SUPPORTING ACADEMIC ENGAGEMENT THROUGH IMMERSIVE TECHNOLOGIES

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Abstract

Academic engagement refers to the overall quality of students' involvement with schooling, including their activities and goals, as well as their connections with peers and educators. Much research has examined the facilitation and support of students' academic engagement within physical classroom settings. However, the field of education has been experiencing a shift from the status quo modus operandi of face-to-face instruction to online synchronous/asynchronous instruction, which has impacted students' engagement. This change has increased the demand to develop and adapt digital technologies that can support the engagement of students throughout online learning processes and their adjustment to the new educational norm. Fundamental research on the development and implementation of immersive technologies could provide a way forward, however we maintain that the development of such technologies needs to be guided by current pedagogical and psychological theories. Hence, in this paper, first we examine empirically substantiated frameworks of engagement and identify aspects that require consideration when developing new immersive technologies. Then, we present a succinct review of the technology-enhanced learning environments literature to determine how engagement has (or has not) been supported through immersive technologies, i.e., virtual reality (VR), augmented reality (AR), and 3D volumetric video. Finally, having embarked on the development of our in-house technology, an immersive 3D video prototype, we present the technology setup alongside the co-creation process that we are implementing to guide its development. Based on pedagogical and psychological research, we highlight several vital factors substantiating students' engagement, including the significance of the teacher's role and the importance of teacher-student and student-student interactions. These factors serve to guide our qualitative data collection during co-creation sessions to uncover students' and teachers' new perspectives of engagement in relation to the affordances that immersive technologies should offer. Our work presents insights to educators, technology designers and researchers about important educational frameworks and considerations directing our development of immersive technologies in support of academic engagement.

Keywords: *Academic engagement, immersive technologies, students, teachers, technology development.*

1. Introduction

Students' academic engagement and suitable strategies to promote it have been well-researched in face-to face classroom settings (Skinner, Furrer, Marchand & Kindermann, 2008). Numerous theories and frameworks are found in the literature informing pedagogical practices (Matos, Reeve, Herrera & Claux, 2018), with much focus on positive influential factors, such as classroom structure, teacher support, teacher-student relationships, constructive feedback, peer relationships, and task characteristics (Fredricks, Blumenfeld & Paris 2004). However, with the accelerated need of online synchronous/asynchronous education delivery, new types of interactions supported by technology need to be established. Many online learning environments have focused on supporting learning performance and management, rather than embracing pedagogical principles (Alqurashi, 2016). Concepts of engagement, social presence and immersion have mostly been associated with gamification approaches rather than learning technologies (Antonaci, Klemke, Lataster, Kreijns & Specht, 2019). We maintain that catching up with the new educational norm, digital technologies and technology-enhanced learning (TEL) environments need to adapt and develop in order to support pedagogical learning processes including the different constructs of engagement. We maintain that immersive technologies offer a wider range of affordances for engaging students in learning activities e.g., full-bodied immersive/interactive experiences beyond text and videos. We further postulate that even though emerging immersive technologies, such as 3D live video streaming (e.g., holograms), are at an early technical stage for wide adoption, it is of outmost importance to involve stakeholders from different fields in the conceptualisation of those technologies. Through the means of co-creation, it is possible for us to discover TEL-native ways of learning, avoiding the bias of only extending pre-existing teaching methods using new technology, and rather utilising what the new technology can offer for supporting engagement, learning and teaching. We have therefore assembled a multi-disciplinary team, consisting of educational technologists, educational psychologists, software engineers and human-computer and child-computer interaction designers to advance 3D live streaming technologies from a technical and a pedagogical perspective using co-design methodologies.

In this paper, we present a theoretical background on engagement as guiding pedagogical construct to inform the development of immersive technologies in educational contexts. We further provide an overview of related work on engagement in TEL. We then outline our current and future work on developing "beyond the imaginable technologies for sustaining remote life"[1], striving to propose a promising approach to TEL, towards supporting academic engagement in different forms.

2. Theoretical Framework

2.1. Academic Engagement – Definition, Models and Associations

Academic engagement is a complex and multifaceted construct and has been well investigated from the perspectives of education and psychology, with most authors agreeing that it can be differentiated into cognitive, behavioural, emotional, and agentic engagement, all of which have a direct impact on students' academic success and well-being at all levels of education (Fredricks et al. 2004; Reeve, 2013; Skinner et al. 2008). According to Fredricks et al. 2004, cognitive engagement refers to students' psychological investment devoted to learning and the usage of self-regulation and learning strategies, whereas behavioural engagement is displayed through rule compliance in the classroom as well as active participation in learning activities and other school related activities. Fredricks et al. 2004 also indicate that emotional or affective engagement refers to students' affective states or reactions in the classroom. Agentic engagement, on the other hand, is seen as students' proactive and constructive contribution towards the conditions and content of learning activities and instruction (Reeve & Tseng, 2011; Reeve, 2013).

As engagement is a prominent educational construct, multiple frameworks and models have been developed to understand how it works. Skinner et al. 2008 present the *Self-System Model of Motivational Development*, explaining the contextual and individual differences through which engagement is fostered in K12 classrooms. In the model, actions result from the interplay of the context and self (e.g., behaviours and emotions), which in turn results in outcomes (e.g., learning and achievement). This model showcases the complexity of internal dynamics (e.g., behaviour and emotions) and external dynamics (e.g., contextual factors such as classroom relationships) of engagement. In the same vein, considering the key psychological role that emotions play in learning and development, Pekrun & Linnenbrink-Garcia, 2012 put forward a model in which engagement is seen as a mediator between students' emotions and their achievements. In addition, Reeve (2013) proposes a model of student's engagement based on Self-Determination Theory (SDT) constructs, called *student-teacher dialectical framework*. The model shows the interplay between the learning environment (e.g., relationships, classroom affordances, etc.) and the quality of the student's motivation (e.g., intrinsic motivation, psychological needs, personal goals, etc.), as moderated by the quality of teacher motivating styles towards the student.

With several factors contributing to students' engagement, we focus on:

Teacher's role. Teacher's support, both academic and interpersonal, has an influence on behavioural, cognitive, emotional and agentic engagement (Fredricks et al., 2004; Cohen, Moed, Shoshani, Roth & Kanat-Maymon, 2020). Engagement is fostered when teachers create respectful and socially supportive learning environments, encourage understanding, and support autonomy; hence, teachers need to focus on both social and intellectual dimensions (Fredricks et al., 2004, Cohen et al., 2020). Moreover, research shows that teachers' effective feedback (i.e., clear descriptions, suggestions for improvement, assistance in reflection) is positively associated with behavioural engagement (Monteiro, Carvalho & Santos, 2021) and emotional engagement (Tvedt, Bru & Idsoe, 2021).

Peer interactions. Perceptions of relatedness with classroom peers, including a general sense of getting along with each other, receiving respect, and not getting teased, is positively associated with

[1]BIT: TIP https://sites.utu.fi/bittip/

behavioural engagement (Mikami, Ruzek, Hafen, Gregory & Allen, 2017). Students who are more accepted by peers show fewer steeper declines in behavioural engagement in late primary school (De Laet, Colpin, Vervoort, Doumen, Van Leeuwen, Goossens & Verschueren, 2015). Furthermore, interview studies showed that primary school students felt high emotional engagement when collaborating on tasks with peers (Parsons, Malloy, Parsons, Peters-Burton & Burrowbridge, 2018), and secondary school students named relationships with peers as one of the most important factors influencing their engagement (Yusof, Oei & Ang, 2017).

From this, the engagement construct as investigated and discussed in the face-to-face classroom environments' literature could be seen from the perspective of the role of interpersonal relationships among students and between students and teachers (this is also in accordance with the social cognitive theory of Bandura, 2005, which indicates that we learn through "social modeling"). Therefore, when developing immersive digital technologies or TEL environments for online/blended learning we must consider how these technologies could support relationships (e.g., supporting social presence (Rötkönen, Suero Montero, Pope & Sutinen, 2021)) that afford the reproduction of complex contextual and interpersonal dynamics, which could foster the evolution of engagement as if it were in the classroom.

2.2. Engagement within Technology-enhanced Learning Environments

Research on technology-enhanced learning (TEL) environments' implementation in K12 education reports, for instance, that collaborative technologies such as Google Docs, Google Classroom and Edmodo are positively linked to engagement (Bond, 2020). A game-based immersive AR environment for first language vocabulary learning has been reported to improve cognitive engagement in 2nd graders (Wen, 2021), where cognitive engagement was analysed in terms of the interactive, constructive, active, or passive (ICAP) framework (Chi & Wiley, 2014). Research also shows that technologies that support freedom of movement could foster higher levels of engagement in/during learning activities, including flexible classroom environments that can be transformed according to the specific needs of the learning activity to promote engagement (Ozkan Bekiroglu, Ramsay & Robert, 2021). Dunleavy, Dede & Mitchell, 2009, for instance, on their study about the affordances and limitations of AR in education report that the interactive and situated narrative alongside the collaborative problem-solving affordances of the AR simulation were highly engaging for students, though an added cognitive burden was also reported in terms of the management of the technology for teaching and learning. On the other hand, the use of immersive virtual reality (VR) in K12 education is relatively limited, with Freina & Ott, 2015 reporting matters of safety regulations as one likely reason for the slow uptake (i.e., the equipment such as 3D goggles is recommended to be used by 13-year-olds and older). Nevertheless, affordances of immersive VR technologies such as easy customisation for specific group of students, simulation of real-life interactions with people, objects and places, and virtual simulation of time in which long periods can pass by quickly, to name a few, makes the use of this immersive technology very appealing in educational environments (Beck, 2019). Yet, considerations in terms of how such immersive technologies should support pedagogical processes and constructs, such as engagement, is still under-researched and not well-understood.

3. Immersive 3D Video Prototype

Figure 1. Left) immersive 3D video prototype schematic. Right) Setup implementation with students ©2022 BIT: TIP.

* *For anonymity, students' faces have been blurred*

Our live sensory immersive 3D video prototype (*Figure 1*) has been created to support the rapid demand of high-fidelity distance learning in order to overcome the limitations of current video conference solutions (e.g., 2D images, limited full body interactions, etc.). Though research exists on immersive virtual learning environments, there is still a need to further research on the development, implementation and educational affordances of immersive volumetric video technology as it is in its infancy (Pope et al. 2020). Nevertheless, immersive 3D video is now possible from a hardware perspective and involves capturing spatial position in addition to colour information so that when an immersive virtual reality (VR) or AR headset is worn it is possible to move around and experience a real remote place and people. This also opens the door to additional affordances, for example mixing real and virtual interactive elements in new ways. With 2D and 3D display screens, e.g., on desktop computers and tablets, the digital and digitised elements can be ubiquitously involved even without a headset. Our prototype consists of a set of stereo or active depth cameras, such as the Intel LiDAR L515, arranged around the edges of a room. The cameras are calibrated and fused together to produce a set of depth maps for the scene, mapping each pixel to a spatial location. These depth maps are then encoded into a regular colour video format such as HEVC using a colour mapping. At the remote end, arbitrary viewpoints can then be rendered from these depth maps in real-time using novel algorithms being developed by our research group. The results are being displayed on a web-based desktop application, and in a Microsoft Hololens 2 to create the immersive AR experience where people appear as holograms. The key challenge is to minimise latency whilst maintaining a stable image given the high level of noise from the cameras.

4. Co-creating New Perspectives of Engagement

We maintain that the development of immersive technologies needs to be guided by current pedagogical and psychological theories in order to facilitate its sustainable integration and uptake in the educational arena. Furthermore, it is important that students' and teachers' perspectives of engagement are taken into account, as they will be the key end-users of the technology when deployed in educational contexts. Instead of focusing merely on present theories, therefore, it is important to gain new insights into how students and teachers conceptualise engagement in TEL environments and to identify what factors are important to them in such spaces.

To accomplish this, we propose the collection of data via multiple methods of co-creation, including interviews, role-playing scenarios and the creative constructions of classroom spaces and agents. To inform the technology development, we opt to focus on behavioural, emotional, and agentic engagement, as we maintain that these forms are the ones most likely to provide ideas for new affordances, as well as being the ones most easy for students and teachers to reflect on and conceptualise. During already implemented co-creation sessions using a role-play strategy, for instance, we examined what aspects of teacher-student relationship, teacher's feedback (e.g., in the form of rewards and praise), autonomy support, and group work were most important for supporting the students' engagement on a given task, as well as the role that the physical classroom space and technology played (e.g., in accordance with the known factors that contribute to engagement). This process was facilitated by physical prompts (e.g., Lego, glasses, cardboard spaces) as well as by our early immersive 3D video prototype. The collected data, thus, will inform the next phase of development, during which suitable affordances will be extracted, i.e., examining which new identified factors can be transferred into the technology and/or how these may be reimagined within the technology. This process will follow a systematic content analysis approach involving the multidisciplinary team.

5. Future Outlooks

Our ongoing multi-disciplinary research on advancing immersive 3D live streaming technologies within educational contexts opens new methodological, theoretical and technical perspectives of TEL, by considering established pedagogical theories and constructs, such as engagement, as well as by involving students and teachers in the development through co-creation. In this paper we have challenged the view that technologies are merely tools serving to enhance face-to face learning. We continue to strive toward developing novel TEL-native learning paradigms built on well-established pedagogical constructs and embracing new affordances provided by emerging technologies that allow for new ways of learning.

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