Immersive Environments in Higher Education: The Digital Well-Being Perspective

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Abstract. In less than half a century, digital environments have pervaded nearly all aspects of our lives. Presently, the importance of Immersive Environments (IE) in education is rapidly increasing, offering interesting new opportunities for learning in higher education, but at the same time presenting some risks related to their use. In particular, the IE pose some issues to be considered in terms of digital well-being, such as access and inclusion, cognitive overload, and physiological discomfort. Furthermore, it has to be considered that there is a lack of a general methodology and a theoretical grounded approach for the implementation and evaluation of IE for educational purposes. The main aspects to be considered for their impact on the digital well-being have been collected from the current literature and analysed, exploring 4 main dimensions: cognitive, physiological, social and educational. Based upon the findings a first set of guidelines on digital well-being for IE in education have been developed leading to the production of a learning scenario that has been evaluated, by several stakeholders. The results of this evaluation process are positive, underlining the compliance of the learning scenario with the digital well-being requirements for an effective IE integration in the educational context.

Keywords: Immersive environments · Digital well-being · Higher education

1 Introduction

1.1 Immersive Environments

In less than half a century, digital environments have pervaded nearly all aspects of our lives. From "informatics" to "information and communication technologies", to "pervasive computing and IoT" to the "social media" boom in the second half of 2010's, digital is increasingly a key aspect of everyday life. As demonstrated during the COVID-19 lockdown period, digital technologies have become an essential instrument to support work, education, social activities, and also affective interactions. Thus, many people on the right side of the digital divide have a very powerful tool at their disposal, whose evolution, benefits, and potentials are yet to be fully understood, as well its risks and drawbacks such an overuse and lack of physical interaction. In light of these developments, digital well-being, illustrated in the next section, is key to making it possible for everyone to take advantage of something that we may well define as a "cognitive-social

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infrastructure" connecting a large part of us. Presently we are at a time in which Immersive Environments (IE) are at the cusp of a new stage with even further potential but also, posing new challenges.

IE are part of immersive technologies grouped under the umbrella term Extended Reality (XR) that encapsulates the full spectrum of Augmented Reality AR), Mixed Reality (MR), 360° video and Virtual Reality (VR) as distinguished in the well-known "Reality-Virtuality (RV) Continuum" [1, 2].

On one side there is the real world, where everything experienced is part of our shared physical reality. On the other side there are the virtual worlds (also the metaverse, to use a term that came back to the forefront after Mark Zuckerberg) where all perceived content is artificially generated and has no connection to real-world objects or places. Between these two extremes are two conceptualized mixed reality environments: Augmented Reality (AR) where computer-generated content is embedded in users' perceptions of the real-world environment; and Augmented Virtuality (AV), where the perceived world is mostly computer-generated with real-world content mixed or overlaid. The XR can be enjoyed at different degree of immersiveness, according to the display device used: from low immersiveness of planar screen devices (e.g. notebooks, tablets, smartphones) through cardboards to the highest degree of immersiveness with Head Mounted Displays (HMD).

Together with immersiveness, another key concept in IE is the presence, considered as "the subjective experience of being in one place or environment, even when one is physically situated in another" [3]. In the literature [4] linked to the concept of presence or 'being there' is often the concept of immersion. Immersion is an experience where one is intensely absorbed in something, "I am in" where one is inclined to temporarily forget their surroundings [5]. For example, when a person is immersed in music, a work of art, a performance, a scenic view, or even in their thoughts. Delving deeper, a clear distinction between presence and immersion is provided by Slater and Wilburn [6]: "Immersion is a description of a technology and describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant. […] Immersion can be an objective and quantifiable description of what any particular system does provide. Presence is a state of consciousness, the (psychological) sense of being in the virtual environment. […] The fundamental idea is that participants who are highly present should experience." Thus, immersion is a technological attribute that can be objectively assessed, in contrast there is another position in which immersion is considered a psychological phenomenon, i.e., a subjective and individual belief [3].

The capacity of being immersed in environments, which can be real, virtual and/or augmented, to explore and to interact with them and with other people is presenting new interesting scenarios in several fields, as entertainment and culture, but mainly in education giving also the chance of a full and direct interaction with environments hardly to be visited in person (e.g. an archeological site, an ocean floor, a volcano interior, a surgery room, a dangerous working place as a refinery or an oil plant), with, or without, the guidance of the teacher.

As demonstrated by the growing number of studies in this topic and by some EU initiatives [7, 9] the importance of IE in education is rapidly increasing. At the same

time, due to the risks associated with these technologies, it is necessary to understand and thus balance the opportunities with the main drawbacks, particularly in this educational perspective [10].

The present work refers particularly to the use of 360° videos in Higher Education. According to Milgram, the 360° video is placed in between Augmented Reality and Augmented Virtuality being therefore able to exploit the strengths of both while allowing a relatively ease of production and distribution among the students. From a technical point of view, a 360° video (frequently called also "spherical videos" or "immersive videos") are video recordings where a view in multiple directions is recorded simultaneously. They are typically shot using a specialist omnidirectional camera, or a collection of separate, connected cameras mounted as a spherical array. The 360 videos can be non-interactive or interactive. Non-interactive 360 videos are experiences where the viewer cannot influence the viewing experience except pausing the video or moving their head to orient their gaze. Interactive 360 videos are experiences where the viewer can interact with the user interface or other interactable elements using a controller. For example, a 360° video can embed interaction points such as hotspots, hyperlinks, texts, images or 2D videos, quiz with multiple choice questions, true/false, etc., area highlights, teleport in another point of the 360° video.

1.2 Digital Well-Being

The term "digital well-being" refers to the concept of well-being in a society where digital technologies have covered every aspect of our life, just thinking of the last years of the pandemic that forced us behind a screen for work, education and also recreational purposes. Digital well-being is not a new concept and also the European Digital Competence Framework for Citizens [11] associated it to the safe use of technologies. However, since the role of digital technologies is constantly evolving, it is necessary to recontextualize it and expand its meanings.

The well-being and health concepts are strictly related as defined by World Health Organization: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"[1]. This definition underlines the several dimensions included in the health definitions (physical, mental and social) not only related to a concept of disease. Similarly, the aspect of digital well-being requires investigation and understanding in a multidimensional aspect. In fact, the definition of digital well-being in a publication of Burr, Taddeo and Floridi [12] as the "impact of digital technologies on what it means to live a life that is good for a human being in an information society" highlights its multidimensional nature.

Thus, it is necessary to understand the implications in terms of digital well-being when introducing the IE in the educational field, also considering the lack of a general methodology and a theoretical grounded approach for the deployment and evaluation of IE for educational purposes.

[1] https://www.who.int/about/governance/constitution

2 The Dimensions of Digital Well-Being

2.1 The Approach to the Digital Well-Being

In accordance with these premises, the digital well-being in education cannot be approached only with technological or educational considerations but it needs a multidisciplinary approach considering all the different aspects of the well-being. With no pretense of exhaustivity, in this preliminary work, four main dimensions have been identified for investigating the relationships between digital well-being and IE, namely:

- **Cognitive**: about the threats posed by the technology (i.e., cognitive overload or isolation);
- **Physiological**: about effects of the IE on the user (i.e., the motion sickness in wearing helmets);
- **Social**: about possible impact of IE on relationships within working groups (i.e., classrooms);
- **Educational**: about learning opportunities offered by IE.

For each dimension a selection of the current literature has been analysed leading to the following findings.

2.2 Cognitive Dimension

From a cognitive perspective, some interesting aspects that require careful consideration in the educational field emerged from literature. Some studies [13, 14] showed that IE has an impact on memory, being able also to alter it, and this can be exploited in particular for psychological therapy [14]. The possibility to alter memory in a positive way is the basis of the study by Cuperus and van der Ham [13], that altered the memory of soccer players through a manipulation of VR replay to investigate if this manipulation could affect feeling of competence, as well as subsequent sports performance. The results underlined that the replay manipulation positively correlated with feeling of competence without any influence on sport performance.

Besides the effect on memory, the IE can also have a positive impact on the mood, and apathy, recognizing in IE the role of cognitive stimulator for improving well-being as explored by D'Cunha and collaborators [15] in a mini review on the VR/AR use for dementia and cognitive impairments.

2.3 Physiological Dimension

From a physiological point of view some drawbacks have been reported for IE use, such as cybersickness and simulator sickness, that should be carefully considered especially for its extended and prolonged use.

As reported in the study of Davis, Nesbitt & Nalivaiko [16] some individual factors could influence cybersickness, as age, gender, illness and also duration of the IE experience [16, 17]: in particular the susceptibility of cybersickness symptoms is high in children from 2 to 12 years old but decrease in the 12–21 age range. Moreover, a

particular attention to the duration of the content and the tasks to be carried out by the user conveyed through immersive technologies must be taken into consideration when designing the contents in the educational field.

2.4 Social Dimension

The social dimension refers in particular to the dynamics of social relations using IE. A demonstration of influencing the interpersonal emotions by IE derived from the study of Schutte & Stilinović [18]. They showed that the higher engagement level, with respect to 2D, can influence the emotions as empathy. Future research should investigate and focus on the impact of IE on empathy and other characteristics as effective interpersonal communication, emotion expression, psychological and physical well-being. Furthermore, Liu and collaborators [19] demonstrated that the use of 360° videos in VR environments positively affect young's emotional well-being with respect to viewing the same videos on smartphones, while for elderly people the contrary happens, having more positive emotions with the smartphone. This implies that the characteristics of the subjects is an important factor for a fruitful immersive experience.

Another interesting aspect is the dynamics of social relations between young and older adults. Hauskneck and collaborators [20] explored the idea of using Alternate Reality Games (ARG) for intergenerational collaborative learning between 9–13-year-old and their parents. Even if positive results have been found in terms of parent-child relations, one challenge encountered was related to the directions and desires of each pair guided by traditional societal roles (e.g., the need of father to be the leader in the game not allowing the son to negotiate the games direction.

The dynamics of social relations in terms of traditional roles in IE should be deeply investigated, especially considering the integration of IE in an educational context and thus the role between students and teachers.

2.5 Educational Dimension

The educational dimension of digital well-being refers to the opportunities offered by IE as vicarious learning experiences and the balance with possible risks derived from their use. As previously explained, the IE represents an opportunity of a full and direct interaction with environments hardly to be visited in person for students. Their use in higher education context offers several benefits for learning process such as motivation, interest in learning, and for improving/acquiring skills [7, 21, 22]. Considering the usefulness HMDs, they offered some advantages for understanding and retaining visual and spatial aspects of a place (cognitive skills), for psychomotor skills acquisition when related to the movement of the head (as visual scanning or observational skills) and for controlling emotional response to stressful or difficult situations (affective skills) [22]. On the other hand, it has to be considered that a widespread use of IE may offer little additional benefits compared to less immersive technologies or traditional instruction, being in some cases counterproductive, because of the physical discomfort and cybersickness derived from their use [22].

Finally, a transversal theme is related to the ethical aspects in IE use. Madary & Metzinger [23] identified some aspects: among those the unknown effect of long-term

immersion, especially in young people not yet fully developed from a psychological and neurophysiological point of view and the problem of the type of data collection from during immersive experiences (e.g., eye movements, facial gestures). Ramirez & LaBarge [24] raised the attention on the virtually real experience offered by IE, that resembles real experience, and on the equivalence principle that "if it would be wrong to allow subjects to have a certain experience in reality, then it would be wrong to allow subjects to have that experience in a virtually real setting". These aspects and those will come with the development of technologies and devices must be considered when integrating the IE in the educational setting.

The Fig. 1 summarizes the main pros, cons, and threats of literature findings in each considered dimension.

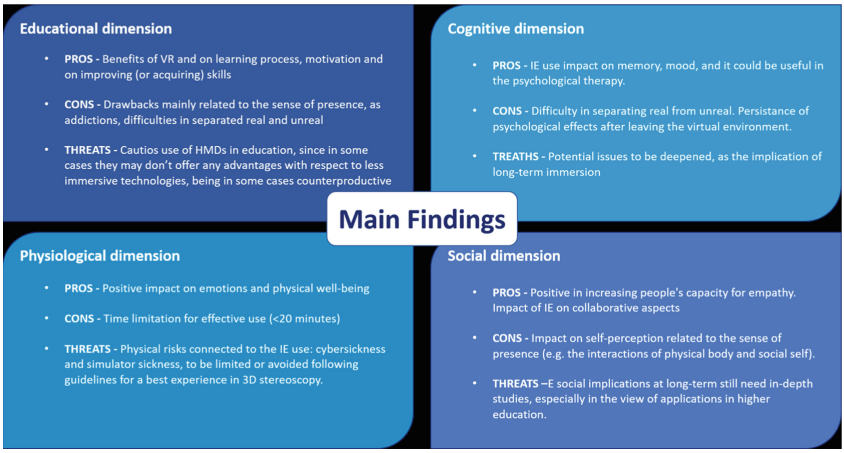

Fig. 1. PROS, CONS and THREATS of main literature findings in each dimension

3 The Design and Evaluation of Learning Scenario in a Well-Being Perspective

3.1 The Digital Well-Being in IE

Although the design of learning scenario is a well-established practice, its creation in an IE poses some specific issues in terms of digital well-being such as access and inclusion, student's engagement, and physiological discomfort mitigation.

According to the literature findings the authors have developed a preliminary set of guidelines for digital well-being using IE, highlighting some aspects that need to be carefully considered for teaching with IE in higher education.

Area 1 - Access and Inclusion

This Area is dedicated to the recommendations for ensuring the IE experience to all students regardless of physical (disability or impairments) or technological (digital divide) aspects.

When planning for IE experience, it is necessary to consider:

- the accessibility to the technologies (PC, smartphone or tablet) for all students both for activities proposed in the classroom and for remote activities, thus avoiding planning learning activities that require specific (and expensive) software and devices;
- the accessibility to the technologies in terms of digital competences of students, providing some training activities to make easier to enjoy the immersive experience;
- the role of teachers during IE activities, as a guide for the students for a more understandable experience;
- some modalities (as, subtitles) and assisting technologies for the inclusion of students with different impairments.

Area 2 - Student's Engagement

This Area is dedicated to the recommendations to foster student's engagement during the IE experience and thus making the learning experience more effective.

In particular, it is necessary to consider the following points:

- Context: tailoring teaching technology to students' needs (personalization);
- Visual aspect of IE: the interface needs to be nicely designed
- Quality: the educational and the training topic must be attractive and the interaction during the learning need to be fluid without any technical drawbacks such as slow response.
- Complexity: repeating the same scenario, directing the learner's attention to different aspects (himself/herself, others, place, tools…). It's an effective way to capture the complexity of certain phenomena. At the same time the possibility to watch the same learning scenario as many times needed allows students to reduce the novelty effect of using immersive environment, thus focusing on learning;
- Control of the difficulty level: to suit the students' level of knowledge and ability;
- Feedback: the possibility to have the guide of teachers that provide feedbacks during the activities in IE;
- Collaborative activities: the possibility to make immersive activities in groups (both in presence and in on-line modalities), thus experiencing teamwork (collaboration) in this particular context.

Area 3 - Physiological Discomfort

This Area is dedicated to the theme of physiological discomfort that may be derived from the use of IE (such as, cybersickness).

Although the most recent technologies seem to be reducing this issue, it is important to underline an important approach for avoiding this unpleasant situation:

- Training and Repetition: the possibility to be trained before the IE experience and to repeat the same scenario several times, to understand the degree of the discomfort and to be more confident with this technology.

3.2 The Tool for the Scenario's Design

According to the context described in Sect. 1 and 2, a learning scenario has been designed and evaluated leveraging IE in higher education while addressing the digital well-being according to the literature findings. A template for the scenario's design has been developed as a tool for designing the activities also in relation to the technologies used as shown in Fig. 2.

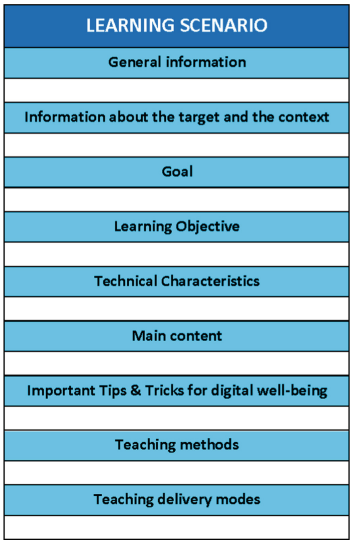

Fig. 2. The template for the design of learning scenario

3.3 Learning Scenario: The Crime Scene Investigation

For evaluating the compliance with the digital well-being, a learning scenario, integrating a 360° video into the didactic path of the lesson has been designed and implemented although the restrictions due to the pandemic unfortunately did not allow to test it until now. Thanks to a 360 camera, the reconstruction of a crime scene was filmed. The lesson has been conceived to be carried out synchronously, in presence with the use of computers and HMD. The duration of 360° video was planned in 10 min and included in a lesson of 120 min (1h = 40 min of lessons with 1 breaks of 20 min). The crime scene is the fundamental part of an investigation, but there are some problems relating to the physical presence on the scene, such as risk of contamination or destruction of evidence that can prevent investigators from staying, visiting and re-visiting the scene. Therefore, it is important to visually capture the crime scene and each evidence to help the investigations. In this sense the 360° video helps the students to acquire the key competencies needed for evidence collection in a crime scene. Furthermore, the 360° video allows the students to review the crime scene as many times as they need to focus on different aspects, compared to the educational visit on the rebuilt crime scene. This

learning scenario is developed under the subject "Forensic Biological Investigations. Criminalistics", aiming at developing competencies for the biological analysis on the crime scene following the international standard: acquisition of analytical procedures for beginners in the forensic field; ability to apply the knowledge in the analysis of a crime scene; ability to critically analysed to use the acquired knowledge in a productive and proper way; ability to work in a multidisciplinary team.

3.4 The Evaluation Process

This scenario has been independently evaluated to understand how much the digital well-being aspects have been correctly addressed for offering a balanced IE experience. This step has been carried out with a specific questionnaire administered, through a Google Modules Form, involving several stakeholders within higher education context (students, professors, and researchers). This questionnaire includes 4 questions where participants report, in their opinion, to what extent (Completely, Above the average, An average, A little bit, Not at all) the scenario meets the aspects of digital wellbeing (Access and Inclusion, Student Engagement, Physical Discomfort, plus a General consideration). A final open-ended question asks for further considerations. The questionnaire has been introduced by an explanation of the digital well-being dimensions considered, in order to make the stakeholders aware of the meanings of digital well-being.

Twenty participants have been enrolled for the evaluation of the Crime Scene scenario, collecting the evaluation forms from 10 Master Students, 4 Researchers, 3 PhD students, 3 Professors and from 4 countries 15 from Italy, 2 from Netherlands and Sweden, 1 from France.

3.5 The Results of Evaluation Process for Learning Scenario

The learning scenario "Crime Scene Investigation" reached positive evaluation: for the 55% of participants it addressed the digital well-being aspects (Access and Inclusion, Student Engagement, Physical Discomfort) "above the average" ("an average" - 25%, "completely" - 15%). In particular, the better addressed aspect was Student's Engagement with 70% of responders agreeing on "above the average" evaluation. While achieving positive results, the Physiological Discomfort seems to be the aspect with lower score with respect to others ("An average" - 35%), and this has been underlined into one specific comment in the open questions:

> *"It would be helpful to address physiological discomfort mitigation by devising other methods".*

The other comments suggested to focus on the visual aspect of the IE to favour student's attention:

> *"It would be good to consider the visual aspects of the IE. Is it complex and fascinating enough to trigger involuntary attention (instead of directed attention) and does it constitute a larger whole? Do all the elements fit together? (balance between complexity and coherence)"*

and on the collaborative aspects that could safeguard the digital well-being that required further considerations:

"...If the work were to be in groups this may affect digital well-being as the immersion time is less prolonged and there is no isolation…"

"The engagement could be further explained regarding the collaborative part and how it would be tackled when students use HMD".

Finally, one comments raise attention on a possible strategy for guaranteeing a more inclusive IE experience for students with visual impairments (Fig. 3):

"In order to strengthen the inclusion aspect, it would foresee subtitles for students with hearing loss or alternative modality for students with visual impairments".

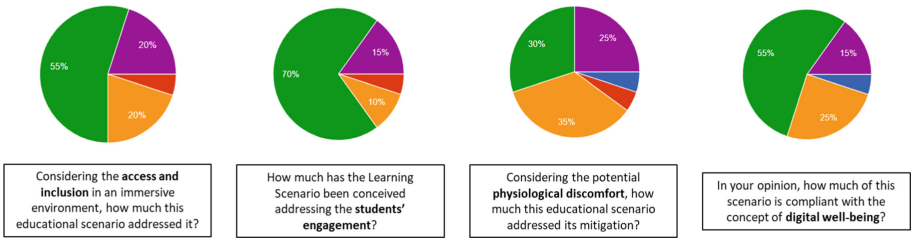

Fig. 3. Synthesis of evaluation for the learning scenario "Crime Scene Investigation". Legend: Blu, *Not at all*; Red, *A little bit*; Yellow, *An average*; Green, *Above average*; Violet, *Completely*. (Color figure online)

4 Conclusions

Presently, the importance of IE in education is rapidly increasing, offering new interesting opportunities for learning in higher education, but at the same time presenting some risks related to their use. In particular, the IE poses some specific issues in terms of digital well-being, such as access and inclusion, cognitive overload, and possible physiological discomfort. Furthermore, it has to be considered that there is a lack of a general methodology and a theoretical grounded approach for the deployment and evaluation of IE for educational purposes. A better understanding of how the digital well-being aspects shall be taken into consideration when designing an educational product requires a multidisciplinary approach considering the different dimension of well-being.

This preliminary work has collected and analysed some up-to-date selected literature identifying and exploring 4 main dimensions: cognitive, physiological, social and educational. Following to the literature findings, a first set of guidelines has been produced and, on their basis, a learning scenario (360° video of a "Crime Scene Investigation") for the use of IE in higher education has been produced.

Although, due to the restrictions posed by the pandemic, this educational tool has not been tested in the classroom yet, the learning scenario has been independently evaluated, by international stakeholders (researchers, teachers, students) for assessing its compliance with the digital well-being in IE.

The results of this evaluation process positive, underlining the compliance of the learning scenario with the digital well-being requirements for an effective IE integration in the educational context, paving the way for future studies of learning scenario testing and refinement.

4.1 Future Perspectives

Several points need to be further deepened. The first is related to the inclusive perspective of IE, since there is a lack of specific guidelines on how to support the learning of students with disabilities in this kind of virtual environment. The second point is linked to the ethical implications that may be derived from the hypothetical adaptation of the IE on the emotional state of the students (confused, bored, frustrated or interested, enthusiastic, stressed…), especially in terms of personal data collection. Finally, it has to be considered the use of interactivity for socialization, exploring the collaborative practices and understanding its possible dynamics, since the virtual collaboration may avoid isolation (especially using HMD) and a long immersion time.

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