



Enhancing Safety Education through the Looking Glass: Acceptance of Augmented Reality

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Abstract

This study explores the acceptance of augmented reality (AR) in safety classes using the Technology Acceptance Model (TAM). Participants from safety classes were exposed to AR-based activities, and their perceptions of AR's usefulness and ease of use were measured through surveys. The findings reveal that participants found AR highly useful in enhancing safe learning experiences, visualizing safety procedures, and facilitating engagement. Participants also reported that AR applications were intuitive and user-friendly. The study supports the TAM model, indicating that perceived usefulness and ease of use strongly influenced participants' attitudes and intentions toward AR. Educators should prioritize emphasizing usefulness and ease of use to promote successful integration of AR in safety education.

Keywords: Augmented Reality; Virtual learning; Learning environment; Safety Education

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1.0 Introduction

In the age of rapid technological advancements, the 21st century has witnessed a significant transformation in various fields, with education being a prominent area of impact. Sheikhaboumasoudi et al. (2018) found that traditional teaching and learning methods are evolving to incorporate technological advancements, providing novel approaches to instruction and enhancing student engagement and learning outcomes (Vanka, Vanka, and Wali, 2019). Among the emerging technologies, Augmented Reality (AR) has gained considerable attention in the educational landscape. AR, which overlays computer-generated images onto a user's view of the real world, presents a profound shift from traditional teaching aids to a more immersive and interactive learning environment. The application of AR in education has demonstrated potential benefits, such as improved visualization of complex concepts, enhanced student engagement, and increased motivation for learning. (Lopez, Cuji, Rios, & Abasolo, 2022). The integration of AR in education is particularly noteworthy. The post-globalization world is witnessing the rapid development of technology, encouraging the use of various technologies in all sectors, including education. The Malaysian education system has shown enthusiasm for implementing these new technologies with the aim of enhancing students' focus, interest, and comprehension throughout the teaching and learning sessions¹.

Safety education, a critical component of general education aimed at reducing the risk of injury and promoting safety consciousness, is one area where AR has shown promising potential. (Stokes, McFadden, Salcedo, & Beres, 2021) Given the often

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complex and abstract nature of safety concepts, AR's ability to provide realistic, visual, and interactive learning experiences presents an innovative way to enhance the teaching and learning of safety. However, the successful integration of AR in safety education is largely dependent on its acceptance by the end-users - the students. Previous studies have shown that several factors, including perceived usefulness, perceived ease of use, and attitudes towards the technology, influence students' acceptance of new technology in education.

Despite the potential benefits of AR in safety education, there need to be more comprehensive studies that explore students' acceptance of this technology using a well-established theoretical framework (Jdaitawi & Kan'an, 2021).. Furthermore, while AR has been increasingly adopted in various educational settings, its acceptance in safety classes still needs to be explored.

This research seeks to bridge this gap by applying the Technology Acceptance Model (TAM) to examine the acceptance of AR in safety education. The TAM, a widely used model for understanding the acceptance and adoption of new technologies, posits that an individual's intention to use technology is determined by perceived usefulness and perceived ease of use.

1.2 Research Questions

The study will address the following research questions:

1. How do students perceive the usefulness of AR in safety education?
2. How do students perceive the ease of use of AR in safety education?
3. What is the relationship between students' perceived usefulness and ease of use of AR and their intention to use AR in safety education?
4. How do students' attitudes towards AR influence their intention to use AR in safety education?

This study aims to provide insights into the factors influencing students' acceptance of AR in safety education by addressing these research questions. The findings will contribute to understanding how educators can effectively integrate AR into safety classes to enhance teaching and learning outcomes.

2.0 Literature Review

2.1 The Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), first introduced by Davis in 1986, is one of the most widely accepted models for understanding users' acceptance of new technologies. It is built on two principal constructs: Perceived Usefulness (PU) - the degree to which a person believes that using a specific system would enhance their performance, and Perceived Ease of Use (PEOU) - the degree to which a person believes that using a specific system would be free from effort. Numerous studies have employed TAM to investigate the acceptance of various technologies in different contexts, including education. However, research on the application of TAM in examining the acceptance of AR in safety classes could be more extensive. (Kwok, Yan, Qu, & Lau, 2020; Uymaz & Uymaz, 2022)).

AR, a technology that superimposes a computer-generated image on a user's view of the real world, providing a composite view, has been increasingly used in various educational settings. It offers a unique, immersive, and interactive learning experience that allows for the visualization of complex concepts, which can be particularly beneficial in safety education. Despite the potential benefits of AR, its successful integration into classrooms depends mainly on students' acceptance. Thus, understanding the factors influencing students' acceptance of AR in safety education is crucial. (Fauzi, Ali, & Amirudin, 2019).

2.2 Augmented Reality for Education

Augmented Reality (AR) has emerged as an influential technology that can significantly enhance safety education across multiple contexts. The following literature review discusses the current AR application in safety education, mainly focusing on its implementation in the educational system, its characteristics, and a specific case study in the agriculture industry.

AR's use in the educational system has been expanding rapidly due to technological advancements in the post-globalization world. Education systems worldwide have shown interest in implementing new technologies like AR to enhance students' focus, interest, and comprehension throughout teaching and learning sessions. In Malaysia, an educational application for Form 4 Biology Science in secondary schools utilizes AR technology. This application covers mitosis, meiosis, and respiration, presenting them in dedicated stereoscopic and photo-realistic views. It not only facilitates students' understanding of biology concepts but also enables individualized interaction and social communication, enhancing the effectiveness and attractiveness of the learning environment. From the literature is the Augmented Reality Intervention for Safety Education (ARISE), an AR 3D simulator developed to enhance safety education in agriculture, one of the most dangerous U.S. occupations. ARISE presents farm accident situations with immersive media technology, aiming to promote safe and healthy working habits. AR technology was influential in creating an impactful role in enhancing agricultural safety, thus highlighting the potential of AR technology for innovative safety education programs. Another study highlights the use of AR for safety education in the chemical industry. The application of Augmented Reality can bridge the gap between theoretical knowledge and practical skills by allowing trainees to practice procedures in a more practical environment. This demonstrates the potential of AR in delivering practical training in high-risk industries where safety is paramount.

There are also several AR applications in safety training across industries like construction, oil and gas, and manufacturing, where AR is used to provide immersive, realistic simulations of potential hazards in the work environment. This allows workers to learn to respond to these hazards in a safe, controlled setting before they encounter them in the real world.

3.0 Methodology

This study adopted a mix-methodology research design, to investigate the acceptance of Augmented Reality (AR) in safety classes and

3.1 Participants

The participants of this study were students enrolled in safety classes across various educational institutions. A purposive sampling strategy was used to select participants who were exposed to AR technologies as part of their curriculum. This group was chosen because their direct exposure to AR technologies in an educational setting provided valuable insights into the technology's adoption and acceptance.

3.2 AR-Based Activities

The AR-based activities integrated into the safety classes varied in content and design, depending on the specific safety concepts being taught. These activities could involve interactive simulations of safety scenarios, demonstrations of safety equipment usage, or virtual tours of high-risk environments. The primary purpose of these AR applications was to enhance the comprehension and application of safety knowledge by providing immersive, realistic, and interactive learning experiences.

3.3 Data Collections

Data were collected using a self-administered online survey designed based on the Technology Acceptance Model (TAM). The survey was divided into several sections, each designed to measure different aspects related to AR acceptance:

Perceived Usefulness: Questions in this section gauged participants' beliefs about the degree to which using AR would enhance their performance in safety classes. **Perceived Ease of Use:** This section contained questions that sought to understand participants' perceptions of the ease of use of AR in safety classes. **Attitude towards Using AR:** This section included questions about participants' positive or negative feelings about using AR in safety classes. **Behavioral Intention to Use AR:** Questions in this section aimed to measure participants' intentions to use AR in the future.

The survey items were rated on a five-point Likert scale, ranging from "strongly disagree" to "strongly agree."

3.4 Data Analysis

The collected data were analyzed using statistical methods. Descriptive statistics were used to provide an overview of the participants' responses, and inferential statistics were used to investigate the relationships among perceived usefulness, perceived ease of use, attitude towards using AR, behavioral intention to use AR, and experience with AR technologies. The statistical analysis aimed to provide insights into the factors that influence students' acceptance of AR in safety education. This methodology is expected to offer robust and reliable results that can guide educators and curriculum designers in integrating AR technologies into safety education effectively. This study aimed to understand students' acceptance of Augmented Reality (AR) in safety education, guided by the following research questions

4.0 Findings

This part will present the total demographic of respondents that involve in the study.

Table 1.2 shows the academic courses of the respondents.. There are only 36 (36%) of the students that come from science courses meanwhile another 64 (64%) from non-science courses.

	Frequency	Percent (%)
Science	136	36
Non-Science	164	64
Total	300	100

Table 1.1 Safety Courses of Respondents

The results obtained from the survey data provided insights into students' perceptions of AR in safety education:

4.1 Perceived Usefulness

The survey asked students to rate their perceptions of the usefulness of Augmented Reality (AR) in their safety education classes on a 5-point Likert scale, where 1 represented "strongly disagree" and 5 represented "strongly agree". Usefulness was measured through several indicators including enhancement of understanding, improvement in class performance, and effectiveness in grasping complex

safety concepts. A large majority of students (approximately 80%) rated AR as either "useful" (4) or "very useful" (5) in their safety education. In particular, students felt that AR provided a more immersive and interactive learning environment, which helped them better understand and apply safety concepts in a real-world context. For instance, students mentioned that the 3D visualization capabilities of AR allowed them to grasp complex safety procedures and precautions more effectively than traditional 2D diagrams or text descriptions.

4.2 Perceived Ease of Use

Approximately 75% of students indicated that they found AR "easy" (4) or "very easy" (5) to use. These students reported that they were able to quickly learn how to navigate the AR platform, interact with the virtual elements, and incorporate the AR tools into their learning process. They appreciated the intuitive interface and user-friendly design of the AR applications, which they said reduced the cognitive load of learning new technology while trying to understand safety concepts.

4.3 Attitudes towards AR

Generally, students exhibited positive attitudes towards AR, which significantly influenced their intention to use AR in safety education. Students who held positive attitudes towards AR were more likely to express an intention to use AR in their safety classes.

4.4 Intention to Use AR

There was a positive correlation between students' perceived usefulness and ease of use of AR and their intention to use AR in safety education. Students who found AR useful and easy to use were more likely to express a willingness to use AR in the future.

5.0 Discussion

5.1 Perceived Usefulness

Students reported that the use of AR improved their performance in safety classes. Specifically, they noted that AR enabled them to engage more deeply with the course material, leading to better retention of information and higher scores on assessments. They also expressed that the interactive nature of AR made the learning process more enjoyable, which increased their motivation to participate in class and complete assigned tasks. Despite the overall positive feedback, a small proportion of students (about 10%) expressed neutral or negative views on the usefulness of AR. Some of these students felt that the technology was somewhat distracting or overwhelming, suggesting that not all students may find AR beneficial in the same way. This highlights the need to consider individual learning styles and preferences when integrating AR into educational settings., the majority of students perceived AR as a valuable tool in enhancing their understanding and performance in safety education. This finding suggests that AR holds significant promise for improving learning outcomes in safety education by providing a more engaging and interactive learning experience. However, the varied responses also underline the importance of implementing AR in a thoughtful and inclusive manner, taking into consideration the different learning needs and preferences of students.

In this survey, students were asked to assess the usefulness of AR in safety education on a 5-point Likert scale, where 1 represented "strongly disagree" and 5 represented "strongly agree". The measures of usefulness incorporated various factors such as enhancement of understanding, improvement in class performance, and effectiveness in grasping complex safety concepts. The results showed that a significant majority of students, approximately 80%, found AR to be "useful" (4) or "very useful" (5) in their safety education. They perceived that AR had a positive impact on their learning, particularly in terms of understanding and applying safety concepts. Students reported that AR's immersive and interactive capabilities, such as 3D visualization, allowed them to comprehend complex safety procedures better than traditional teaching methods. They also noted an improvement in their performance in safety classes, suggesting that AR could enhance their academic performance, which aligns with the TAM's construct of perceived usefulness.

In addition, students reported that AR made learning more enjoyable, which could increase their motivation and engagement in safety education. This perceived usefulness of AR in making learning more engaging and motivating is an important factor that could positively influence students' attitudes towards using AR in safety education, as suggested by the TAM. (Rodríguez-Abad, Fernandez-De-La-Iglesia, Martínez-Santos, & Rodríguez-González, 2021). However, around 10% of students had neutral or negative views about the usefulness of AR. Some of these students felt that the technology was somewhat distracting or overwhelming, indicating that the perceived usefulness of AR might vary among students due to differences in learning styles and preferences. This underscores the need to consider individual differences when integrating AR in educational settings and provides an opportunity for further research to understand how to maximize the perceived usefulness of AR for all students. In conclusion, most students perceived AR as a useful tool in safety education, suggesting that AR has the potential to enhance learning outcomes and improve academic performance in this field. These findings support the TAM's proposition that perceived usefulness is a critical factor influencing the acceptance and use of new technology. However, the varied perceptions of AR's usefulness also highlight the importance of personalized and adaptive approaches when implementing AR in educational settings.

5.2 Perceived Ease of Use

The Technology Acceptance Model (TAM) posits that the perceived ease of use of technology is a critical determinant of its acceptance and usage. In the context of this study, this involves the extent to which students believe that using AR in their safety education would

be free of effort. Students were asked to evaluate the perceived ease of use of AR in their safety education on a 5-point Likert scale, where 1 represented "very difficult" and 5 represented "very easy". The survey included items that asked students about their comfort level in using AR, the ease with which they learned how to use the AR tools, and the user-friendliness of the AR applications.

Despite the overall positive response, around 15% of students found the AR technology "difficult" or "somewhat difficult" to use. These students expressed challenges such as understanding how to interact with the AR interface, dealing with occasional technical issues, and managing the volume of information presented through AR. According to TAM, these perceived difficulties could negatively affect these students' attitudes towards AR and potentially their intentions to use it in future safety education classes.

These findings align with the TAM, which suggests that perceived ease of use is a significant factor in technology acceptance. Mailizar and Johar(2021) highlight the need for careful planning and support when implementing AR in safety education to ensure that all students can effectively engage with this technology, regardless of their prior experience or comfort level with such technologies Kim & Shim, 2022). Providing clear instructions, hands-on training, and ongoing technical support could mitigate these challenges and improve students' experiences with AR in safety education, ultimately increasing their acceptance of this innovative learning tool.

5.3 Attitudes towards AR

Generally, students exhibited positive attitudes towards AR, which significantly influenced their intention to use AR in safety education. Students who held positive attitudes towards AR were more likely to express an intention to use AR in their safety classes. According to the Technology Acceptance Model (TAM), an individual's attitude towards a technology plays a pivotal role in determining their intention to use it. This attitude is influenced by the perceived usefulness and ease of use of the technology. In the context of AR in safety education, students' attitudes towards AR were gauged through a series of survey questions. Overall, the students exhibited positive attitudes towards AR in safety education. Many students reported that they found AR to be a useful and engaging tool that added value to their learning experience. They appreciated the immersive and interactive nature of AR, stating that it helped them better understand and remember safety concepts and procedures.

The students' positive attitudes towards AR significantly influenced their intention to use AR in their safety classes. Those who held positive attitudes towards AR were more likely to express a willingness to use AR in their safety education. This correlation is consistent with the TAM, AR. Some found the technology to be overwhelming or distracting, and others perceived it as less useful than traditional teaching methods (Ashri, 2020).

5.3 Behavioral Intention to Use AR

The survey data provided insights into students' intentions to use Augmented Reality (AR) in their safety education. The intention to use technology is a critical factor in the Technology Acceptance Model (TAM) and is influenced by perceived usefulness, ease of use, and attitudes towards the technology. The data showed a strong correlation between students' perceived usefulness and ease of use of AR and their intention to use AR in safety education. Students who found AR both useful and easy to use showed a strong intention to use this technology in their future safety education. This is in line with the TAM, which suggests that when users perceive technology as beneficial and easy to handle, they are more likely to plan to use it (Bathini, Kundoor, & Mathai, 2022).

Furthermore, students' attitudes towards AR also significantly influenced their intention to use it. Those who held positive attitudes towards AR, appreciating its immersive and interactive learning experience, were more likely to express an intention to use AR in their safety classes

6.0 Conclusion & Recommendations

The results of this study suggest that students perceive AR as a beneficial and user-friendly tool in safety education. The high perceived usefulness indicates that AR could play a vital role in enhancing students' understanding and application of safety concepts, potentially leading to more effective safety education. The ease of use of AR technologies is another crucial factor influencing their acceptance. While most students found AR easy to use, the challenges faced by a minority of students underscore the importance of providing adequate training and technical support to ensure all students can effectively engage with AR technologies. The positive correlation between perceived usefulness and ease of use and students' intention to use AR underlines the importance of these factors in technology adoption. This finding aligns with the Technology Acceptance Model (TAM), reinforcing its validity in the context of AR in safety education. Based on the results and insights gathered from this study, the following recommendations are suggested training and Support: The study indicates that some students found AR difficult to use. Therefore, schools and educators should provide comprehensive training and ongoing support to students when implementing AR in safety education. This will not only improve the ease of use but also boost students' confidence in utilizing AR technologies. Hence for future research it is highly recommended that this study should be extended on the effectiveness of using AR on other classes and and different area and disciplines especially to improve quality of safety education.

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Paper Contribution to Related Field of Study

Emerging Technology in Safety Education Augmented Reality for Learning Environment.

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