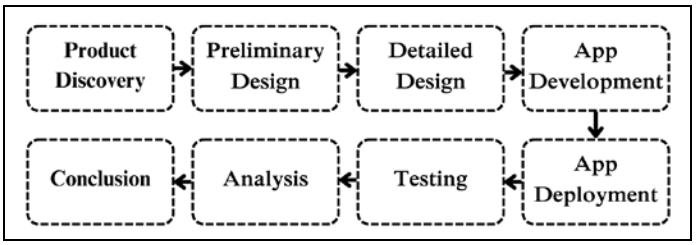

Figure 1: Process adapted from Jake Knapp's (2019)

Begin with product discovery by identifying user goals and needs. Clearly delineate the goals and objectives of the AR project. Pinpoint the precise user needs and issues that the AR experience intends to address. This process involves gathering information about the target users, defining the AR project's goals, and conducting thorough user research. Subsequently, formulate an initial design by generating ideas. Conduct brainstorming sessions to foster innovative ideas for AR experiences. To generate multiple ideas and options, encourage cross-team collaboration during brainstorming sessions. Deliberate on how AR can effectively meet the outlined user needs and accomplish the project objectives. In the realm of AR, it is imperative to create a storyboard before the main project initiation to ensure a proper narrative flow. Figure 2 illustrates examples of the storyboard for this AR project.

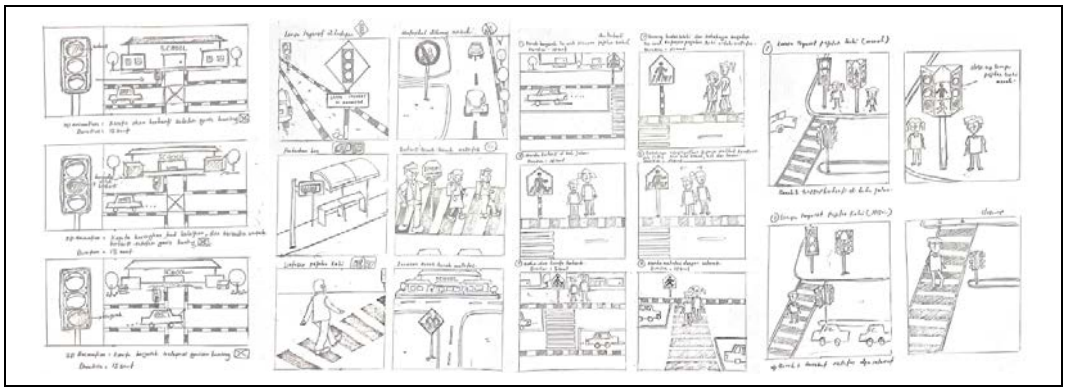
Figure 2: A hand-drawn sketch of the storyboard

The third step involves a detailed design that includes prototypes. Once we have compiled a list of ideas, we evaluate them based on their feasibility, significance, and alignment with our current objectives. A prototype has been developed based on the most promising concept to demonstrate and test the idea. To facilitate rapid iteration and feedback, prototypes can be low-fidelity representations of the AR experience.

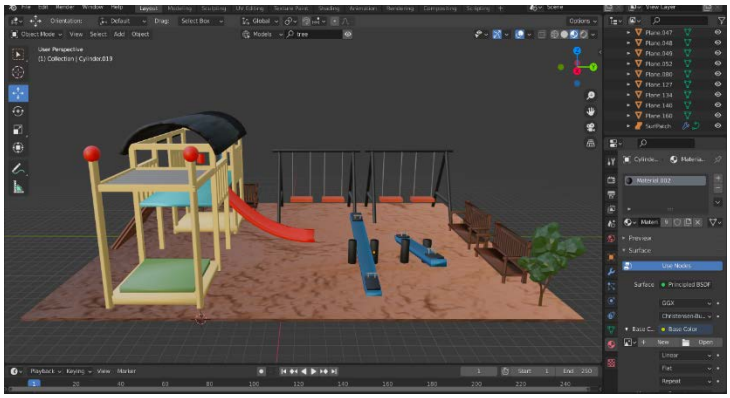

Figure 3: Environment Prototype in Blender3D

The subsequent step is application development, encompassing the configuration of elements and the implementation of interactions. App development typically involves the process of supplying or adjusting various components, features, or aspects of a system, software, hardware, or a similar entity to meet specific needs or preferences, as illustrated in Figure 3. These elements may encompass software settings, hardware parameters, network configuration, or any other adjustable component in the system that enables users or administrators to customize the system according to their requirements.

Figure 4: Environment Setup in Adobe Aero

Following application development comes the crucial phase of application deployment, which is the process of making a software application or system available and operational for end-users or within an organization's infrastructure. App development entails configuring elements and implementing interactions. This generally involves providing or adapting various components, features, or aspects of a system, software, hardware, or a similar entity to meet specific needs or preferences. The implementation of interaction refers to the process of designing, developing, and integrating various features, functionalities, or interfaces within a system or application to facilitate interaction between users and the system itself. This process encompasses programming, design, and usability considerations to ensure that users' needs and expectations are met during their interaction with the system or application.

Moving forward is the testing phase, an integral part of software development and quality assurance. This phase involves a systematic and structured process to evaluate a software application or system thoroughly. The primary objective is to identify defects, errors, or issues and ensure that the software meets the specified requirements and functions correctly.

The following stage involves analysis. In this scenario, we selected a class of second-year students to evaluate the application using the Game Experience Questionnaire (GEQ) model. The details of this testing method are discussed in Section 4: Testing below. By following these steps, Berry and his team

aim to provide a structured framework for creating AR experiences. Iterative development, user-centered design, and continuous testing and improvement are all emphasized in this method. The objective is to develop an engaging and powerful AR experience that meets user needs and achieves the project's stated objectives.

3.1 Design and Development Process

In the system architecture phase, our primary goal is to ensure that these AR learning applications are user-friendly and interactive for students. The development phase encompasses various steps, including 3D modeling of objects, enabling touch interaction by students with augmented 3D models, incorporating animations, and integrating sound effects. Figure 5 illustrates the overall design and development phases of the applications.

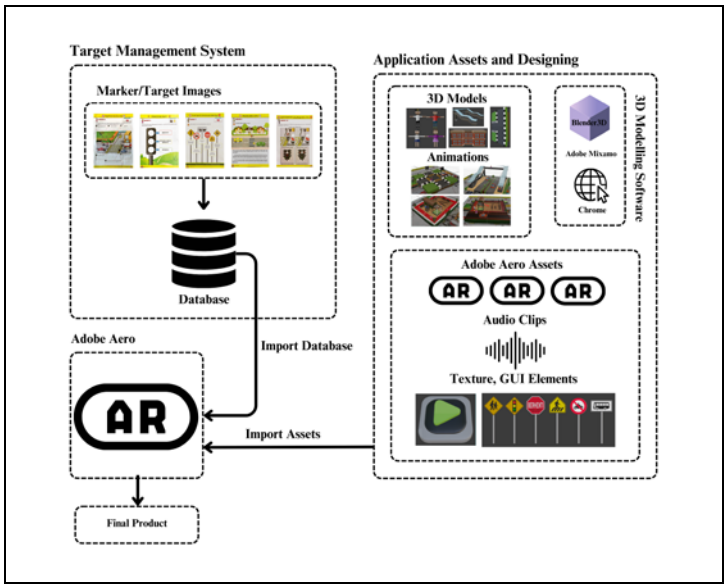

Figure 5: Design & Development Phases Applications

Commence with a target or marker, which constitutes the activity pages of the PKJR Year 2 book. The image anchor, a 2D image serving as a target for the AR experience, is employed. AR application image targets are uploaded to Adobe Aero using both the digital and physical versions of the image in the same aspect ratio. The image anchor assigns a rating to each target image based on feature points, as illustrated in Figure 6. For the design of 3D models and animations, we utilize Adobe Aero free assets and 3D design software such as Blender, along with other freely available internet resources. All design and developmental content of the AR application is seamlessly integrated within the Adobe Aero Application.

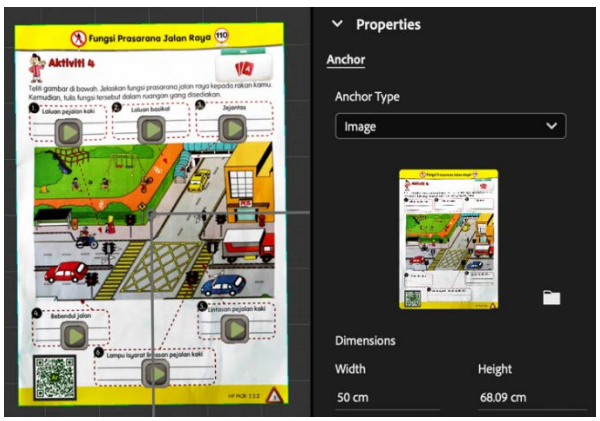

Figure 6: Anchor/Marker Image

3.2 Applications Workflow

These applications showcase virtual educational content within the real-world environment when the image targets become visible in the camera view of smartphones or tablets. Through this method, students have the ability to view and explore virtual 3D content in the physical world and engage with the augmented environment linked to the image targets in their books or hand notes. The entire workflow of the applications is detailed in Figure 7.

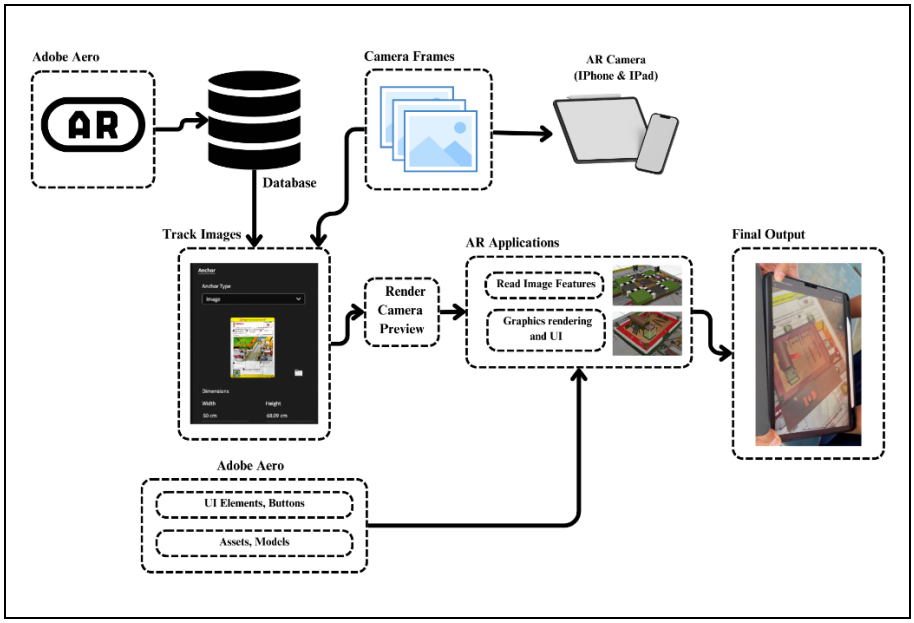

Figure 7: Design and Development Phases of the Applications

The following steps outline the process of experiencing AR technology in this project:

1. Scan the page of the target book using an IOS device (iPhone/iPad).
2. Store the features of the target page in the database.
3. When the features match with the database, the application augments virtual content onto the surface of that image target.
4. The AR application visualizes the learning content and graphics using the image captured by the device.

4. Testing

Our proposed approach aims to investigate the effectiveness, quality, and evaluation of the experience of AR applications as a novel educational medium for children, specifically focusing on road safety content. In this contemporary era, leveraging such technology for educational training motivates students to learn beyond traditional methods. AR learning techniques provide the opportunity to educate students in an attractive, inspiring, and engaging manner.

As mentioned above, this AR application shares similarities with games by including animation and road safety lessons, the GEQ methodology was adopted. Since our selected participant was year two student, which is around 8 years old, the number of questiosns has been reduced to 15 questions from 33 originally. However, it is still adapted to match the experience of using the AR application.

4.1 Participants

This test involved 31 second-year primary school students aged eight. The selected school is Sekolah Kebangsan Gangsa, Durian Tunggal, Melaka as shown in figure 8 below.

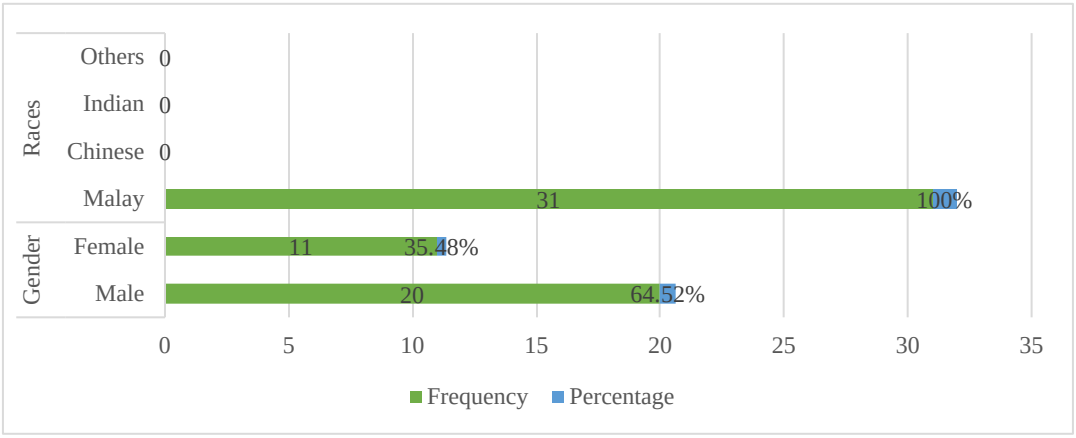

Figure 8: Demography Respondent Data

Authorization was obtained from the school authorities before the experiment session began. The school principal was notified of the survey, along with the number of participating students to evaluate this AR experience application. The students are informed that they will have two sessions in one day for two hours during the Bahasa Melayu class. In each session, they must complete tasks aimed at helping to evaluate the AR experience and objective effectiveness. All participants gave their consent to participate in the research project and the questionnaire used in the experiment.

Session 1 is AR experience application and session 2 is a survey and questionnaires. Initially, each student will have the opportunity to engage in the AR trying out experience sequentially. Two students will participate in a minimum of three activities, followed by the subsequent students performing the same tasks. This rotation will continue until all students have completed their turns. On average, each student's involvement in the tasks will span between 6 to 15 minutes.

4.2 Procedures

The GEQ was applied to evaluate the gaming experience (Law et al., 2018), consisting of 33 questions on a 5-point Likert scale to indicate the level of agreement, with responses of “strongly disagree”, “disagree”, “neutral”, “agree” and “strongly agree”. The questions were categorized to measure 7 subscales, defined in Table 1.

The approach for children is to understand the given survey questions either by reading aloud or repeatedly. When faced with unfamiliar words, explanations were given using simpler terms they were more familiar with. The average time taken for this questionnaire is between a minimum of 7 minutes and a maximum of 10 minutes. Throughout the survey, videos will be recorded as additional method support to collect data about the participants' feelings and reactions while conducting the AR experience.

Table 1. Dimension of Game Experiences Questionnaires (GEQ).

Positive Affect	1 I thought it was fun
Negative Affect	2 I felt bored 3 I found it tiresome
Tension	4 I felt irritable 5 I felt annoyed 6 I felt pressured
Challenge	7 I felt challenged
Competence	8 I was good at it 9 I felt skillful 10 I felt successful

	11 I felt competent
Flow	12 I was deeply concentrated in the game
Immersion	13 It felt like a rich experiences 14 I felt that I could explore things 15 I found it impressive

5. Analysis

The purpose of this test is to make sure the project works well; users can understand it and it does what it is supposed to do as described in the first chapter. The results of the questionnaire are as shown in figure 9 below.

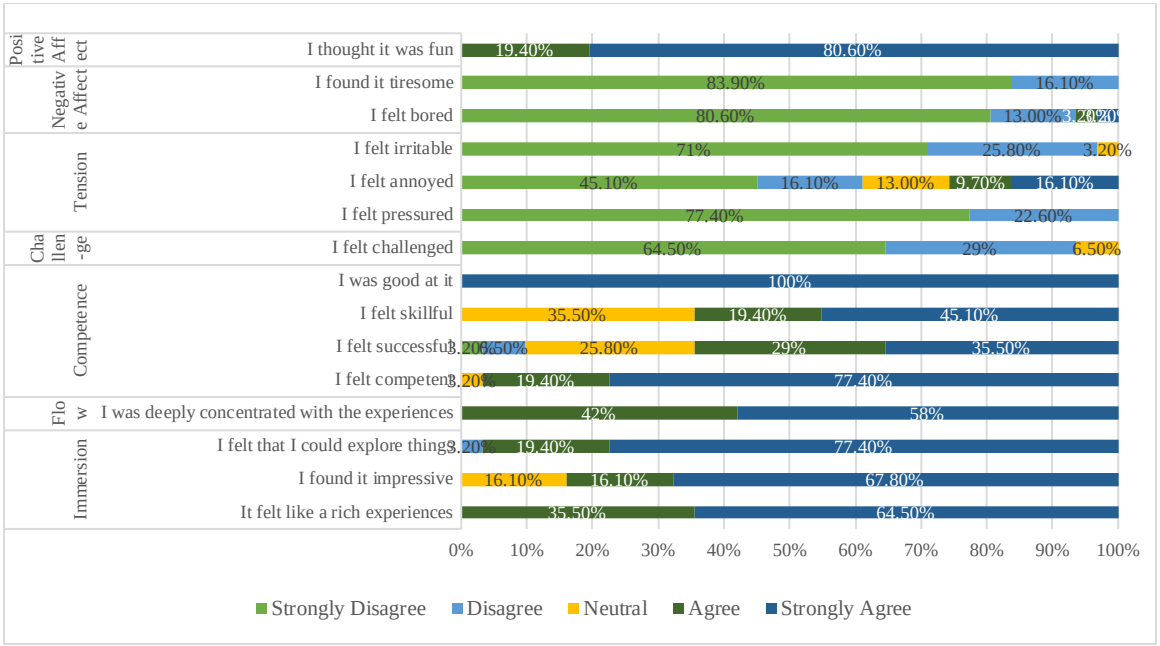

Figure 9: Result Questionnaire

The quality of this AR application is evident when examining the high percentage scores on all positive variables and the low percentage scores for negative variables. According to the chart analysis, the data collected shows that the respondents strongly agree that the application is geared towards aspects of positive impact, competence, flow, and immersion. A total of 80.60% strongly agreed that the AR experience application is very fun and enjoyable. Everyone (100%) felt that they were good at the application after the test. Furthermore, as many as 45.10%, 35.50%, 77.40%, 58%, 77.40%, 67.80% and 64.50% of students strongly agree that they are skillful, successful, competent, easy to focus and concentrate, can explore things, feel this application is impressive and feel rich experiences after testing is carried out.

On the other hand, many individuals expressed strong disagreement that this application has aspects of negative effects, tension, and challenges. In terms of negative affect, 83.90% and 80.60% of students strongly disagree that this AR experience application is tiresome and boring. Similarly, to the aspect of tension and challenge, 71%, 45.10%, 77.40% and 64.50% of students strongly disagree that this AR experience application is irritable, annoyed, pressured and challenged.

The study's findings indicated that participants demonstrated proficiency when utilizing the AR application as a learning tool. Moreover, the results concerning the effectiveness, quality, and evaluation of the AR experience suggested that the delivery of information was more user-friendly and effective for the respondents.

6. Conclusion and Future Recommendation

This project has significant weaknesses, according to analysis and testing. Many students often have difficulty holding and positioning the scanning device correctly when trying to capture information from a surface/marker. This highlights the critical need for the development and implementation of comprehensive guidelines tailored specifically for students or users. These guidelines play an important role in empowering individuals to understand and use scanning devices independently, thereby increasing their overall efficiency and self-sufficiency in using this technology for surface scanning applications. Also, many feedback comments have highlighted the potential of enhancing AR applications through the addition of background music. Additionally, the incorporation of animated characters acting as live instructors throughout the entire experiment has been recommended to further enhance students' understanding of the virtual experiment.

An interactive combination of AR technology and gamification elements is the e-main application's strength. Including gamification elements in AR applications adds excitement and innovation to project interactions, making them more appealing and engaging for students. Additionally, AR is an interesting learning method in a new way.

However, based on user analysis and reviews, this AR application can be improved in several ways. One of the ways is to make a clear guideline way to hold the device. Providing clear instructions on the proper use of scanning devices to accurately identify specific surfaces is extremely important. Equally important is making sure the student (or user) understands what kind of anchor the AR application is using, whether it's a horizontal, vertical, or image target.

In summary, this project provides advantages and positive outcomes for Year 2 students. The use of augmented reality (AR) technology in the application enhances children's engagement in virtual experiments and fosters their acceptance of AR for learning. They can easily comprehend and follow the instructions within the AR application while conducting virtual experiments. Additionally, they gain valuable exposure to AR technology as an innovative learning method, which they can share with friends, family, and teachers to raise awareness about this technology.

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References

Adobe Inc. (2023). Aero. *Augmented Reality. It's Everything You Imagined.*, 1–11.

António, F., & Guilhermina Lobato, M. (2023). Effects of using augmented reality on students' learning. *Trends in Computer Science and Information Technology*, *8*(1), 001–004.

Chang, Y. J., Chen, C. H., Huang, W. T., & Huang, W. S. (2011). Investigating students perceived satisfaction, behavioral intention, and effectiveness of English learning using augmented reality. *Proceedings - IEEE International Conference on Multimedia and Expo*.

Insee. (2020). Definition - Road accidents _ Insee. *Road Accidents*, 1–1.

Kaufmann, H., & Dünser, A. (2007). Summary of usability evaluations of an educational augmented reality application. *Lecture Notes in Computer Science (Including Subseries Lecture Notes Artificial Intelligence and Lecture Notes in Bioinformatics), 4563 LNCS*, 660–669

Lindgren, R., & Moshell, J. M. (2011). *childrens-learning-with-body-based-metaphors-in-a-mixe Supporting children's learning with body-based metaphors in a mixed reality environment.*

Matcha, W., & Awang Rambli, D. R. (2011). Preliminary investigation on the use of augmented reality in collaborative learning. *Communications in Computer and Information Science*, *254 CCIS* (PART 4), 189– 198.

McDevitt Delaney. (2019). 04. AR Creation Process. *AR Design Sprints: How to Improve Your AR Creation Process*, 1–4.

Nischelwitzer, A., Lenz, F.-J., Searle, G., & Holzinger, A. (2007). LNCS 4556 - Some Aspects of the Development of Low-Cost Augmented Reality Learning Environments as Examples for Future Interfaces in Technology Enhanced Learning. In *LNCS* (Vol. 4556).

Rambli, D. R. A., Matcha, W., & Sulaiman, S. (2013). Fun learning with AR alphabet book for preschool children. *Procedia Computer Science*, *25*, 211–219.

Safar, A. H., Al-Jafar, A. A., & Al-Yousefi, Z. H. (2017). The effectiveness of using augmented reality apps in teaching the english alphabet to kindergarten children: A case study in the state of Kuwait. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 417–440.

Saidin, N. F., Halim, N. D. A., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. *International Education Studies*, *13*, 1–8.

Shoaib, H., Waqar Jaffry, S., & Waqar Jaffry, S. (2015). *A Survey of Augmented Reality Inclusivity View project Humanistic Driver Agent (HDA) View project A Survey of Augmented Reality*.

Sin, A. K., & Zaman, H. B. (2010). Live Solar System (LSS): Evaluation of an Augmented Reality book-based educational tool. *Proceedings 2010 International Symposium on Information Technology – Visual Informatics, ITSim'10*, *1*.

Sinha Shweta. (2021b). Augmented Reality (AR) In Education - eLearning Industry. *Augmented Reality (AR) In Education: A Staggering Insight into The Future*, 1–9.

TechTarget. (2022). What is Augmented Reality (AR)_. *What Is the Metaverse? An Explanation and in-Depth Guide*, 1–7.

Wang, R. (2022). Application of Augmented Reality Technology in Children's Picture Books Based on Educational Psychology View altmetric score □. *Sec. Educational Psychology*, *13*, 2022.

World Health Organization. (2022). *Fact sheets Road traffic injuries WHO TEAM*.

Ya Midak, L., Kravets, I. V, Kuzyshyn, O. V, Berladyniuk, K. V, Buzhdyhan, K. V, & Baziuk, L. V. (2020). *Augmented reality in process of studying astronomic concepts in primary school*.