Virtual Reality: Recent Advancements, Applications and Challenges

Emerging Challenges for HCI: Enabling Effective Use of VR in Education and Training

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6.4.1 Abstract

This chapter considers some of the challenges in providing effective virtual reality (VR) environments for teaching and training, where users are encouraged and enabled to be truly engaged in their learning. One approach is to use inquiry-based learning, linking that to the use of VR as a vehicle for education. This chapter introduces the notion of virtual learning spaces in a more general form and makes the case that a virtual learning space is any online environment where the learner perceives that they are interacting or gaming, and thus can be enabled within a virtual environment. Thus, virtual learning spaces are not limited to bespoke education learning software but can be considered in any context where the user perceives that they are engaging, having fun, and exploring, as can be implemented within a VR platform.

Infotainment or gaming is a potential area that we can exploit to improve the effectiveness of training and learning and is particularly relevant within VR learning spaces. This chapter considers both synchronous and asynchronous computer-mediated communication and virtual and immersed virtual reality to illustrate potential virtual learning spaces. The chapter presents some worked illustrations to show how this could be used with the context of teaching Computer Science.

6.4.2 Introduction

The potential to utilize VR, augmented reality and related technology in teaching and learning is growing as the cost lowers and the availability increases. There are several emerging technologies, though these form a spectrum rather than discrete points as the facilities improve. Display technologies for VR include headsets and CAVES that immerse users in computer-generated environments. These can enable immersive training and education [1]. The availability of domestic mainstream technology means that augmented learning is viable [2]. These can be built using bespoke technologies, though many are now built using game environments, and utilizing game engines, and thus falls into the area of serious games, with learning outcomes intended as part of the virtual experience.

This area encompasses the range of technologies, from VR, virtual worlds, virtual environments, augmented reality through to mixed reality. The opportunity to present these through mobile devices, bespoke headsets, as well as interaction through more traditional 2D and 3D computer screens means the distinction between one and another is decreasing and is reflected in the umbrella term of extended reality (XR) [3].

6.4.2.1 Virtual Reality and Education

The growth of virtual augmented and mixed reality in education is growing, though is still in its early stages in terms of its application and evidence of its impact on learning itself [4]. As the cost of equipment is coming down, and with the opportunity for low cost virtual and augmented reality through mobile devices, the opportunity for the use of this type of equipment is expanding, and becoming more mainstream, with new build schools now routinely including virtual reality studios and capacity, whilst solutions such as Google Cardboard mean that the cost of accessing VR type equipment is no longer a significant barrier. However, the effective use of these approaches is also relatively early in its development, with numerous issues in terms of its usability [5].

VR applications in education encompass the opportunities to place learners in a variety of scenarios, and in particular to let them experience different environments whilst situated in the classroom, with tools such as Google Expeditions enabling that with relatively low-cost equipment [6]. Augmented Reality can similarly offer tools to situate computer-generated content within the physical learning space [7]

One of the challenges from a human-computer interaction (HCI) perspective, is how to effectively design and assess the design of, these learning environments, and how to effectively utilize them to truly enhance learning.

6.4.2.2 Usability and HCI Evaluation

Usability testing approaches for VR and AR are improving, as the field is maturing [8, 9]. However, as learning environments, a challenge is how to effectively assess their effectiveness, both from an HCI perspective (i.e. how usable are they) and from an effectiveness as a learning environment (i.e. ow far do they improve the learner’s knowledge and understanding)?

Usability testing can encompass a range of approaches that can be applied to VR and AR systems. When considering their effectiveness as learning and training environments, this adds further dimensions to consider from an HCI perspective.

One approach to usability, that can allow for rapid evaluation of a range of platforms for learning, is heuristic evaluation [10], which has been adapted and used for the evaluation of learning environments [11], and more latterly adopted for AR and VR environments [12, 13, 14], . One particular aspect of HCI and usability testing for VR/AR applications, is the physical side, both in terms of the interaction, and also in terms of the impact on the user. Side effects – e.g. nausea and disorientation – in VR affect the planning of usability testing, and potentially the focus of the users [15]. Aside from the interaction itself, there is also the issue of how to assess the impact on the learner's understanding and knowledge, i.e. what is the learning gain from using such a platform?

6.4.2.3 Enquiry-Based Learning

Inquiry-based learning [16-19] aims to place the learner at the center of the learning process. They learn in a flexible way, at their own pace, in their own language, following their own paths of exploration and inquiry [20]. In this way, the learner's models of their domain of inquiry develop as they discover new things and expand their vocabulary. This approach to learning does not attempt to impose a set model on the learner but allows them to explore - although it has been noted that this process may need some guidance [21, 22]. It thus differs from traditional didactic approaches, as rather than the learner being a passive receiver, they have autonomy, whilst the instructor aims to provide a stimulating environment, to enable, foster, stimulate, and encourage the learner to follow their own learning route. If a learner finds the learning on their own, as an expansion of their current mental model, they will understand both the language and context of their new learning, what it means to them, and what to do with it within their current cognitive dynamics. A virtual environment —or an augmented real environment—can provide ways to let learners explore the virtual world/augmented real world, thus allowing for true and active inquiry style learning.

One of the big issues in education is motivation. How can we persuade people that learning is important and that it is something in which they should engage? For this reason, people have sought methods and techniques to encourage this participation. Now one area where we see high levels of motivation is computer gaming [23]. There has thus been a great deal of work to try and marry these levels of motivation and encouragement to learn (e.g. WEST [24], Wumpus, WUSOR-II [25-27]. The argument, in essence, is that if we transfer the levels of engagement and enthusiasm for playing computer games to learning using a computer we can better deliver education and the motivation and time spent will deliver better learning outcomes Again, this is an area where virtual reality can be exploited, particularly with 3D game engines providing the toolset to create worlds and utilize game style mechanics to motivate the learner/player.

Another area of high motivation is social computing. As people are glued to games there are also glued to social media with the likes of Facebook, Twitter, WhatsApp, YouTube channels, and other media sharing and broadcasting applications. In all of these, there is a notion of sharing something. In terms of sharing a VR this can either be explicit for example in a serious game where users are embedded in a shared and directly experienced 3D world. The aim in this type of experience is to mimic the real world as closely as possible so the result of the simulation and the type of experience you would have in the real world are a close match. The second type of VR is where we share the same metaphor of reality although it is actually far from believable. Second Life [28] is a good example of this. The culture of online Vloggers is another. Users share the metaphor that this maps onto something real although it is clearly not. There is an element of play here also, in that everyone has to indulge in shared beliefs and a made-up reality in order to make it work. Many VR learning spaces are of this second type. They need not map closely to reality, but as long as the reality metaphor holds up, or the common willingness to pretend that this is the case, then we can behave as if we are in the real thing.

6.4.3 Virtual Learning and Training Spaces

It has been argued elsewhere that humans are fundamentally game players both in nature and culture [29]. In this chapter, we will argue that what is a game is very much in the mind of the person engaging in the activity. Indeed, what is a game that may not be a game to others? Again, we can make the distinction between environments that try to directly reflect reality. For example flight simulation games whereby, they are so realistic that you can actually learn to fly, in contrast many activities may be undertaken and the participants regard that undertaking as infotainment or a game whether the designers of that activity originally intended it to be such. For example, one mental model of the auction house eBay is that of a game that can be played night after night. It clearly is not like a virtual reality auction house, but we can enter into the metaphor and it becomes a virtual one. The gamble is that you get what you think you have bought. The rewards of the game are to get a bargain, and the particular extra rewards are if you have used your skill and domain knowledge to spot something the rest of the world (including the seller) have not spotted. This activity is often called gamification. This is taking an existing activity and turning it into a game. As long as the participants are in a gaming context in their heads then it is a game to them. In this context many everyday activities can be made to be games. With virtual, augmented and extended reality, the scope to utilize an immersive and interactive experience as a way to enable inquiry-based learning, means that this can be done explicitly. A challenge here is to ensure that the intended learning is happening and that this is not lost in the experience itself.

So, a challenge is how to ensure a true virtual learning space within a virtual environment. In some response, any online area that the participants engage with computer-based collaboration can be seen as a virtual learning space. The VR learning spaces may be individual or involve others in a shared experience. If the nature of that shared interaction leads to a learning experience, then we can talk about collaborative learning in a virtual space.

Note that such learning encompasses training too—so the form of learning may be more practical and vocational, rather than academic. Indeed, in many respects, VR/AR/XR is better suited to such vocation focus. Examples of such training are more common, as the cost savings and impact on safety are typically more explicit and greater in value. This can include training fire-fighters [30], wind-turbine engineers [31], as well as pilots [32] as mentioned above.

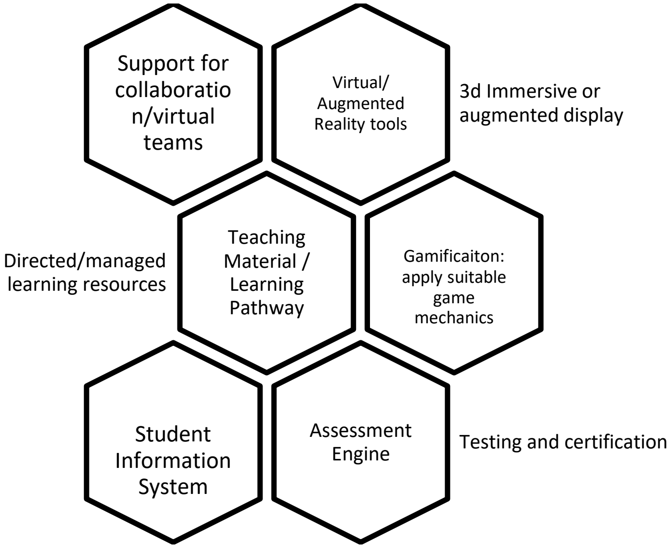

Fig. 1. A framework for supporting learning in VR/AR systems. Adapted from [33].

6.4.4 Integrating XR into a VLE

Effective use of VR/AR/XR in learning and teaching means managing the HCI aspects in two distinct—yet complementary—dimensions; in one dimension, ensuring the HCI in terms of the usability of the virtual environment; in the other dimension, considering the HCI in terms of the educational payload. This assessment of the usability and effectiveness of the system is further complicated by the need to situate it alongside a wider set of tools. For example, Fig. 1 outlines the way that a VR/AR/XR system would sit within a wider framework of a learning platform (VLE), and various functions that support the training/education application context. This can be considered as several layers, with the need to support the VR display and environment, the need to enable and encourage inquiry and exploration, and the requirement to track progress and assess the student (testing and verification).

6.4.5 Conclusions

As discussed in this chapter, inquiry-based learning aims to place the learner at the center of the learning process. By providing a flexible environment for learning, learners can study at their own pace, in their own language, following their own paths of exploration and inquiry. VR and associated technologies offer the potential to create and enable stimulating environments for learning, enabling and stimulating the learner so they can follow their own learning route. Such flexible learning—utilizing game mechanics alongside the immersive/augmented technologies now available—has significant promise in terms of new learning opportunities. Integrating this into/alongside existing training and learning platforms would enable greater use and exploitation of this opportunity. However, ensuring effective design of such systems, in terms of the user experience as both an immersive experience, and as a learning instrument, will require the development of effective HCI techniques to assess both the usability of the virtual environment, as well as the impact on the learning offered by the virtual learning environment: truly immersing VLE into VE.

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