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Virtual Industrial Visits Using Virtual Reality Glasses in Chemical Engineering

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Abstract

Field trips are an essential component of engineering education, providing students with hands-on experience and exposure to real-world applications of engineering concepts. However, traditional field trips can be costly, time-consuming, and logistically challenging to organize and execute. Moreover, the COVID-19 pandemic has made it difficult for students to experience industrial visits. Virtual Reality Glasses have emerged as a solution to this problem. Virtual industrial visits using virtual reality (VR) glasses are an emerging tool for enhancing chemical engineering education. These visits allow students to experience the inner workings of industrial plants and processes, providing a more engaging and interactive learning experience. This paper discusses the usage of VR glasses in virtual industrial visits for chemical engineering students. The findings demonstrated that virtual industrial visits have the potential to significantly enhance chemical engineering education, providing students with a more engaging, interactive, and cost-effective way to experience real-world chemical engineering concepts and applications. The benefits of this approach are examined, including increased engagement, reduced costs, and logistical challenges associated with traditional field trips. The challenges and limitations of VR glasses in virtual industrial visits are discussed, including concerns about safety and the need for effective design and implementation of the VR environment. Ultimately, virtual industrial visits using VR glasses have the potential to significantly enhance chemical engineering education, providing students with a more immersive and realistic learning experience.

Keywords: - Virtual reality, virtual industrial visit, chemical engineering

1. Introduction

Chemical engineering is a field that is constantly evolving, with new technologies and processes being developed and implemented all the time. As a result, it is essential for chemical engineering students to have hands-on experience and exposure to real-world chemical engineering applications. Field trips have long been a staple of chemical engineering education, providing students with the opportunity to see these applications in action and gain a deeper understanding of the field. However, traditional field trips can be costly, time-consuming, and logistically challenging to organize and execute. As a result, many chemical engineering programs are exploring alternative approaches to field trips, including the use of virtual reality (VR) technology to create and experience virtual industrial visits, without the associated costs and logistical challenges (Liagkou et al., 2019; Marks & Thomas, 2022; Swathi, 2022).

Virtual reality technology has been increasingly used

in various fields to enhance learning and training experiences (Hudson et al., 2019). In engineering education, virtual reality has shown promise as an effective tool for enhancing student learning and engagement, particularly in complex and hazardous environments such as chemical plants (Ma et al., 2011; Suarez & Alvarez, 2006). Several studies have explored the use of virtual reality in chemical engineering education. For example, (Gao et al., 2023) developed a virtual reality simulation of a distillation column to enhance students' understanding of distillation process design. The study found that the virtual reality simulation was effective in improving students' conceptual understanding and problem-solving abilities. Virtual industrial visits using VR glasses offer a way for chemical engineering students to experience industrial sites, such as chemical plants and refineries, without having to leave the classroom (Salah et al., 2019). Using VR glasses, students can explore a 3D environment that is designed to simulate the real-world experience of an industrial visit, complete with realistic sights, sounds, and interactive features (Hu-Au & Lee, 2017).

The benefits of virtual industrial visits using VR glasses are numerous. First and foremost, they are cost-effective. Traditional field trips often require significant funding to cover travel, lodging, and other expenses. With virtual industrial visits, the costs are significantly lower, as students can experience the simulation from their own classrooms or computer labs (Makransky & Mayer, 2022). Virtual industrial visits using VR glasses are also logistically simpler to organize (Ausburn & Ausburn, 2004). Traditional field trips require extensive planning and coordination, including arranging transportation, scheduling visits with industrial partners, and ensuring the safety and security of all participants (Zhao et al., 2020). With virtual industrial visits, these logistical challenges are significantly reduced, as the visits can be scheduled and executed entirely within a virtual environment. Another benefit of virtual industrial visits using VR glasses is their flexibility in time. Because virtual industrial visits can be executed entirely within a virtual environment, it can be accessed from anywhere, at any time. This makes them particularly valuable for online chemical engineering programs, as well as for students who may have limited mobility or other challenges that make traditional field trips difficult (Blümel & Haase, 2009).

However, virtual industrial visits using VR glasses are not without their challenges and limitations (González-Peña et al., 2021). One of the biggest challenges is ensuring that the simulations accurately reflect the real-world experience of an industrial visit. This requires careful attention to detail in the design and implementation of the virtual environment, as well as ongoing testing and refinement to ensure that the experience is as realistic and immersive as possible (Paszkiewicz et al., 2021). Another challenge is ensuring that virtual industrial visits using VR glasses provide a comparable learning experience to traditional field trips. This requires careful consideration of the learning objectives and outcomes of the visit, as well as the implementation of the virtual environment to ensure that it is aligned with these objectives.

In this manuscript, the potential of virtual industrial visits using VR glasses as a replacement or supplement to traditional field trips for chemical engineering students are discussed. The benefits of VR glasses for chemical engineering education, as well as the challenges and limitations that must be addressed to ensure the effectiveness of virtual industrial visits, were also analysed in this study. The best practices for designing and implementing virtual industrial visits using VR glasses were discussed, including considerations for learning objectives, user experience, and evaluation.

2. Methodology

The methodology for conducting virtual industrial visits using virtual reality glasses in chemical engineering involves several key steps, including selecting appropriate content, and delivering the virtual experience. The first step in the methodology is to select appropriate content for the VR industrial visit. This involved selecting a few specific chemical engineering sites or plants, such as petrochemicals or offshore. The content should be relevant to the learning objectives of the department and should provide students with a comprehensive understanding of the real-world applications of chemical engineering.

The target group was undergraduate chemical engineering students at a private university in Sarawak, Malaysia. The participants consisted of 20 students who were invited to participate in the questionnaire at the end of the VR industry workshop. These students were invited and asked for their willingness to participate in the VR industry visit workshop. In the 1-hour VR industry visit workshop, the participants were participated in the industry visit using VR glasses (VRG PRO+ from China). Each session was assigned to 5 participants for each 15 minutes VR experience with 5 helpers on the spot to assist. After the briefing, the participants were asked to wear VRG PRO+ virtual reality glasses to view the 360-degree Youtube VR video for 15 minutes by sitting on a chair. 15 minutes were selected to play 3 different petrochemical plant 360-degree Youtube VR videos. The time was limited to avoid vertigo or discomfort rise from the VR glasses experience. The participants were required to sit on a chair to complete their session. For hygiene practices, the VR glasses were cleaned using an alcohol pad before each usage. After participation in the workshop, the participants were asked to answer the questionnaire for the online Google form. It took approximately 20-30 mins to complete the workshop and questionnaire.

The questionnaire is using Google form as the tool and the participants can access it at any time if they can access the internet. The participants were requested to answer questions about the effectiveness of the industry visit

experience using virtual reality glasses and does this approach makes their industry visit experience better or worse. The first question in the questionnaire was seeking for the participants' consent to answer the questionnaire and the participants can select not to participate in the questionnaire. The questionnaire was asked to be completed once per participant after the VR industry visit workshop based on their willingness. 20 responses were collected. The questionnaire was used to collect feedback from participants on the effectiveness of the virtual experience and the instructional materials. The assessment should be used to improve the effectiveness of future virtual industrial visits.

2.1 Ethics Considerations

Ethical approval for this study was obtained from Ethics Office, Curtin University Malaysia and met the requirements described in the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The approval number is HRE2023-0065.

3. Result and Discussion

The results of the study indicated that the VR industry visit was effective in enhancing the learning outcomes of the participants. The study also found that the participants were most likely to try VR for industry visit before COVID-19 is reported 30% of the 20 respondents, during COVID-19 is reported 65% of the 20 respondents, and after COVID-19 is reported 50% of the 20 respondents as shown in Fig. 1. There is a slight reduction in the percentage post COVID-19, but the percentage to be most likely to participate in VR industry visit is reported to be higher than before COVID-19. During the pandemic, VR technology has become more important due to travel restrictions and social distancing measures, making it a safer and more convenient alternative to physical visits (Manca et al., 2013). So, it's highly likely that many people have tried or are willing to try virtual reality for industry visits during COVID-19. After the pandemic, while people may return to physical visits, virtual reality may still be a useful tool for many industries, especially for those that require travel, cost, or time constraints. Therefore, it's also likely that virtual reality technology will continue to be used for industry visits even after COVID-19.

From Fig. 2, 50% of 20 respondents agreed that VR industry visit ease their understanding towards the contents delivered during the visit. 60% of 20 respondents think that VR has increased their interest in the industry visit. Only 25% of 20 respondents have rated "virtual environment able to provide the same experience of industry visit as reality" to be agreed. VR industry visits can enhance understanding of the contents delivered during the visit, as they provide a more immersive and interactive experience than traditional methods, such as videos or brochures (Klačková et al., 2021). With VR technology, users can explore and interact with virtual environments, which can help them better comprehend complex processes or systems. VR technology allows users to experience things that might not be possible in real life, such as exploring hazardous environments or witnessing the workings of complex machinery. This can make the visit more memorable and enjoyable, which can lead to increased interest in the industry. However, while virtual reality can provide an immersive experience, it might not be able to replicate the exact same experience as a physical visit. There might be some aspects of the physical environment that cannot be replicated in the virtual world, such as smells or tactile sensations. Nevertheless, VR can still provide a valuable and realistic experience that can help users understand and appreciate the industry.

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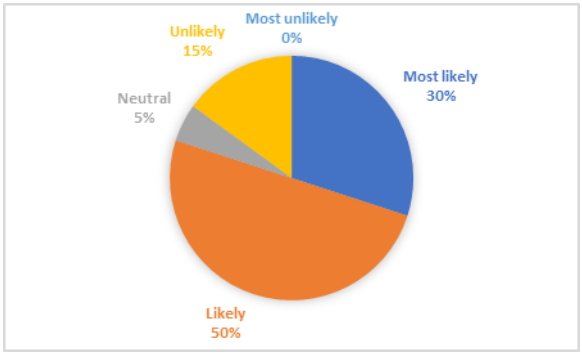
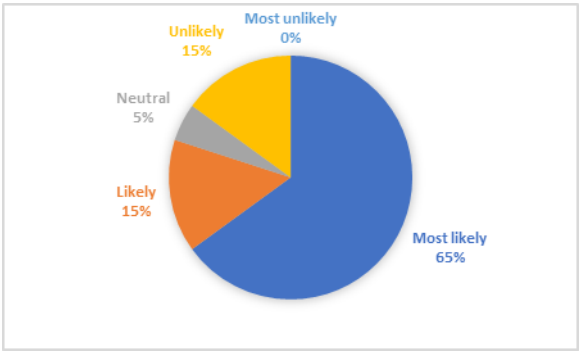
There are 4 major preferences to explore VR industry visit, gain first impression of the site (20%), time efficiency (18%), cheaper option and easy to plan (each score 17%) as shown in Fig. 3(a). and 3(b) shown the common elements that deter the respondents from selecting VR industry visit are impersonal/not tangibility (such as can't smell, ambience) (41%), followed by the lack of social interactions (33%), and technical difficulties (26%). Fig. 3(c) shows most of the respondents are looking for broadening knowledge (19%) and preliminary insights (19%) on place to visit through VR industry visit. 16% of the respondents think that VR industry visit can save money and a more relaxed approach to allow the participants to engage in the VR industry visit, which can provide additional flexibility, in terms of time.

How likely will you try virtual reality (VR) for industry visit before COVID-19?



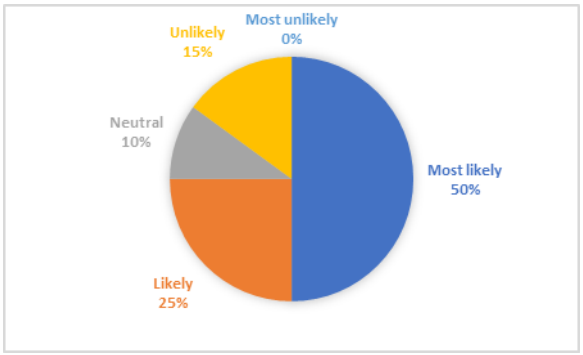
(a)

How likely will you try virtual reality (VR) for industry visit during COVID-19?



(b)

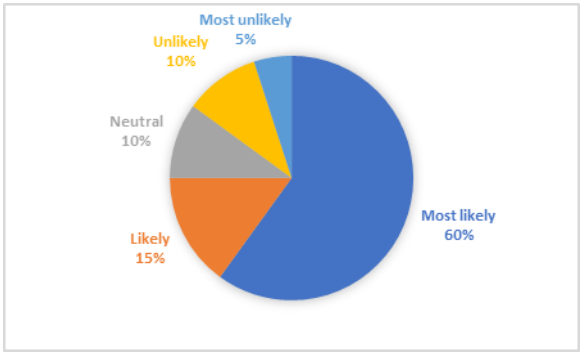
How likely will you try virtual reality (VR) for industry visit post COVID-19?



(c)

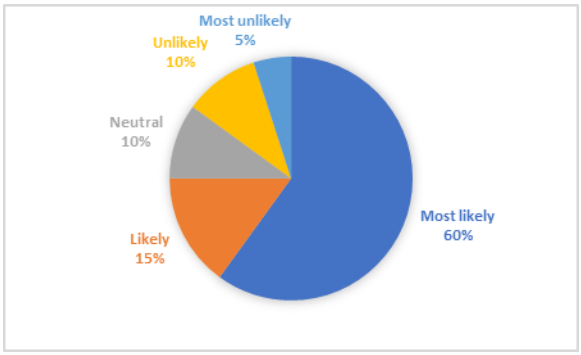
Fig. 1. Comparison on VR for industry visit: (a) before COVID-19, (b) during COVID-19, and (c) post COVID-19

Is virtual reality (VR) industry visit east your understanding towards the contents delivered during the visit?



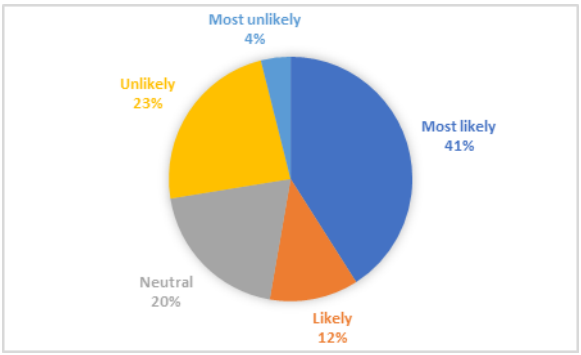
(a)

Will virtual reality (VR) increase your interest in the industry visit?



(b)

Is virtual environment able to provide the same experience of industry visit as reality?

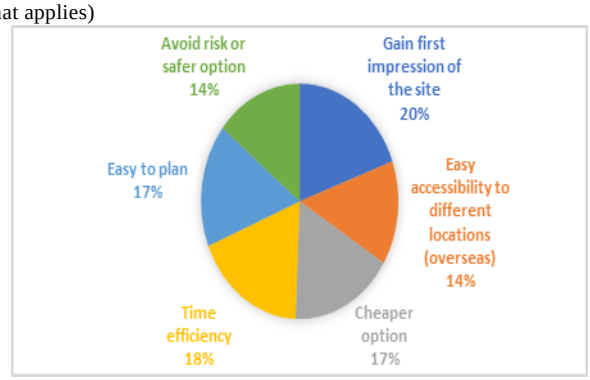


(c)

Fig. 2. VR for industry visit: (a) easier to understand the contents, (b) interest, and (c) same experience with site visit

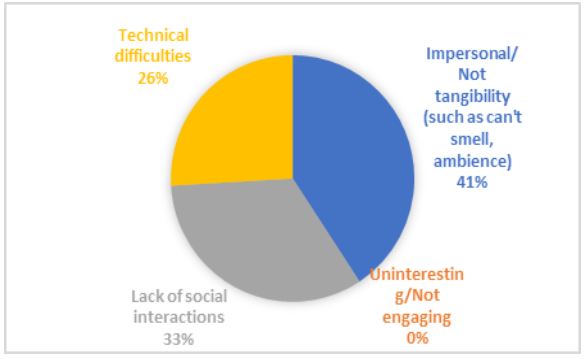
82.6% have agreed that they prefer both VR and face-to-face industry visit as shown in Fig. 4. VR industry visits and face-to-face industry visits both have their advantages and disadvantages. VR industry visits offer a more immersive and interactive experience compared to traditional face-to-face visits. With VR technology, participants can explore virtual environments, interact with virtual objects, and experience simulations that may not be possible in a physical location. VR industry visits can also be more accessible and cost-effective, as they eliminate the need for travel and accommodation expenses. Additionally, VR industry visits can be conducted at any time, regardless of the physical location of the participants. However, face-to-face industry visits also have their benefits. For example, face-to-face visits provide the opportunity to meet industry professionals in person, make personal connections, and build relationships. Additionally, face-to-face visits allow for more spontaneous interactions and conversations, which can lead to valuable insights and opportunities. Finally, face-to-face visits offer a more authentic experience, as participants can see the actual physical facilities and infrastructure of the industry (Zhao et al., 2020). The investigated group has observed an increase in cognitive level for the Reaction Engineering and Process Plant Engineering courses.

What do you like about virtual reality (VR) industry visit? (Select all that applies)



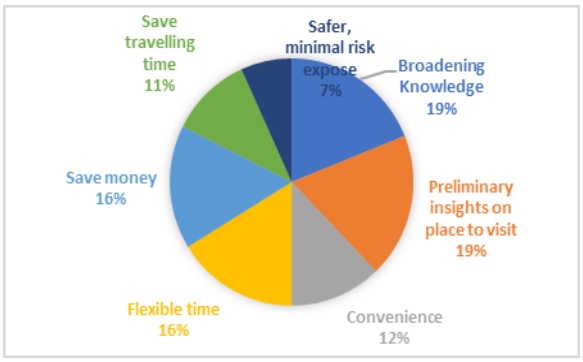
(a)

Which factor(s) deter you from selecting virtual reality (VR) industry visit? (Select all that applies)



(b)

What are you seeking for through virtual reality (VR) industry visit? (Select all that applies)



(c)

Fig. 1. VR for industry visit: (a) benefit(s), (b) deter factor(s), and (c) reason(s)

What are your preference in industry visit?

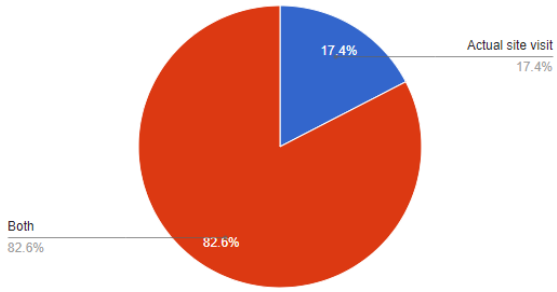


Fig. 4. Participants' preference in industry visit or site visit

4. Challenges and Limitations

While virtual industrial visits using VR glasses offer numerous benefits, there are also several challenges and limitations that must be considered (Damiani et al., 2018). One significant limitation is the technology itself. VR glasses are still a relatively new and emerging technology, and they may not be readily accessible to all students. One significant challenge is the limitations of the VR environment itself. While VR technology has come a long way in recent years, it still has some limitations in terms of visual quality and accuracy (Angelov et al., 2020). The virtual environment may not be able to accurately replicate certain aspects of the real-world industrial setting, such as temperature or pressure changes. This can impact the accuracy of the virtual experience and limit the degree to which students can engage with the virtual industrial visit. Furthermore, virtual industrial visits may not provide the same level of social interaction and networking opportunities as traditional field trips. Field trips provide students with the opportunity to meet and interact with professionals in the field, which can be valuable for networking and career development. Virtual industrial visits may not be able to replicate these opportunities. Another challenge is the potential for

motion sickness or disorientation. Some individuals may experience discomfort or even nausea when using VR glasses, which can limit the effectiveness of the virtual industrial visit. Additionally, the immersive nature of VR can also make it difficult for students to take notes or record observations, which can be important for later reflection and analysis. There is the potential for the virtual industrial visit to be seen as a replacement for traditional field trips, rather than a supplement. While virtual industrial visits offer several benefits, they cannot fully replace the hands-on experience and in-person interactions that come with a traditional field trip. It is important to strike a balance between the two approaches, and to use virtual industrial visits as a complement to traditional field trips rather than a replacement. Overall, while there are challenges and limitations to virtual industrial visits using VR glasses in chemical engineering education, the benefits of this approach are significant (Blümel & Haase, 2009). By leveraging the latest technology, educators can provide students with an engaging and interactive way to learn about the chemical manufacturing process, helping to prepare them for successful careers in this dynamic field (Fracaro et al., 2021).

5. Conclusion

In conclusion, virtual industrial visits using virtual reality glasses have the potential to revolutionize chemical engineering education. They offer a cost-effective, logistically simpler, and flexible way for students to experience real-world chemical engineering applications. The case study presented in this manuscript demonstrated that virtual industrial visits can provide students with an immersive, interactive experience that enhances their understanding of the chemical manufacturing process. However, there are still challenges to overcome, such as the need for high-quality VR equipment and the development of realistic and effective VR environments. Future research in this area should focus on addressing these challenges and further exploring the potential of virtual industrial visits in chemical engineering education. Overall, virtual industrial visits have a promising future in chemical engineering education and should be explored further. As VR technology continues to advance, virtual industrial visits will enable students to gain a deeper understanding of real-world applications of chemical engineering concepts and processes.

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