

APPLICATION OF IMMERSIVE TECHNOLOGIES TOWARDS SUSTAINABILITY IN HIGHER EDUCATION: A CASE STUDY

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ABSTRACT

This paper aims to examine and investigate the challenges that higher education face to play their role towards sustainability in their academic programme to ensure sustainable future-ready graduates, especially in Malaysia. The rise of immersive technologies promotes unique learning experiences through a combination of the digital and real world. This paper provides e with a first-hand experience of deploying immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) that provide students with the opportunity to expose real-world operations and interactive ways to learn and complete their assessments. Metaverse platform was used to develop the AR experience. At the same time, an e-learning platform was used to develop and deliver additional learning materials and provide guidelines on using AR for the students. Google Cardboard and VR Box were used to allow students to experience the virtual 360 tours. An online survey was conducted to access students' perspectives on the application of AR and VR in their learning experiences. The findings indicate that sustainability practices were enlightened with the use of AR and VR that enrich sustainable education in the business course.

KEYWORDS

Immersive Reality, Sustainability, Virtual Reality, Augmented Reality, E-Learning

1. INTRODUCTION

The rise of e-learning in higher education during the COVID-19 pandemic has impacted students learning performance, learning styles, and motivations. The rising use of e-learning as a platform to sustain students learning has shown the students' and instructors' ability and willingness to use e-learning and online tools. Growing numbers of students suffer from mental health (WHO, 2022), which leads to concern about learning performance and quality. This may be due to limited social interaction and exposure to the natural environment. Even though many universities are moving back to classroom teaching, there are increasing concerns about the values of the education outcomes to current and future needs. The OECD Learning Framework

2030 (OECD, 2018), smart education strategies (UNESCO, 2022), and strategy on lifelong learning opportunities for all (UNESCO, 2022) were introduced to improve education quality.

To close the gap between the traditional learning experience and real-world learning experience, this study also draws attention to the higher education institutions' challenges in promoting sustainable practices and development towards the Sustainable Development Goal (SDG) on quality education (United Nations, 2015). Therefore, since immersive reality technology is one of the emerging e-learning technologies that have the ability to create an artificial environment of a real-world setting, immersive reality could provide equal opportunities for students to experience global sustainable education experience. An Immersive Reality in Sustainability (IRiS) model was developed to represent the synthesised literature review on immersive technology and sustainability in the education context.

2. LITERATURE REVIEW

2.1 Immersive Technologies and E-learning

Long before the COVID-19 pandemic struck, immersive technologies and e-learning were developed and implemented in some industries and educational institutions. However, the level of implementation does not attract the world's attention compared to the current movements towards these technologies. The COVID-19 pandemic may be known as the dark days for society, the economy, and the environment. Instead of looking to see the end of the destruction, people around the world collaborate to seek initiatives for survival. In education, the pandemic lockdown leads to the rise of e-learning in educational institutions as an initiative to sustain education and immersive technologies as a platform to overcome travel restrictions.

Extended Reality (XR) is a broad term for immersive technologies such as Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) (Marr, 2019). Now, these immersive technologies have drawn a significant impression on the world on the technologies' ability to change the education and job landscapes (Low, 2022; Likens, 2019), thus, creating a competitive market environment for the production of hardware and software that support these immersive technologies. Technology companies such as Meta, PlayStation, Hewlett-Packard, Vive, and Qualcomm have developed devices to support XR. At the same time, a company such as NVIDIA introduces CloudXR as a platform to deliver XR (NVIDIA, n.d). Moreover, economic sectors such as healthcare, real estate, retail, entertainment, marketing, and education have used XR to improve business operations. In education, immersive technology has the potential to create a meaningful learning experience that will promote an active learning process (Fauconnier, 2001; Jacobs et al., 2022; Kuhail et al., 2022). This indicates the growing market in the coming years.

Unlike immersive technology, e-learning does not create an immersion environment. E-learning is an online learning platform that delivers digital learning resources. Even though both e-learning and immersive technology allow learners to learn beyond the classroom, e-learning materials can only be accessed through a device and cannot be overlaid in a real environment. However, e-learning has been adopted by many universities around the world. Yet, the real potential of e-learning does not take into consideration improvement education due to challenges such as insufficient funds, digital literacy, infrastructure, management support, content development and limited selections of hardware and software (Karim and Hashim,

2004; Rana et al. 2014; Gillett-Swan, 2017). The pandemic lockdown and movement restriction order have urged universities to move towards an online learning approach. Actions and decisions on designing traditional courses in an online environment have led to huge investments in e-learning infrastructure, hardware, software, and support. Even so, the drastic education transformation has discovered other e-learning challenges. Location, electricity supply, internet, and online platforms (Ismail et al., 2020; Mahyoob, 2020; Ismael, 2021; Liubchak et al., 2022; Krassadaki et al., 2022). These new challenges have brought concerns about students' performance, motivation, and health. In light of the growing use of immersive technologies in education, some e-learning challenges, such as location and students' learning, could be addressed through immersive reality.

2.2 Sustainability

Changes in climate, the rise of natural disasters, and the development of life-threatening diseases have triggered a wake-up call to the world. The need for fast solutions and actions to overcome these global issues was addressed, and countries worldwide connected and collaborated to address these concerns. Many global initiatives were introduced. Currently, the Sustainable Development Goals (SDG) is the leading agenda of the United Nations (United Nations, 2015). Countries around the world made tremendous efforts towards SDG.

Sustainable technology is also referred to as green technology, which aims towards social development and economic growth while protecting the environment (Santa et al. 2022). The application of sustainable technology in various businesses has been a growing trend (Saunila et al., 2019; Fernando et al., 2019; Wang, 2022). Indeed the benefits of sustainable technology on renewable energy, energy efficiency, long-term orientation, lean production, and performance improvements (Ferri et al. 2015; Yong et al. 2016; Neves et al. 2022;) have drawn many businesses to invest in green technology innovation. According to Issa and Isaias (2022), a sustainable design should include sustainable measures on the design, safety, manufacture and energy, recycling efficiency, and social impact. In other words, a technology is considered sustainable when it delivers value and provides security to the economy and safety to the people and environment.

Moving towards quality education, the fourth SDG aims to provide a quality education that promotes lifelong, global, and balanced learning opportunities (United Nations, 2015). Since e-learning is a technology, sustainable e-learning refers to e-learning that supports cost and energy efficiency, resources preservations, innovation, user and stakeholders satisfactions, education values, and learning opportunities (LittleJohn, 2003; Robertson, 2008; Issa and Isaias, 2013; Sofiadin, 2020).

2.3 Immersive Reality Contribution Towards Sustainability

The rise of immersive technologies has grown rapidly. Entrepreneurs, business leaders, governments, academicians, and researchers have drawn their attention to unlocking the potential of immersive technologies in various contexts. Recent studies (Bunghin et al., 2018; Luksha and Peskov, 2019; Uskali et al., 2020; Herren, 2022) indicate the potential of AR, VR, mixed reality, and extended reality to make a better future. In business development, Bayerische Motoren Werke (BMW), one of the well-known luxury vehicle manufacturers, have used immersive technologies in their business operations as part of their initiatives towards

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sustainability. Decker (2020) stated that virtual reality, along with big data and Artificial Intelligence (AI), assist the company in achieving a low carbon value chain and efficient lean production. Later in 2021, BMW Brilliance indicated that the company had started implementing a VR training platform for future needs and Mixed Reality (MR) training as a strategy for the BMW iX launch (BMW, 2021). The BMW Sustainability Report 2021 also indicates that e-learning was used to deliver BMW Joylearning to promote lifelong learning (BMW, 2021).

Moreover, many companies and educational institutions have developed and implemented training through an immersive virtual reality (Feng et al., 2022; Sedlak et al., 2022; Pears and Konstantinids, 2021; Ljungholm, 2022) such as cognitive training, individual and collaborative learning, and surgery education. Indeed, the world has seen the potential of immersive technologies to facilitate memorable learning through rich learning experiences. Nevertheless, Bonini (2020) indicates that academicians should be more open and connected to the world to actively participate in building a sustainable future.



Figure 1. Immersive Reality in Sustainability (IRiS) model – prepared by the author

The Immersive Reality in Sustainability (IRiS) model was developed based on the relationship between immersive technologies and sustainability (see Figure 1). Indeed immersive technologies, including the metaverse, could potentially improve the economy. Still, the balance between the sustainability dimensions requires a definition in designing metaverse (Jauhiainen et al., 2023). The application of immersive technologies to create an immersive learning environment has various benefits for students. The immersive reality has the potential to create an active learning process that will enhance students' motivation and engagement to learn, which leads to the promotion of lifelong learning. The freedom to learn and experience a meaningful learning process can be delivered through this approach. Furthermore, the world aims at providing an equity learning opportunity that can be offered through Extended Reality (XR). XR could provide the opportunity for students to gain global exposure to real-world situations without the concerns of location distance, cost of travel, travel restrictions, and limited

sponsorship for studying abroad. To justify the research questions, students were asked to share their perspectives on using VR and AR technology in their learning to discover real-world practices and initiatives in business towards sustainability. Also, findings from the survey will confirm the IRiS model.

3. RESEARCH METHODS

The objectives of this study are to identify 1) the degree of sustainable education students achieve by learning using immersive technologies such as AR and VR and 2) students' perspectives on immersive learning materials in AR and VR. To access the IRiS model, this study conducted six sessions on real-world business practices using immersive technologies. Discussion groups using Nearpod were undertaken to gain students' perspectives on the concept of sustainability in future business practices. Later, the students experienced virtual tours using Virtual Reality (VR) box that enhanced their global exposure to real-life business operations around the world. Upon summative assessment, an Augmented Reality-based platform was designed with learning activities and formative assessments. The Augmented Reality (AR) activity was completed within 45 minutes. Finally, students filled out an online survey during the next class to share their perspectives on using AR and VR in their learning.

3.1 Participants

A total of 77, 66% male students and 34% female students of Information Technology (IT) students enrolled in the Business Fundamentals course have participated in an online survey. Participants were required to complete the consent form before they were allowed to try to use the immersive technologies. Safety and potential side effects were explained to the participants, and they were allowed to withdraw their participation at any time.

3.2 Immersive learning concept and Assessment Tasks

"MyVirtue" is a mobile app that promotes a balanced student life (Sofiadin, 2022). An AR platform was integrated into "MyVirtue" to complete the education pillars. The storyline was designed by the author of this study with objectives to help students to recap what they have learned in preparation for their quiz (see Figure 2). Some of the main elements in the IRiS model (see Figure 1) were integrated into the AR storyline and concepts. Students were required to approach the virtual object located in their classroom using a marker-based AR (see Figure 3). Once they approach the virtual object, they will interact with it by reading the dialogue and answering questions on business management. Learning materials such as notes and question banks from the e-learning platform were reused in designing the AR storyline.

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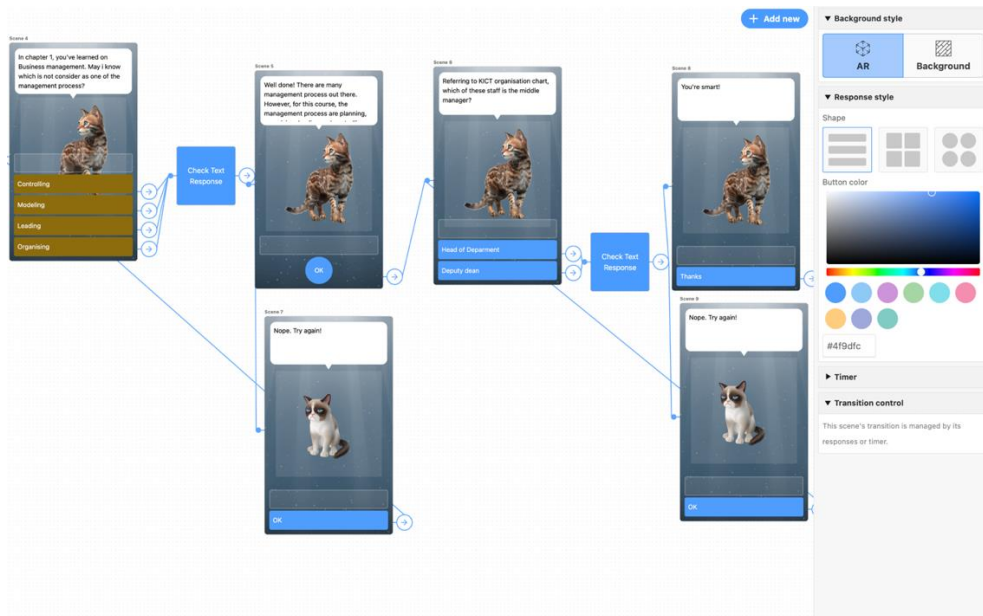


Figure 2. A screenshot of some part of the storyline using the Metaverse platform designed by the author

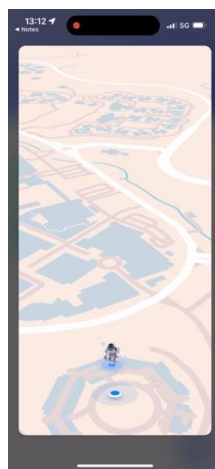


Figure 3. A screenshot of tracking the virtual object

The participants received a 480 minutes lesson on three chapters of the Business Fundamentals course. Real-world examples of using immersive technologies to improve business performance were given, and students were asked to discuss how sustainability can be put into business practice. Later, an example was shared with the students on how one big automotive company uses immersive technologies to achieve sustainability in different kinds of business activities. To enrich students' learning experience and provide a broader learning

environment, a VR box was distributed to the students to experience the virtual tour of international business operations. Students were allowed to use the VR box within five to 15 minutes to avoid motion sickness. Prior to their course quiz, the students received instructions to access an AR-based platform. The storyline for the AR-based platform was designed by the author of this paper to assist their revision as quiz preparation. A handbook was given to guide their learning activities using the AR-based platform. The activity was completed within 45 minutes. Finally, students filled out an online survey during the next class.

Course assessments and reading materials were uploaded to the official e-learning platform. A flow of the three chapters of the Business Fundamentals course was designed in a four weeks timeline. Real-world examples of using immersive technologies to improve business performance were given, and students were asked to discuss how the concept of sustainability can be put into business practice. Later, an example was shared with the students on how one big automotive company uses immersive technologies to achieve sustainability in different kinds of business activities. To enrich students' learning experience and provide a broader learning environment, a VR box was distributed to them to experience the virtual tour of international business operations. Prior to their course quiz, the students received instructions to access an AR-based platform. The storyline for the AR-based platform was designed by the author of this paper to assist their revision as quiz preparation. A handbook was given to guide their learning activities using the AR-based platform. The activity was completed within 45 minutes. Finally, students filled out an online survey during the next class.

4. DATA ANALYSIS AND RESULTS

Since this study conducted a descriptive statistics analysis, measures of frequency, central tendency, and dispersion were performed, as Mishra et al. (2019) suggested. The online survey used Likert 5-point scale. The rule of thumb by George and Mallery (2003) for data reliability indicates that data collection is considered good and reliable when Cronbach's value is between 0.8 and 0.9 (George & Mallery, 2003; Morgan, 2011). Based on the descriptive analysis of students' perspectives on immersive learning materials, Cronbach's value is 0.859, which indicates the data collection was reliable and good. The reliability analysis on students' agreeableness in an immersive learning environment is reliable, with Cronbach's value of 0.829 (see Table 1). The Immersive Learning environment scores more consistently than the immersive learning materials. Standard Deviation also represents the data normality since it is less than half the mean (Mishra et al. 2019).

Table 1. Measures of central tendency and dispersion

Category	Cronbach's Alpha value	Standard Deviation	Mean	Median
Immersive Learning Materials	0.859	0.48182	4.4861	4.4286
Immersive Learning Environments	0.829	0.41851	4.4104	4.4000

Figure 2 shows students' agreeableness towards learning materials used in AR and VR. The figure indicates that most students agreed that immersive learning materials enriched their learning experience and supported sustainability. The mode of the immersive learning materials is five, and the median value is between 4.00 and 5.00. Yet, 9% of students disagreed with the ability of the learning materials to reduce waste and access to restricted locations.

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Table 2. Measures of frequency on immersive learning materials

Statements	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Immersive materials can be reusable.	0	0	17	27	33
Immersive materials deliver better understanding.	0	0	0	9	68
The production of immersive materials creates minimum waste.	0	3	14	26	34
Immersive materials present diversity that helped me in developing new ideas.	0	0	0	9	68
Interactive and light text-based immersive materials create a memorable learning experience.	0	0	1	32	44
Immersive materials provide access to restricted locations due to travel and safety concerns.	0	3	15	26	33
Immersive materials provide exposure to real-life practices.	0	1	2	29	45

Using different immersive technologies (Augmented Reality and Virtual Reality) in students learning experiences results in a high level of acceptance of the positive impact of the immersive learning environment (see Table 3). The mode and median values are five, except for three items that generate a median of 4. These items are on immersive learning environment potential in fostering connectivism, lifelong learning, and good well-being.

Table 3. Measures of frequency on immersive learning environment

Statements	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
An immersive learning environment improves my understanding of sustainable innovations through a real-world example.	0	0	9	28	40
An immersive learning environment allows me to connect with others to improve my understanding and ability to solve a problem.	0	0	14	27	36
An immersive learning environment has opened my eyes to the importance of sustainability.	0	0	5	27	45
An immersive learning environment encourages me to keep learning due to the worldwide learning environment.	0	0	7	32	38
An immersive learning environment enhances my self-efficacy and self-actualisation.	0	0	0	30	47
An immersive learning environment provides me with a clear understanding of the application of my course in real-world practice.	0	1	10	26	40

An immersive learning environment delivers better educational experiences and values.	0	0	2	28	47
The immersive global exposure helps me to understand and learn about diverse cultures in different countries.	0	0	1	22	54
An immersive learning environment improves my well-being	0	3	27	26	21
An immersive learning environment provides the opportunity to gain global exposure without the concerns of high travel costs and safety.	0	0	8	30	39

5. DISCUSSION

The findings proved that an immersive learning experience creates the most memorable real-worldwide learning experience. The survey indicated that both immersive technologies, AR and VR, create a learning environment that enhances learning engagement, quality, motivation, and awareness of real-life practices while addressing sustainability measures on health, environment, cost-efficiency, community, consumption, and innovation. These technologies increase education opportunities to provide equal access to global experience while reducing travel costs and creating safer and more interactive learning environment learning beyond classroom walls. This indicates that the immersive learning experience supports the United Nations (2015) SDG on quality education. Thus, this finding addressed the research objectives of identifying the degree of sustainable education that students achieve by learning using immersive technologies such as AR and VR.

The data analysis also indicates that immersive learning materials promote sustainable design regarding reusability, learning design, safety, and social value. This answered the research question of identifying students' perspectives on immersive learning materials in AR and VR. Still, the leading VR concern is the motion-sickness. 2.5% of students felt motion sickness in a short period. This side effect may reduce with more frequent use of VR devices along with improvements on upcoming VR devices (Greenwald, 2022; MetaQuest, 2022).

Students' perspectives on the immersive learning materials and environment showed promising results on using AR and VR as a platform to create an immersive real-world and worldwide learning experience. The findings confirmed the elements of the IRiS model as well as by recent literature review (Decker, 2020; Ali, 2022; Jauhiainen et al., 2023). Thus, this study significantly contributes to the theory and practice between immersive technologies and sustainability.

6. CONCLUSION

The world's urgent call for sustainable actions requires support and commitment from everyone, regardless of age, background, location, and culture. Thus, it is crucial to expose the current generations to real-world sustainable issues, solutions, development, and practice to ensure they

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can participate in climate change combat. Furthermore, the student's experiences in virtual real-world situations could prepare them to become future-ready graduates.

Immersive technology is rapidly growing its potential in the world. The learning engagement and motivation created through the immersive environment will enhance the quality of students' and future graduates' competencies and promotes lifelong learning more interactively. In addition, this study could create a sustainable education that delivers a rich and memorable learning experience. Due to the limited existing study on the application of immersive reality and technologies towards sustainable education, this study will significantly contribute to both practical and theoretical aspects of sustainability and education and the establishment of a new IRiS model.

The development of an immersive education platform will be the next focus of this study. The student sample will be increased to assess the effectiveness of immersive technologies towards sustainable education.

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