Using Immersive Technologies to Enhance the Student Learning Experience

Abstract

Purpose – The aim of this paper is to evaluate undergraduate student perceptions about the application of immersive technologies for enhancing the student learning experience. The study assesses the viewpoints of students from varying multidisciplinary backgrounds about whether immersive technologies can enhance their learning experience and increase their level of engagement in the context of higher educational delivery.

Design/methodology/approach – The research utilised a case study methodology adopting a questionnaire-based research mixed methods approach. In total, 83 participants completed the questionnaire. The purpose of the research was to evaluate and interpret students' perspectives at higher educational level about the use of immersive technologies towards enhancing their learning experience. There was also a focus on remote educational delivery due to the legacy of Covid-19.

Findings – The findings suggest that there is still more empirical work to be undertaken regarding the application of immersive technologies in higher education. The study revealed that there are immersive benefits though preference for face-to-face teaching remains popular. The negative connotations associated with immersive technology use in higher education, (e.g., VR), such as cost of equipment and motion sickness substantiates the themes identified in the academic literature.

Originality/value – The study explores a diversity of immersive technologies and their application in HE contexts. Findings indicate that whilst there are acknowledged pedagogical benefits of immersive technology use in HE prevalent barriers remain that require further empirical research if immersive technology use is to be universally utilised in the HE sector.

Keywords Higher education, immersive technologies, virtual reality, augmented reality, immersion, engagement.

Paper type Research paper

Introduction

The phrase immersive technologies is a term that is conceptually diverse residing in the fact that its subjectivism rests in how the theory of immersion is perceived and defined. Generally, the core principles or outcomes through using immersive technologies is for the user to experience a sense of illusion being almost transported to another place or immersed in a different world or environment (Baxter and Hainey, 2020). When considering the term immersive technologies, it is often predominantly associated with technology such as augmented reality (AR) and virtual reality (VR). However, the notion of immersive technologies now transcends beyond AR and VR with the concepts of extended reality (XR) and mixed reality (MR). Immersive technologies such as AR, VR and MR can support learning paradigms such as experiential learning in educational settings and permeate into mobile learning environments (Cook and Gregory, 2018). The changing landscape of educational delivery, facilitated by the onset of Covid-19, has meant that educationalists have had to reconceptualise how course content is delivered online as academic institutions embrace remote online delivery.

Defining engagement in the context of online learning is problematic with many perspectives having been proposed though despite this, it is predominantly the students who decide how they engage online (Tualaulelei et al., 2021). Designing course curriculum for remote educational delivery has presented pedagogical dilemmas for educators during the Covid-19 era (Hughes, Henry, and Kushnick, 2020). Considerations associated with mode of online delivery, whether asynchronous or synchronous, incorporation of virtual learning platforms and associated technology to enhance the learning experience as well as relating course content to learning outcomes present problematic scenarios for educators. Despite these potential issues, it has been implied that the use of technology can have a positive impact on student engagement (Dumford and Miller, 2018). Combined with the adoption of technology, the role of the teacher and the educational practices they implement to foster student engagement online has an impact on both student motivation and engagement (Chiu, 2021).

The application of immersive technologies, dependent upon the manner of educational provision and pedagogical approach adopted, can through their affiliation with the concept of immersion, assist towards enhancing student engagement in the context of remote educational delivery. This paper aims to assess the pedagogical role immersive technologies can provide towards enhancing student engagement in the context of remote educational delivery. Furthermore, whilst it is acknowledged that extensive research has been undertaken in the academic literature in relation to immersive technology use in HE (Liu et al., 2022, Radianti et al., 2020), the additional aims of this research are as follows. The research provides an exploratory study to substantiate or refute whether undergraduate student perspectives and knowledge about utilising immersive technology use in HE correlate to prior themes already identified in the academic literature. The study also reflects significantly upon the challenges of using immersive technologies within HE with the issues identified in this study perceived as a continued stumbling block towards its utilisation in the classroom. Future directions are also proposed regarding how to advance the area of immersive technologies in the context of the fluctuating pedagogical landscape that has materialised since Covid-19.

The paper is divided into the following sections. The first section of the paper provides an overview of the salient theoretical constructs associated with immersive technologies thereby identifying the theoretical underpinnings they accommodate. Following this, an attempt is made to clarify the terms of VR, AR, MR and XR. In doing so, educators new to this area can gain an understanding of the terminology. Some of the salient pedagogical theories associated with immersive technologies are then reviewed to identify their benefits from a teaching and learning perspective. Challenges associated with utilising immersive technologies are identified followed by the primary study, presentation of results, discussion, limitations, and future directions.

Immersion, Flow and Presence

Immersion is a term that is difficult to define as it is often used interchangeably with the phrase's presence and engagement (Nilsson, Nordahl and Serafin, 2016). It is a multifaceted concept sometimes conceptualised from a technological perspective often being associated with immersive technologies such as VR and digital games (Feng et al., 2018). When perceived from a technical perspective, immersion can be associated with physical immersion via the process of *"... immersing sensory organs into physical devices like head mount displays and headphones"* (Mennecke et al., 2011, p. 420). Definitions of immersion are often associated with connotations of being in a submerged state of mind with the sense of being focused on an alternate world, reality, or environment with the individual often unaware that they are engaged in such domains (Adams, 2014). This relates to the psychological sphere of immersion (Mennecke et al., 2011). The concept has additional connotations with the word experience where in the context of gaming, immersion relates to gameplay experience (Cheng and Cairns, 2005). When an individual is truly immersed in an activity, for example, using an immersive technology, it can provide them with a sense of escapism through undertaking a new persona or identity (Hudson et al., 2019). A salient theoretical underpinning of the concept of immersion is the notion of "flow" which has been conceptualised as an *"extreme version of immersion"* (Hudson et al., 2019, p. 461) where individuals lose sight of their self-awareness and consciousness undertaking a task that they enjoy. Flow theory equates to a sense of challenge that involves deep concentration and cognitive awareness when absorbing information when engaged and focused towards completing a certain task. It is often perceived as being a subjective experience where the immersive experience can sometimes be emergent (Csikszentmihalyi, 1985) when attempting to attain both proximal and distal goals.

The concept of presence is also inextricably connected with the theory of immersion in the context of immersive technologies. Presence, in the domain of immersive technologies such as VR equates to the illusion of being there or present within a virtual environment or space (Slater, 2018). Presence is initiated when an individual or individuals overlook the use or role of technology in their virtual experience (Lombard et al., 2017). It is subjective, more perceptual, as opposed to a cognitive illusion (Slater, 2018) which in the context of presence theory can relate to the idea of transportation in which three different types can be categorised. According to Lombard and Ditton (1997) these are the perceptions that (1) "You are there" meaning that the user is transported to another place; (2) "It is here" where a different environment and its associated assets are transported to the user and (3) "We are together" in which two or more individuals are transported together to an environment that they share. Often associated with the sensation of being there, transcended into a virtual environment, is the concept of spatial presence. Willans (2012, p. 899), conceptualises spatial presence as a perceptual emotion utilising a definition provided by Schubert (2009). Spatial presence is stated as: "*A perceptual emotion consciously experienced as the feeling of being there in virtual environments, mediated real (remote) environments, or real environments is referred to as spatial presence"*. Within the context of presence theory also resides the notion of social presence where it has been argued that the notions of intimacy and immediacy are central to this strand of presence (Short et al., 1976). Closely related towards one another, *"... intimacy refers to the feeling of connectedness that communicators feel during an interaction, while immediacy is the psychological distance between the communicators"* (Oh et al., 2018, p. 2). Social presence theory is often used to relate to how individuals socially and collaboratively interact in online learning environments (Lowenthal, 2010, 125) and that it can be applied towards the notion of online community building (Leong, 2011).

Closely associated with the concepts of immersion and flow is the notion of self-determination theory (SDT) as proposed by Ryan and Deci (1985). SDT is a theory that posits that for individuals to progress and develop as human beings they require support in three main domains, namely: autonomy, competence, and relatedness (Chiu, 2021). Autonomy relates to an individual having complete control over one's actions in the context of activities that are of interest, benefit, and enjoyment to that person. Competence is associated with the notion of mastery, growth, and personal development. The requirement for competence is best realised within *"...well-structured environments that afford optimal challenges, positive feedback, and opportunities for growth"* (Ryan and Deci, 2020, p. 1). Relatedness corresponds to belonging to something or someone as if part of a community. For an individual to be truly engaged and immersed in an activity, they must be sufficiently motivated to initially commence that endeavour. Though the concept of motivation is a multi-faceted concept it is often connected with two key strands of motivation, namely, intrinsic, and extrinsic. For example, in educational contexts, intrinsic motivation relates to students performing a task or learning activity for its own sake due to the enjoyment, self-interest and sense of fulfilment of the learning process (Diseth, Mathisen and Samdal, 2020). By way of contrast, extrinsic motivation relates to a student who might be driven towards completing a task due to the incentive of receiving reward such as a good grade or recognition of some kind or acceptance from other students (Covington, 2000).

Immersive Technologies

Dependent upon perspective and application, the concept of immersive technologies is a divergent phrase to define due to the varied constructs it is associated with and research fields where it is applied. Tham et al. (2018, p. 1) provide a broad yet useful definition that identifies immersive technologies as being associated with *"... the vast domain of wearables and related embodied technologies that are not just about physical objects that extend human capacity but also software applications that create augmented simulations for more seamless, thus immersive, experiences in human-technology interactions"*. Other perceptions of immersive technologies state that their intended effect on users is to allow them to transcend the boundaries between physical and real worlds simultaneously allowing them to experience a feeling of immersion (Lee, Chung and Lee, 2012). It can be argued that the notion of immersive technologies is an umbrella term that encompasses the software and hardware associated with technologies such as VR and AR. Despite there being a lack of consensus about what immersive technologies are (Suh and Prophet, 2018), certain types of these technologies can be utilised in tandem with one another such as immersive virtual reality serious games (Feng et al., 2018) and augmented reality and games (Molnar and Szuts, 2019). The primary aim in doing so, it can be surmised, is to maximise the immersive experience and enjoyment for users via a subsequent increase in motivation and engagement when undertaking a particular activity.

Virtual, Augmented, Mixed and Extended Reality

According to Kardong-Edgren et al., (2019, p. 29), due to the diverse categorisation of definitions surrounding virtual reality (VR) more specific and accurate classifications of the concept are needed as *"... the application of the term engenders confusion".* An overall unified definition of virtual reality is difficult to pinpoint because it is often open to interpretation due to the way in which it is perceived. It can be argued that similar dilemmas exist in terms of lack of consensus when attempting to define augmented reality (AR), mixed reality (MR) and extended reality (XR). One commonality between the different types of virtual reality is the notion of 'virtuality' which relates to the notion of virtual representation often of an environment or world of some kind (Farshid et al., 2018). Furthermore, Farshid et al., (2018, p. 659), use the term "virtual reality continuum" that indicates connotations with the diverging types of realities of which virtual reality (VR) is one dimension of this virtual representation.

Like VR, there is no definitive consensus regarding the definition of AR (Carreon et al., 2020). The key differentiation between the two terms resides in the words 'virtual' and 'augmented'. AR enhances an individual's perception or visualisation of reality whereas VR replaces a realistic depiction of something in the real world (e.g., an environment) with a computer-generated one. AR is designed to modify the view of reality, hence sometimes also referred to as computer-mediated reality (Rijcken, 2019). AR and VR can also be distinguished between the hardware they use to provide a user with an immersive engaging experience. According to Berryman (2012), for AR to be utilised, the user must be able to distinguish reality and the digital information transmitted to the display, there must be a device of some kind that points to the information (e.g., a smartphone), the use of a tracking device to align the digital information with what the user is seeing with the computer software being able to display this to the user. To be experienced and be fully immersed, VR requires the use of Head-Mounted Displays (HMDs) and optics such as the HTC Vive and Sony PlayStation VR that can provide a *"... high-definition resolution, a wide field-of-view, and a high refresh rate"* (Caserman et al., 2019, p. 155). The HMDs can either be wireless or tethered (Volkow and Howland, 2018). Furthermore, VR also utilises handheld motion controllers such as the Oculus Touch, Vive and PlayStation Move. Users of VR can also experience a greater sense of immersion using haptic gloves, often classified as traditional gloves, thimbles, and exoskeletons (Perret and Vander Poorten, 2018).

In addition to the concepts of VR and AR, the terms mixed reality (MR) and extended reality (XR) have evolved. MR can be defined as: *"... the computer-supported augmentation of a real environment with virtual elements"* (Reis et al., 2021, p. 1). First coined by Paul Milgram (1994), MR allows users to interact with virtual objects in a mixed reality environment where an individual engages with them as if they were real objects (Moro, 2020). In contrast to VR, MR relates to the inclusion of real and virtual content, specifically the incorporation of virtual objects to enhance the user's immersive experience in their physical environment. VR on the other hand, does not depict anything associated with the real-world to the user but projects entirely computer-generated context (Rauh, 2021). The term MR often relates to the continuum of experiences inclusive of both AR and VR (Volkow and Howland, 2018). Augmented Reality (AR) and Augmented Virtuality (AV) are considered to constitute MR (Rauh, 2021).

XR is often perceived as being an umbrella term that encompasses AR, MR, and VR technologies (Fujiuchi and Riggie, 2019). XR refers to *"... all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables"* (Fast-Berglund, Gong and Li, 2018, p.32). The term combines all three of the alternative realities (i.e., AR, VR, MR) and according to Palmas and Klinker (2020, p. 322) the term can be perceived as being a *"... variable for all future technologies that will be implemented under this umbrella term".*

Remote Learning , Engagement, and Immersive Technologies

Since the advent of Covid-19 the delivery of education online via synchronous and asynchronous channels has substantially increased (Baxter and Hainey, 2023). In the context of higher education, universities are now delivering their courses utilising blended or remote learning educational delivery models. The running of classes online in real-time refers to synchronous delivery whereas asynchronous delivery relates to online learning without the inclusion of any real-time element of teaching. The pedagogical benefits of synchronous and asynchronous online education have been articulated in detail in the academic literature. Synchronous online learning, when conducted via blended or remote delivery, can facilitate instant communication among students in real-time in addition to establishing an online community or community of practice (CoP), (Lin and Gao, 2020). The notion of establishing an online CoP relates to the aspect of relatedness in feeling part of something, such as a community (Ryan and Deci, 2020). In conjunction with the increased use of social media within higher education (Dragseth, 2020), immersive technologies can be used to supplement the student learning experience as well as facilitate and support community building. For example, virtual reality environments, via the concept of presence and utilisation of avatars, social interaction among participants can be promoted thereby increasing student motivation and engagement (O'Connor, 2018). Co-creation of VR environments, using web-based authoring tools such as InstaVR, WondaVR and Google CoSpaces Edu can support the pedagogy of social constructivism facilitating situated learning in the context of knowledge sharing and development (Wang and Sun, 2021).

Like VR technologies, AR systems can accommodate various pedagogical approaches that are applicable in the domain of online learning whether synchronous or asynchronous that include constructivist, situated and enquiry-based learning (Bower et al., 2014). Garzón et al., (2020) undertook a quantitative meta-analysis of 46 empirical studies associated with AR use in education investigating how pedagogical approaches affect the impact of AR on education. The empirical findings indicated that collaborative learning (CL) was the primary pedagogical approach that was accentuated via AR interventions. Furthermore, it has been argued that AR based learning can enhance a learner's achievements and motivation via factors such as sensory immersion, navigation, and information manipulation (Hincapie et al., 2021).

Though immersive technologies appear to be able to accommodate a divergent range of pedagogies, it is also their immersive qualities that have the potential to enhance and support student engagement in the context of blended and remote delivery. The technology and use of hardware via the use of equipment such as HMDs can enhance the user experience through immersive visualisation systems, through the concepts of spatial presence and flow that can result in immersive experiences for an individual improving their overall performance and enjoyment (Brondi et al., 2016) of a specific task. Furthermore, immersive technologies have the potential to aid student motivation and engagement in terms of the realism of how information is presented and interacted thereby reducing a student's cognitive load (Osypova et al., 2021). In addition, whereas VR fosters the imagination and illusion of virtual worlds, the potential of AR's ubiquity allows for the augmentation and contextualisation a student's vision within information sound, video, and graphics (Osypova et al., 2021).

Much has already been documented in the academic literature about the use of immersive technologies for teaching and learning purposes (Hagge, 2021; Theodoropoulos and Lepouras, 2021; Chen and Hsu, 2020; Barr, 2018). Immersive technologies such as AR and can support the flexible nature of blended or hybrid delivery courses due to having a strong adherence to the perceptions of portability, adaptability and assimilation into the learning process and student experience.

Challenges associated in using immersive technologies

The evolving potential and diversification of use of immersive technologies have been firmly documented in the academic literature. However, it can be argued that there is a relative unevenness in terms of empirical studies investigating the challenges associated in using immersive technologies, such as VR, in industry or educational settings. The application of immersive technologies is at times perceived to be the pedagogical holy grail when associated with the domain of teaching, learning and at times, training purposes. Whilst the immersive qualities of VR and AR appear to be beyond dispute, it is important for educators not yet accustomed with such technologies to be informed about potential challenges in their use, their applicability towards specific course content and when best to integrate their use into hybrid course delivery.

Some empirical studies have focused on applying the technology acceptance model (TAM) and the theory of planned behaviour (TPB) in the context of immersive technologies regarding the perceptions of its use and its intention for use (Fussell and Truong, 2021). The study by Fussell and Truong (2021) investigated the students' intentions to use VR technology for training where the aspects of user experience and enjoyment were salient factors in the adoption among students. However, one of the findings and recommendations of the study stated that students might not use VR in a dynamic learning environment if they do not understand how it works and how its use is likely to benefit their learning. A study undertaken by Koutromanos and Mikropoulos (2021), proposed MARAM, a mobile augmented reality acceptance model that classifies factors impacting teachers' intention to use AR applications for educational purposes. The study identified variables relating to attitude, perceived usefulness, and perceived enjoyment. However, the variable of facilitating conditions received a low score. In the context of the study, it was recommended that to score more highly with this variable, that necessary support should be provided for schools and teachers to create the required infrastructure and resources to use mobile AR and that teachers should be allocated more time to prepare for their lessons using AR. Another salient finding of the study was that there was a correlation between mobile self-efficacy and perceived ease of use. This suggested that teachers who are more accustomed to using mobile devices may integrate AR applications more in their teaching in comparisons to staff who are unfamiliar with the technology.

A study by Alalwan et al. (2020) interviewed 29 primary school teachers to explore their views regarding the benefits and challenges of using AR and VR technologies to teach science subjects. One interesting finding was that according to some schoolteachers, AR was simpler to use as opposed to VR in relation to hardware and software requirements. AR was also perceived to be a more convenient as a teaching and learning approach due to its affiliation with mobile phone use. Challenges faced by schoolteachers in using AR and VR in the study were factors relating to lack of guidelines, health impairment, lack of practice, limited instructional design, lack of time and competency.

Calvet et al., (2019, p. 4) state in their research that despite the acknowledged benefits of immersive technologies in higher education they have failed to attain *"widespread adoption"* due to their perceived limitations relating to usability factors, display quality and lack of realism and recognition inaccuracies. According to Yildirim (2020, p. 231) VR technology, from a consumer driven perspective has not yet reached alleged critical mass primarily due to a human factor issue that could *"... potentially constipate the adoption and proliferation process of VR technology..."*, namely, cybersickness. Furthermore, Yildirim (2020) also states that the financial factor of cost and the requirement of additional VR-ready equipment and peripherals that include high-performance computers could also be a stifling component towards the technology achieving widespread utilisation. Several studies have explored the human factors/ergonomic (HFE) issues associated with VR HMDs such as the one undertaken by Chen, Wang, and Xu (2021). Their study evaluated VR HMDs focusing upon human factors such as such as human performance, pressure, fatigue, and visual induced motion sickness. The research further stated that more HFE studies associated with HMDs will contribute towards identifying a more human centred design potentially overcoming ergonomic barriers towards their use. Furthermore, Hamilton (2018) presents work that reflects upon accessibility issues impacting virtual reality environments in the context of VR and gaming. Developer issues focusing upon and potentially addressing simulation sickness, binocularity of vision, physical context, and the spatiality of an environment require further attention to enhance developer perception and best practice when tackling accessibility concerns in this evolving discipline.

Research design and case study background

The research adhered to a mixed methods design (Creswell, 2021) instead of applying a monomethod approach. Monomethod research designs are used in research studies that utilise either only a qualitative or quantitative approach throughout the duration of a particular study (Teddlie and Tashakkori, 2009). In contrast, mixed methods research involves a researcher or team of researchers integrating various strands of qualitative and quantitative research methods […] *"… for the broad purposes of breadth and depth of understanding and corroboration"* (Johnson, Onwuegbuzie, and Turner, 2007, p. 123). It was decided that the adoption of mixed methods research would provide a degree of exploration, analysis, and interpretation regarding the analysis of differing qualitative and quantitative perspectives from participants. Furthermore, it has been acknowledged in the academic literature that case study research can accommodate quantitative and qualitative research approaches (Yin, 2014). It was considered that the analysis of qualitative and quantitative data would provide scope for interpreting and contrasting the views of participants in addition to placing the research into context. A self-administered web-based questionnaire using SurveyMonkey was applied utilising a series of open and closed questions. Non-probability sampling, sometimes also referred to as convenience or availability sampling was used. Convenience sampling was selected as this was the most efficient method for gathering raw data from the available population at the time the study was being undertaken. The initial aim was to obtain a generalisable, representative campus wide overview of the utilisation of Immersive Technologies, however the overall number of results was low possibly due to the following two factors. Firstly, immersive technologies are in the early stages of adoption in higher education as a teaching approach and platform and not always entirely popular (Marks and Thomas, 2022) and secondly, as a consequence of this the response rate was low and the results of the study will suffer from a nonresponse bias (Fricker, 2012).

The overall methodology was that of an embedded individual case study with the primary unit of analysis being a higher educational institution based in Scotland. The questionnaire was sent to students at the institution's main campus using the student services app. The schools involved were Business and Creative Industries, Computing, Engineering and Physical Sciences, Education and Social Sciences and Health and Life Sciences. The primary focus of the study was to obtain undergraduate student perspectives relating to viewpoints associated with knowledge and experience of utilising immersive technology within their degree programmes. The study itself was exploratory in nature and was designed to compare and contrast student outlooks on this topic and to evaluate whether identified themes correlated or refuted those already present in the academic literature.

A combination of descriptive statistics (*N,* mean and standard deviation), and non-parametric inferential statistics including Mann-Whitney U tests and Wilcoxon-matched pairs signs rank tests were used. Thematic analysis was applied to identify any relevant themes extracted from the qualitative data and to formulate any new themes not yet stipulated in the literature. Ethical approval was granted from the School's research ethics committee, application 16711.

The aim of the questionnaire was to ascertain student views regarding the application and potential challenges associated in using immersive technologies for teaching and learning purposes in the context of teaching and learning. The questionnaire also aimed to identify the students' experience of using immersive technology in education, whether immersive technologies have the potential to enhance the student learning experience and any challenges with using immersive technologies in higher education.

Presentation of Results

83 participants completed the *Using Immersive Technologies to Enhance the Student Learning Experience* questionnaire conducted at the University's main campus. 28 participants (34%) were in Year 1, 17 (20.5%) were from Year 2, 21 (25.3%) were from Year 3 and 16 (19.2%) were from Year 4. 1 participant (1%) did not specify. The mean year was 2.3 (SD = 1.14) with a range of 1 to 4. 16 participants (19.%) were from the School of Business and Creative Industries, 30 (36%) were from Computing, Engineering & Physical Sciences, 14 (17%) were from Education & Social Sciences and 21 (25%) were from Health & Life Sciences. 30 participants (36.1%) were males, 49 (59%) were females, 2 (2.4%) were third gender/non-binary and 2 (2.4%) preferred not to say. The mean age of the participants was 33 years of age (SD = 12.00) with a range of 17 to 61. Figure 1 provides an illustrative representation of the age demographics of the participants. The 17-61 age range is indicative of the sample population and can be attributed to the fact that discipline areas included undergraduate in addition to postgraduate students.

[Figure 1]

Participants were asked to rank their familiarity with various immersive technology concepts including Virtual Reality, Augmented Reality, Mixed Reality, Extended Reality, Serious Games and Games-Based Learning. Table 1 shows the ranking of the familiarity of the concepts/terms surrounding immersive technologies.

[Table 1 here]

Virtual Reality and Games-based Learning seemed to be the most familiar terms where Mixed and Extended reality seemed to be the least familiar which is interested due to the linkage between the terms. Participants were asked to what extent they had been introduced to immersive technology during the course of the programme or modules to enhance their learning experience. 46 participants (55.4%) stated not at all, 4 (5%) stated to a small extent, 18 (22%) stated to some extent, 11 (13%) stated to a great extend and 3 (3.6%) participants stated to a very great extent.

Participants were also asked to rate their familiarity with some of the following VR Kits: Oculus Rift S, Oculus Quest 2, Sony PlayStation VR, HTC Vive Cosmos, Valve Index, Windows Mixed Reality Google Daydream View, Google Cardboard and Samsung Gear VR. The results are displayed in Table 2.

[Table 2 here]

Participants seemed to be more familiar with the Sony PlayStation VR, Oculus Quest 2. and Oculus Rift S and less familiar with the Google Daydream View, HTC Vive Cosmos and Valve Index. 2 participants (2.4%) of the participants stated that they owned a VR development kit for the purpose of developing VR applications. The majority of participants (70, 84%) did not own their own VR HMD for entertainment purposes where 16% of participants did. Participants were asked to rank their preference of the types of VR device for the purposes of learning and for entertainment from the following:

- Standalone devices - all necessary components to provide VR experiences are integrated into the headset.
- Tethered devices - headsets that act as a display to another device like a PC or a video game console.
- 360 film accessible on mobile.
- VR as 2D on mobile.

Table 3 shows the rankings of the preferences of VR for the purposes of learning and entertainment.

[Table 3 here]

Wilcoxon-matched pairs signed ranks tests showed that there was no significant difference between the preference for the technology in relation to entertainment and learning. Table 4 shows the results.

[Table 4 here]

Participants were asked if immersive technologies have the potential to provide supplementary support to the teaching and learning process during remote educational delivery. 36 participants (43%) agreed, 18 participants (22%) strongly agreed, 22 (26.5%) neither agreed nor disagreed. Participants were asked to indicate how beneficial immersive technologies are towards accommodating several teaching and learning approaches remotely online. The ranking is displayed in Table 5. Table 6 illustrates a breakdown of participant response per academic discipline area in relation to the same question. Participants were also asked if they preferred traditional face to face classes as opposed to delivery using immersive technologies. 32 participants (38.5%) strongly agreed, 9 participants (11%) agreed, 27 (32.5%) neither agreed nor disagreed, 6 (7%) disagreed and 8 (10%) strongly disagreed. Table 7 illustrates the perceived benefits towards accommodating teaching and learning using immersive technologies split by gender. Figure 2 denotes some of the key themes extracted from the qualitative open-ended feedback regarding how immersive technologies have the potential to enhance the delivery of teaching and learning.

[Table 5 here]

[Table 6 here]

[Table 7 here]

[Fig 2 here]

Participants were asked how suitable immersive technologies would be for teaching a number of subjects. The results are displayed in Table 8.

[Table 8 here]

The results indicate that computing related subjects innately seem to be more suitable in relation to the application of Immersive Technologies. Immersive Technologies seemed to be perceived as more suitable for teaching Computer Networking, Computer Science, Cyber Security and Physics. They were considered to be less suitable for: Accounting, Sport and Exercise, Sport Development and Mental Health Nursing. Table 9 shows the perceived suitability of Immersive Technologies for teaching subjects split by gender.

[Table 9 here]

Mann-Whitney *U* tests indicated that there were three significant differences in perceptions of suitability for using Immersive Technologies for the following subjects: Chemical Engineering, Chemistry and Mechanical Engineering. Males considered Immersive Technologies to be significantly more suitable for teaching these particular topics, however it should be noted that these are male dominated subjects (Chemical Engineering ($Z = -2.986$, $p < 0.003$), Chemistry ($Z = -3.367$, $p < 0.001$), Mechanical Engineering ($Z = -2.140$, $p < 0.032$)).

Participants were asked to state how the use of an Immersive Technology might enhance the way in which their subject area is delivered. Some of the answers were as follows:

- *"Help experience different perspectives and create environments for experimental studies."*
- *"Simulation would be increasingly beneficial for nursing especially practicing skills before going out on placement to build confidence and self-esteem".*
- *"I could see molecules and pull them apart also learn from home".*
- *"Seeing how physics and mathematics interact in a 3d environment".*
- *"Immersive technology in the right topic can help enjoyment, motivation and possible aid memory retention for certain subjects".*

Participants were asked to rank the order of preference that they would like to see some of the following Immersive Technologies in their course from the following: Augmented Reality, Virtual Reality, Extended Reality, Mixed Reality, Serious Games, Games-based Learning. Table 10 shows the rankings of the preferences.

[Table 10 here]

The top preference seemed to be for Mixed Reality and Serious Games where the least levels of preference for technology in particular subjects seemed to be Virtual Reality and Augmented Reality.

Participants were asked how strongly they agreed with the following statement: "I *would only use an immersive technology if I understood how it works and how its use would benefit my learning.*" 75 participants answered this particular question. 38 participants (50.6%) agreed, 22 participants (29.3%) strongly agreed, 8 participants (10.6%) neither agreed nor disagreed, 5 (7%) disagreed and 2 (3%) strongly disagreed. One participant responded with: "*I have extremely bad motion sickness and can't use Virtual Reality for more than 10 minutes*".

Participants were also asked to rate how strongly they agreed with this particular statement in relation to motion sickness: "The human factor issue of motion sickness would make me less inclined to adopt the use of Virtual Reality." 76 participants answered this question. 14 (18%) strongly agreed, 19 participants (25%) agreed, 11 21 (27.6%) neither agreed nor disagreed, (14.5%) disagreed, and 11 (14.5%) strongly disagreed. Participants were also asked to rank the potential drawbacks of the use of Immersive Technologies for educational purposes. The results are displayed in Table 11.

[Table 11 here]

The three top main drawbacks were: cost of equipment, health issues, and lack of clarity about why they were being asked to use the technology. The three least important drawbacks were difficulty in being able to use the technology remotely, lack of self-efficacy in using the technology and ensuring that there is enough equipment for the students to use simultaneously.

Participants were asked in an open-ended question what the primary drawback of utilising Immersive Technologies were. The primary drawback seemed to be cost. Other interesting qualitative responses included:

- *"Personally, I think that it's the costs of the headsets and the amount of time it would take to set up each class or explaining how to use each device to students".*
- "*I just don't see how it could be useful. We've already got plenty of technology separating us from each other removing any humanity from the courses. Not to mention it adds yet another barrier between student and actually being able to practice their subject. We really don't need any more of this*".
- *"Less face-to-face contact, all our activity being online and losing touch with reality and actual face-to-face connections".*
- "*Using technology in a busy classroom isn't always as easy as it should be. The ClassVR interface and teacher portal provide the simple-to-use tools needed to ensure this exciting and engaging technology can deliver a rich, reliable experience for you and your students. Evidence shows virtual reality has the tools to push the boundaries of your teaching, and helps students meet their learning goals. ClassVR offers a great way to engage your students and enhance your existing lessons with VR designed specifically for schools".*

Figure 3 illustrates some of the salient themes identified from the qualitative thematic analysis related to potential drawbacks and obstacles towards the use of immersive technologies in higher education.

Figure 3 Participants were finally asked if using Immersive Technologies in their classes would make them feel anxious. 76 participants answered this question where 18 participants (24%) strongly agreed, 17 participants (22%) agreed, 12 participants (15.7%) neither agreed nor disagreed, 10 participants (13%) disagreed, and 19 (25%) strongly disagreed.

Discussion

The findings presented in this study have identified some common themes in the academic literature regarding immersive technology use in higher education. One salient substantiation of the literature was that immersive technologies were perceived by the participants to be highly beneficial in providing an immersive learning experience. This finding reinforces work by Suh and Prophet (2018) who undertook a literature analysis on the state of immersive technology research. Based on their literature analysis, one of their findings stated that current research into user perceptual and sensory stimuli as well as immersive technology content can enhance immersive experiences for users. It was also stated by the participants that immersive technologies have the potential enhance visualisation of course material (Won et al., 2019) and overall student engagement and enjoyment. These are regular themes that are often recounted in the immersive technologies' literature. Interestingly, there was also a preference towards traditional face-to-face classes as opposed to using immersive technologies for teaching and learning purposes. This finding may imply that in the context of teaching and learning, the use of immersive technologies is beneficial to coincide with educational delivery in certain subject areas though this is something, to the best of our knowledge, that is not always widely reported in the literature. A surprising finding was when participants were asked for their preference about what immersive technologies students would like to experience in their courses. The primary preference appeared to be for mixed reality and serious games where augmented and virtual reality had the least levels of preference.

In relation to the potential drawbacks of using immersive technologies for educational purposes the findings correlated with a lot of themes already identified in the academic literature. Two salient examples would be the factor of cost in terms of purchasing equipment (Wray, Kemp, and Larsen, 2023) and associated health issues with technology such as VR (motion sickness), (Chang, Kim and Yoo, 2020). Previous work undertaken by Baxter and Hainey, (2020), more specifically focused on VR use in higher education, identified similar benefits and drawbacks related to the technology's use in higher education.

Conclusions and research implications

The research presented in this study has provided an updated perspective in terms of assessing the application of immersive technologies in HE. The identified benefits of immersive technologies will remain constant yet will simultaneously evolve. It can be argued that most empirical studies within the academic literature agree about this. However, the potential drawbacks associated with certain immersive technologies such as VR, require further investigation to assess how its use can be successfully integrated in a teaching and learning context. It is evident that the portability and versatility of immersive technologies make them well versed towards catering a diverse range of teaching and learning approaches. How these various pedagogical approaches can be best applied and to what specific subject area is something that merits additional exploration. Further empirical studies of this nature will also aid towards providing practical solutions for educators to overcome any obstacles when embedding immersive technology into the classroom.

The potential for using immersive technologies such as AR, VR, XR and MR in higher education have excellent possibilities for aiding students studying practical based subjects. For example, health care subjects such as medicine, nursing and midwifery or other practical subjects that include civil or aeronautical engineering. Academics can learn the lessons of these immersive approaches thereby applying the generalist pedagogical principles to their own subject areas. Through immersion and engagement in replicated 3D work-based scenarios required skill sets can be learnt and enhanced for future industry professionals. Dependent upon relevancy towards specific subject areas, immersive technologies such as VR and AR as well as XR and MR can provide students with a more interactive experience in understanding their subject areas whilst making the learning more interesting and enjoyable. For example, in the sphere of anatomy, medical procedures can be learnt and perfected in a safe simulated replicated environment where students can engage in decision making processes when practising various medical procedures. Complex issues can also be visualised which aids on the job learning providing the relevant graduate attributes required working within the medical profession. Specific subject discipline concepts can be delivered in class in a real-time environment that simulates reality.

Limitations and future directions

The primary limitation of this research is that generalisations cannot be formed based on a singular case study and the limited sample size. What might be beneficial and is an area of consideration for future research by the authors is to perform research related to the themes explored in the research among several different HE institutions. This would allow for more specific and credible generalisations to be formed thereby contributing to the body of knowledge in this area. Investigating the application of immersive technologies towards certain educational subject areas in HE will aid towards solidifying how they can be applied at certain stages within course curriculum. Furthermore, it would be useful to ascertain what type of educational delivery approaches immersive technologies can support such as blended or hybrid and how the use of these technologies can impact on the student learning experience. Best practices in terms of integrating the use of immersive technology into classroom settings is an additional area that merits further investigation. Empirical studies designed to guide educators about the integration, use and pedagogical evaluation of using immersive technologies in their subject areas would aid the contribution to knowledge in this diverse area.

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Table 1: Ranking of familiarity with Immersive Technology Concepts

Technology	Ranking	Mean	SD
Virtual Reality	1st	3.27	1.15
Games Based Learning	2nd	2.99	1.09
Serious Games	3rd	2.80	1.21
Augmented Reality	4th	2.80	1.13
Mixed Reality	5th	2.49	1.18
Extended Reality	6th	2.15	1.16

Figure by authors

Table 2: Familiarity with VR Technology

Technology	Ranking	Mean	SD
Sony PlayStation VR	1st	2.40	1.37
Oculus Quest 2	2nd	2.06	1.22
Oculus Rift S	3rd	1.99	1.22
Google Cardboard	4th	1.95	1.19
Samsung Gear VR	5th	1.88	1.10
Windows Mixed Reality	6th	1.73	1.06
Valve Index	7th	1.66	1.09
HTC Vive Cosmos	8th	1.64	1.04
Google Daydream View	9th	1.55	0.90

Figure by authors

Table 3: Rankings of preferences of VR for learning and entertainment

Technology	Learning			Entertainment		
	Ranking	Mean	SD	Ranking	Mean	SD
VR as 2D on mobile	1st	3.36	1.00	1st	3.41	0.83
360 film accessible on mobile	2nd	2.68	0.81	2nd	2.75	0.94
Tethered Devices	3rd	2.24	0.98	3rd	2.17	0.93
Standalone Devices	4th	1.69	0.96	4th	1.64	0.94

Figure by authors

Table 4: Wilcoxon results between preferences of devices for entertainment and learning

Pairing of Learning and Entertainment	Wilcoxon result
VR as 2D on mobile	$Z = -1.084$ ($p < 0.278$)
360 film accessible on mobile	$Z = -0.715$ ($p < 0.474$)
Tethered Devices	$Z = -1.455$ ($p < 0.146$)
Standalone Devices	$Z = -0.151$ ($p < 0.880$)

Figure by authors

Table 5: Ranking of perceived benefit towards accommodating teaching and learning.

Learning and teaching approaches	Ranking	Mean	SD

Provide an Immersive Learning Experience	1st	3.90	1.03
Improve the visualisation of how material is presented	2nd	3.88	1.02
Enhance student performance and enjoyment	3rd	3.80	1.08
Increase online social interaction	4th	3.64	1.09
Enhance student engagement	4th	3.64	1.10
Support collaborative learning	5th	3.55	1.11
Support Problem Based Learning	5th	3.55	1.11
Support and facilitate student motivation	5th	3.55	1.14
Enhance learning via procedural knowledge	6th	3.53	1.05
Accommodate learning from mobile devices	7th	3.48	1.18
Support instant communication and feedback	8th	3.47	1.19
Support Enquiry Based Learning	9th	3.43	1.11
Enable community building	10th	3.41	1.24
Increase an individual's perceived self-efficacy	11th	3.28	1.17

Figure by authors

Table 6: Ranking of perceived benefits towards accommodating teaching and learning per discipline area.

Learning and teaching approaches	**Business and Creative Industries**			**Computing Engineering and Physical Sciences**			**Education & Social Science**			**Health & Life Science**		
	Rank	**Mean**	**SD**	**Rank**	**Mean**	**SD**	**Rank**	**Mean**	**SD**	**Rank**	**Mean**	**SD**
Provide an Immersive Learning Experience	1st	4.19	1.05	1st	4.03	0.76	3rd	3.79	1.25	2nd	3.62	1.20
Improve the Visualisation of how Material is Presented	2nd	4.06	1.18	3rd	3.97	0.93	2nd	3.86	1.03	1st	3.71	1.01
Accommodate Learning from Mobile Devices	3rd	3.94	1.12	12th	3.30	1.24	4th	3.64	1.15	6th	3.33	1.15
Support Problem Based Learning	4th	3.88	1.02	8th	3.47	1.01	5th	3.57	1.22	4th	3.48	1.25
Support Collaborative Learning	4th	3.88	1.20	7th	3.60	1.00	8th	3.29	1.20	4th	3.48	1.12
Enhance Student Engagement	5th	3.81	1.05	5th	3.70	0.92	2nd	3.86	1.17	7th	3.29	1.35
Enhance Student Performance and Enjoyment	5th	3.81	1.17	2nd	4.03	0.96	1st	3.92	0.86	4th	3.48	1.25
Increase Online Social Interaction	5th	3.81	0.98	4th	3.77	1.04	6th	3.50	1.02	4th	3.48	1.29

Support Enquiry Based Learning	6th	3.75	1.29	10th	3.37	0.93	7th	3.43	1.16	6th	3.33	1.20
Enable Community Building	6th	3.75	1.34	9th	3.40	1.13	9th	3.14	1.41	5th	3.38	1.24
Enhance Learning via Procedural Knowledge	6th	3.75	1.06	6th	3.63	0.85	9th	3.14	1.17	3rd	3.52	1.21
Support and Facilitate Student Motivation	7th	3.69	1.25	6th	3.63	0.96	5th	3.57	1.28	5th	3.38	1.24
Support Instant Communication and Feedback	7th	3.69	1.35	11th	3.33	1.24	6th	3.50	1.16	3rd	3.52	1.08
Increase an Individuals Perceived Self-Efficacy	8th	3.67	1.05	12th	3.30	1.09	9th	3.14	1.35	8th	3.10	1.26

Figure by authors

Table 7: Ranking of perceived benefit towards accommodating teaching and learning split by gender

Learning and teaching approaches	Male			Female		
	Ranking	Mean	SD	Ranking	Mean	SD
Provide an Immersive Learning Experience	1st	4.17	0.75	2nd	3.78	1.10
Enhance student performance and enjoyment	2nd	4.07	0.91	3rd	3.67	1.12
Improve the visualisation of how material is presented	3rd	4.03	0.89	1st	3.82	1.03
Enhance Learning via Procedural Knowledge	4th	3.90	0.88	11th	3.35	1.07
Enhanced student engagement	5th	3.83	0.95	5th	3.53	1.14
Support and Facilitate Student Motivation	5th	3.83	0.91	10th	3.39	1.20
Support Problem Based Learning	6th	3.73	0.98	6th	3.49	1.16
Support Collaborative Learning	6th	3.73	0.91	7th	3.47	1.17
Increase Online Social Interaction	6th	3.73	0.94	4th	3.61	1.13
Support Instant Communication and Feedback	7th	3.60	1.22	9th	3.41	1.15
Accommodate Learning	8th	3.57	1.10	8th	3.43	1.21

from a Mobile Device						
Support Enquiry Based Learning	8th	3.57	1.01	9th	3.41	1.14
Enable Community Building	8th	3.57	1.14	12th	3.33	1.28
Increase an individuals perceived self-efficacy	9th	3.43	1.19	13th	3.19	1.12

Figure by authors

Table 8: Ranking of how suitable immersive technologies would be for teaching certain subject areas.

Subject	Rank	Mean	SD
Computer Networking	1st	4.08	0.94
Computing Science	2nd	4.00	1.01
Cyber Security	3rd	3.78	1.02
Physics	4th	3.71	0.85
Civil Engineering	5th	3.69	0.92
Biomedical Sciences	6th	3.67	1.04
Forensic Science	7th	3.65	0.93
Mechanical Engineering	8th	3.64	1.01
Chemical Engineering	9th	3.59	0.95
Events Management	10th	3.58	0.92
Business and Marketing	11th	3.55	0.94
Chemistry	12th	3.54	0.92
Paramedic Science	12th	3.54	1.14
Nursing Studies	13th	3.41	1.20
Psychology	14th	3.35	1.01
Social Work	15th	3.32	1.05
Midwifery	16th	3.30	1.17
Mental Health Nursing	17th	3.28	1.13
Sport Development	18th	3.26	1.11
Sport and Exercise Science	19th	3.24	1.11
Accounting	20th	3.16	1.04

Figure by authors

Table 9: Suitability of Immersive Technologies for Teaching Subjects Split by Gender

Learning and teaching approaches	Male			Female		
	Ranking	Mean	SD	Ranking	Mean	SD
Computing Science	1st	4.03	0.98	2nd	4.00	1.04
Chemical Engineering	2nd	4.00	0.89	14th	3.33	0.91

Computer Networking	2nd	4.00	0.93	1st	4.08	0.95
Biomedical Sciences	3rd	3.93	0.96	8th	3.57	1.08
Mechanical Engineering	3rd	3.93	1.15	10th	3.48	0.92
Physics	4th	3.86	0.92	5th	3.63	0.83
Civil Engineering	5th	3.83	1.07	5th	3.63	0.84
Forensic Science	6th	3.79	1.08	6th	3.61	0.84
Cyber Security	7th	3.69	1.17	3rd	3.84	0.94
Nursing Studies	8th	3.62	1.21	15th	3.31	1.19
Paramedic Science	8th	3.62	1.24	9th	3.51	1.08
Events Management	9th	3.55	1.15	7th	3.60	0.80
Midwifery	9th	3.55	1.18	17th	3.16	1.16
Business and Marketing	10th	3.34	0.90	4th	3.65	0.97
Sport and Exercise Science	10th	3.34	1.29	17th	3.20	1.02
Psychology	12th	3.28	1.07	13th	3.37	0.99
Social Work	13th	3.25	1.14	11th	3.39	1.02
Sport Development	14th	3.24	1.24	16th	3.27	1.04
Accounting	15th	3.17	1.10	18th	3.12	1.03
Mental Health Nursing	15th	3.17	1.23	12th	3.38	1.10

Figure by authors

Table 10: Ranking of the preferences of the technology

Technology	Ranking	Mean	SD
Mixed Reality	1st	4.13	1.33
Serious Games	2nd	4.03	1.65
Extended Reality	3rd	3.91	1.40
Games-based Learning	4th	3.61	1.95
Augmented Reality	5th	2.63	1.52
Virtual Reality	5th	2.63	1.69

Figure by authors

Table 11: Ranking of the drawbacks of the use of Immersive Technologies for educational purposes in order of relevancy.

Drawbacks	Ranking	Mean	SD
Cost of equipment (e.g., VR Kit, high powered machine)	1st	1.91	1.68
Health issues (e.g., motion sickness, nausea, eye strain)	2nd	3.69	2.95
Lack of clarity about why you are being asked to use the technology	3rd	4.00	2.84
Lack of guidelines on how to use the technology	4th	5.15	2.22
Accessibility issues impacting its use	5th	5.40	2.29
Technical difficulties in using the technology	6th	5.93	2.14
Complex nature of configuring the hardware	7th	7.35	2.18
Preference of other modes of educational delivery	8th	7.76	2.87
Lack of time to learn how to use the technology	9th	8.51	2.31
Ensuring there is enough equipment for students to use simultaneously	10th	8.78	3.27

Lack of self-efficacy in using the technology	11th	9.45	2.03
Difficulty in being able to use the technology remotely	12th	9.50	3.09

Figure by authors

Figures for paper: Using Immersive Technologies to Enhance the Student Learning Experience.

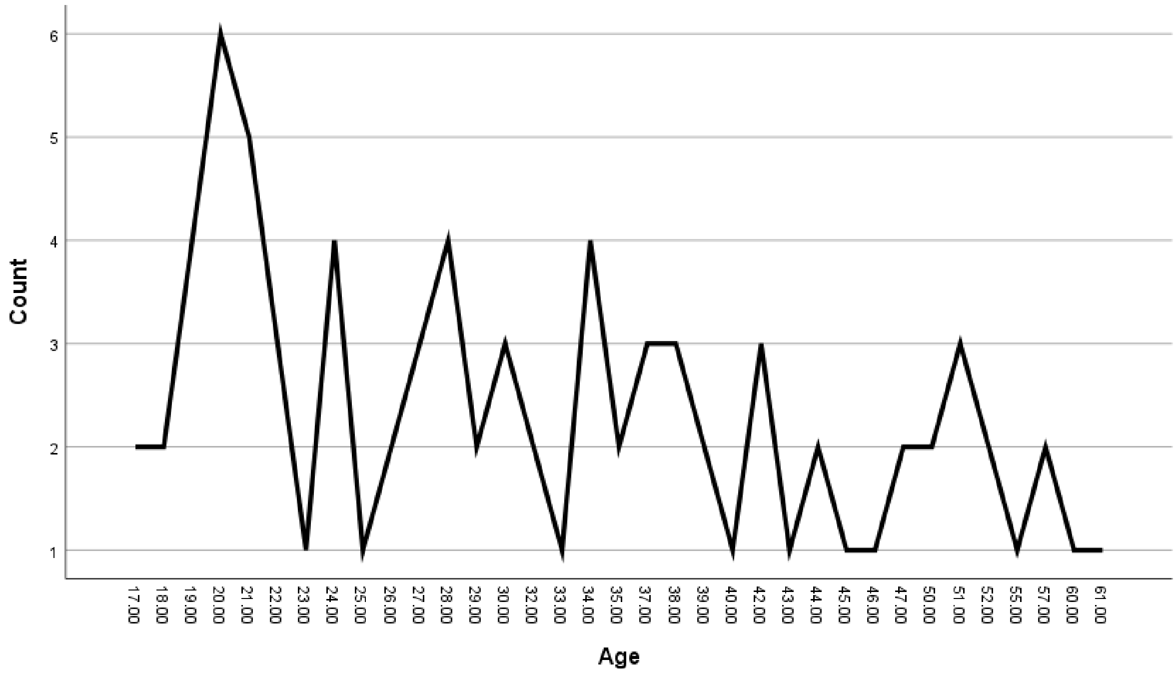

Figure 1: Demographic age range of participants (figure by authors)

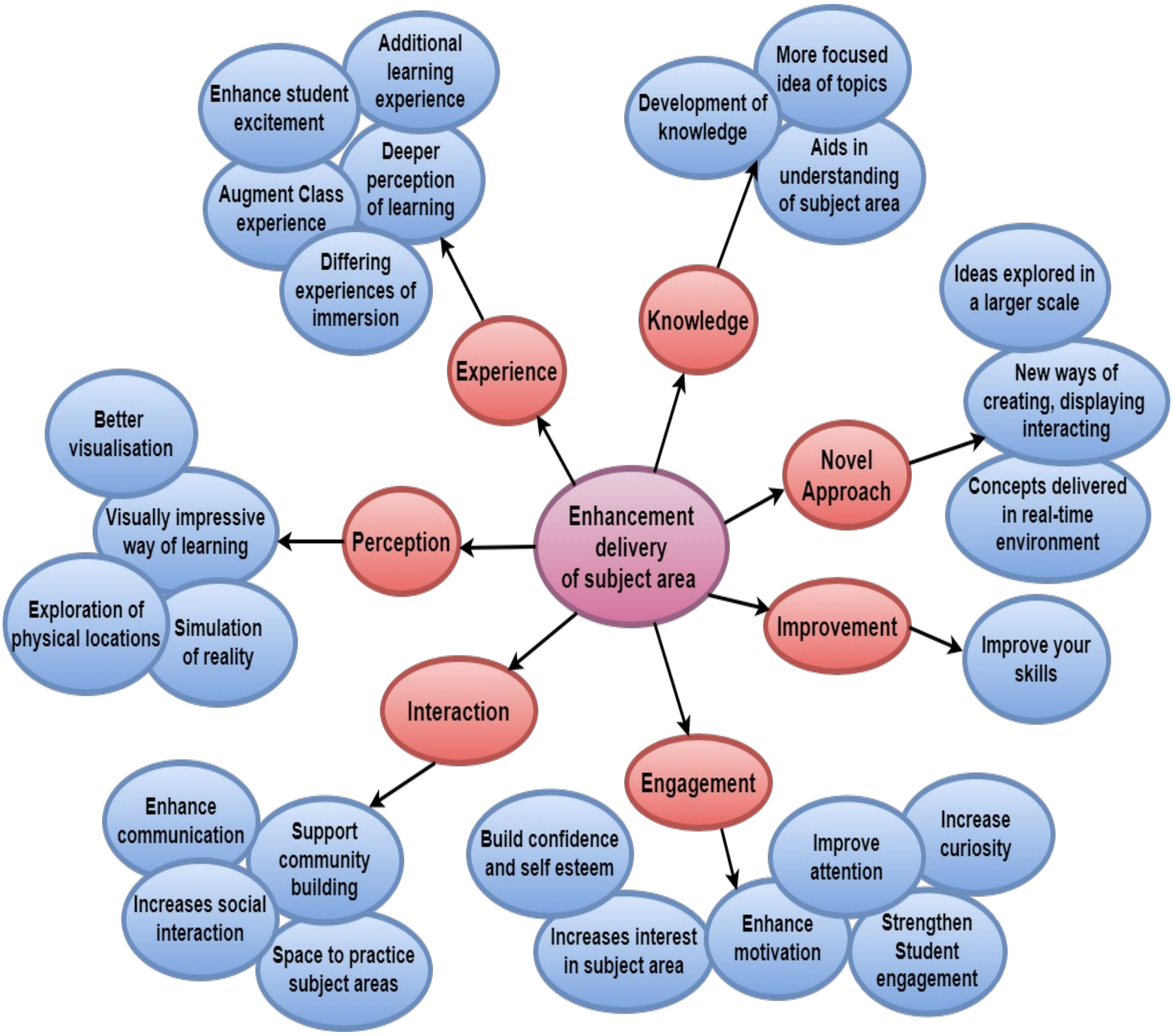

Figure 2: Perceived benefits of using immersive technologies (figure by authors)

Figure 3: Barriers towards Immersive Technology in HE contexts (figure by authors)