Exploratory 3D Virtual Classrooms for Online Learning and Teaching

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Figure 1: 3D virtual classroom. (a) The welcome scene showing the course handbook and six portals for six topics. (b) The lecture hall scene for each topic, showing the lecture materials. (c) The discussion room scene showing the seminar materials.

Abstract

Due to COVID-19, many classes are taught online, which limits student-instructor interactions, and negatively affects the learning and teaching experience. In this project, we aim to enhance the online learning and teaching experience by proposing 3D virtual classes through emerging technologies. *DES001 Explore Design* is a year one introductory course for design school students at Xi'an Jiaotong-Liverpool University. Taking this course as an example, we present the functional and non-functional requirements for 3D virtual classrooms clarified through questionnaires and interviews with stakeholders. After confirming the requirements, we developed a 3D virtual classroom to support the learning and teaching activities. The system supports web, mobile and immersive VR experiences across devices, and the system design is of high interactivity, compatibility, and customisability. Initial results showed that it is easy to use and effective in engaging students in online learning.

1 Introduction

To facilitate the first-year undergraduate students in their major selection, Xi'an Jiaotong-Liverpool University has introduced 'Taster' courses, covering an overview of the programmes within the schools and allowing students to get familiar with different disciplines. For the Design School (DES), the *DES001 Explore Design* course aims to introduce the domain knowledge covering Urban Planning and Design, Architecture, Civil Engineering, and Industrial Design in a composite course. Due to COVID 19, online teaching is facing the challenge of improvement the students' engagement. Virtual Reality (VR), on the other hand, encourages active, exploratory learning [1]. The learning-by-doing approach in VR has been shown to have a positive impact on student motivation and engagement, especially in exploratory activities [2]. VR will benefit such taster courses because it can (1) attract and motivate student learning in exploratory courses, (2) encourage the learning-by-doing approach and enhance student engagement, and (3) be used as a communication tool for instructors to teach design principles, technology concepts and engineering practices in an interactive way. Motivated by the the potential benefits shown in previous work, we aim to explore feasible ways to engage students in exploratory courses using VR technologies. We conducted interview and survey studies to elicit requirements, and developed a 3D virtual classroom based on Spatial[1]. Initial evaluation results showed that functionalities support in the virtual teaching space successfully met the teaching and learning needs of DES001.

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2 Design and Implementation

2.1 Requirement Gathering

We defined groups of stakeholders and call for expression of interest to get involved in this projects. Stakeholders of this project include instructors of DES001 and students taking or having taken the course. In total, we conducted four interviews with instructors from the four departments and collected twelve questionnaire responses from students. The specification of user and system requirements is presented in Table 1.

Table 1: Summary of functional requirements (FR) and non-functional requirements (NR).

#	Requirements
FR1	The virtual classroom should allow students view learning materials (slides, videos, 3D models, etc.)
FR2	Users need to have their own virtual avatars
FR3	The virtual classroom should allow students to explore
FR4	There should be a variety of forms of interactions
FR5	Ideally the system should have a homework evaluation system, and can be combined with existing teaching software
NR1	The system should support use of VR devices, web, iOS and Android systems
NR2	The scene should not be too monotonous; the interactions should be attractive for students to use
NR3	The system components should be modular, easily adaptable and customisable as required
NR4	The system should be able to host a tutorial session (20-30 students)
NR5	The network latency of the system should not be higher than that of existing mainstream online meeting applications

2.2 3D Virtual Classroom

Based on the obtained requirements, we presented several options for the design and development of the virtual classroom to the stakeholders, including developing the system from scratch using the Unity game engine, and building on existing platforms such as Mozilla Hubs and Spatial. These options were shown with system demos that were evaluated by the stakeholders. In the end, the stakeholders supported the use of Spatial for the construction of the virtual classroom. In this section, we present the results of system development.

[1]https://www.spatial.io/s/DES001-62cdd08976b38c000111f297

2.2.1 Scene Construction

The construction of the 3D virtual classroom follows the course syllabus design. A welcome scene is displayed when the students first enter the scene, displaying the course handbook and six portals leading to the different topics (see Figure 1a), including Urban Planning and Design, Architectural Design, Civil Infrastructure, Architectural and Construction, Industrial Design and Sustainable Design. A lecture hall (see Figure 1b) and a discussion room (see Figure 1c) were created for each of the six different topics. The lecture halls include learning materials that were prepared by instructors in the forms of PowerPoint slides and videos; and the discussion rooms include seminar learning materials such as exercise sheets and tutorial videos.

2.2.2 Functionality Support

The 3D virtual classroom has addressed the requirements specified in Table 1 and achieved the main functionalities.

Topic-related learning materials were built into the scenes (**FR1**, see Figure 2a). Instructors are allowed to adjust the content of these materials and upload new materials. In addition, users can upload their own photos to create 3D avatars (**FR2**). Avatar's skin colour, body shape and clothes can also be customised (see Figure 2b). Users can use the first-person view to move freely in each scene (**FR3**). The portals allow quick switches between the scenes (see Figure 1). In addition to the basic movements, perspective changes, and video chats, the system allows eight preset actions that allow for rich social interactions (**FR4**, see Figure 2c). In terms of **FR5**, our university adopts Mediasite to host online videos. Thus, it has been integrated to the 3D virtual classroom.

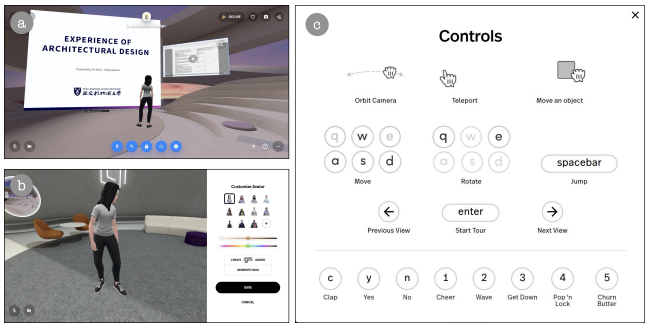

Figure 2: Some functional requirements supported in the 3D virtual classroom: (a) students can view various lecture materials; (b) create their own virtual avatars; and (c) experience rich interactions and socialise with peers.

For non-functional requirements, the application runs with support for VR (e.g. Oculus Quest), web, and mobile devices (**NR1**, see Figure 3a-c). The virtual classroom consists of 15 scenes that structured the lecture content in 3D and allows students to experience rich social interactions (**NR2**, see Figure 1 and 2). The lecture materials and rooms are modularised components (**NR3**). The instructors can customise the position and scale of components, and several other operations (see Figure 3d). **NR4** is met and each classroom can hold up to 50 people online at one time (see Figure 3e). Regarding **NR5**, latency is largely dependent on the users' network quality. We observed poor network connection when the users are located in mainland China without using a VPN.

3 Discussion

The 3D virtual classroom has been put into use and evaluated by 368 first-year students from the Design School at the Xi'an Jiaotong-Liverpool University during the 2022-2023 academic year. Here we briefly discuss the strengths and limitations of the system.

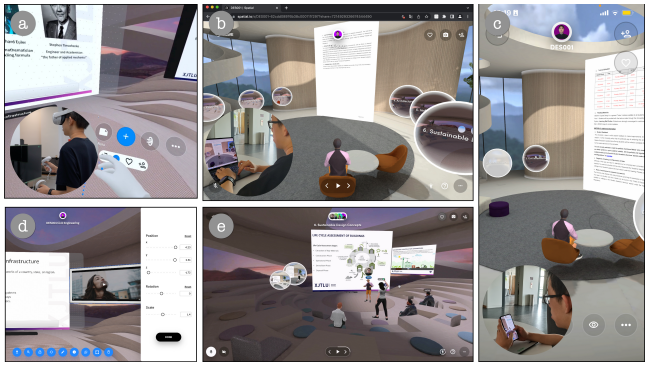

Figure 3: Non-functional requirements supported in the 3D virtual classroom: (a) a first-person perspective from the Oculus Quest 2, (b) a laptop web browser view, and (c) a smartphone view; (d) the editing view of the lecture slides; (e) multiple students using the 3D virtual classroom together.

Easy to use. We prepared manuals and tutorials for students, but found that many could get to use the 3D virtual classroom without any instructions needed.

Highly interactive. Students and teachers can gather in the virtual classroom from a distance. It simulates the onsite learning experience and the rich interactions supported in the system allowed highly interactive online teaching and learning activities.

Cross-device support. Students using web, mobile, and VR devices can join together in the virtual classroom. This is important for an inclusive learning experience.

Increased engagement. Compared to video-based online learning, the virtual classroom created a sense of 'being there' and engaged students in explorations.

Highly customisable. The 3D virtual classroom can be easily adapted for used in other courses. The components in the space can be customised according to the needs of the courses.

Capacity and latency. The system has two major limitations: the maximum capacity for concurrent use is 50 and users may experience latency if the network requirements are not met. These technical issues have a negative impact on the wide adoption.

4 Conclusion

In this paper, we present a 3D virtual classroom for exploratory online learning of a taster course at Xi'an Jiaotong-Liverpool University. The development is based on key requirements obtained through questionnaire and interviews. The 3D virtual classroom as a result of user-centred design has provided an immersive learning environment for students. It has engaged students with different subject areas and helped them better understand different programmes within the school. Our system demonstrated strengths in ease of use, interactivity, compatibility, user engagement, and customisability.

Acknowledgments

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