Towards a Framework on Accessible and Social VR in Education

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Abstract

In this extended abstract, we argue that for virtual reality to be a successful tool in social learning spaces (e.g. classrooms or museums) we must also look outside the virtual reality literature to provide greater focus on accessible and social collaborative content. We explore work within Computer Supported Collaborative Learning (CSCL) and social VR domains to move towards developing a design framework for socio-educational VR. We also briefly describe our work-in-progress application framework, Circles, including these features in WebVR.

Keywords: Virtual Reality, multi-device, multi-user, WebVR, interaction techniques, education, collaboration, CLSL.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Applied computing—Education—Interactive learning environments

1 Introduction

Contemporary education now accepts that learning resides within the cognitive processes of the learner, their bodies, the environment, and in their social interactions [1]. Additionally, there is a strong impetus within learning institutions to make all learning materials more flexible, and thus more accessible, within a Universal Design for Instruction (UDI) framework [2]. This suggests that contemporary virtual reality (VR) learning experiences need to evolve towards including more collaborative experiences [1][3] to enhance learning effects in social learning spaces, and to explore how to make VR content more accessible via a more flexible delivery approach.

In this extended abstract, we overview the pedagogy arguing for more accessible and collaborative learning experiences, with some examples from the VR literature. We then use this knowledge to prototype a design framework to help guide VR developers and researchers towards more multi-device accessible and multi-user collaborative VR learning content, briefly describing our own work-in-progress VR learning framework, Circles.

2 Related Work

Most VR educational efforts are designed upon experiential learning foundations i.e. "improved contextualization of learning" [4]; but we must also consider social learning spaces such as classrooms and museums. The popular Learning Together and Alone instruction framework posits that group collaboration and reflection allow for greater learning achievement [1].

Additionally, to better serve a more diverse range of students (cultural, ability etc.) UDI [2] suggests that all classroom material allows for several ways to be disseminated (e.g. a text document should also be easily readable by a text reader).

Some social VR learning applications include Greenwald et al.'s CocoVerse that allows multiple users to connect in VR to co-create a "3D whiteboard for teaching and learning" [5] and Monahan et al.'s mCLEV-R which includes cooperative learning on non-immersive devices [6].

In non-learning, but relevant multi-device examples, we have Figueroa et al.'s "Heterogeneous Distributed Mixed Reality (HDMR)" that suggests similar performance across various VR platforms and Roberts et al.'s Gazebo building research provides a framework for designing collaborative VR interactions [7].

Common properties within VR learning frameworks include flexible communication and avatar representation; but also, applications that support either HMD or non-immersive devices, though rarely both. In addition, modern VR also tends to focus on HMDs that still trigger cybersickness [8] in many users, and though the use of VR headsets in public spaces is understudied, similar research suggests that "social embarrassment" [9] also lowers VR accessibility. Finally, not all social interactions are necessarily collaborative where "you are linked with others so that you cannot succeed unless they do (and vice versa)" [1]. Fortunately, Robert et al. [7] and Snibbe et al.'s social immersive media [10] suggest methods for socially scalable collaboration.

To create more accessible and social learning framework, to better activate UDI and Together and Alone learning opportunities, it will be important to support multiple forms of VR and a variable number of users within truly collaborative interactions.

3 Towards a Design Framework

Within social learning spaces, it is clear that VR content that can be accessed via multiple pathways and includes socially scalable interactions is advantageous. Below, we can start to form a design framework around these and other more familiar concepts.

Table 1: Early design considerations for socio-educational VR.

Design Principle	Description
Device Accessibility	Support multiple VR types such as desktop, mobile, and HMD to better serve learners with various abilities.
Social Scalability	Should allow for multi-user collaboration and scale to variable group sizes.
Flexible Communication	Include various forms of communication e.g. voice and gestural.
Customized Avatar	Avatars can be customized by the user.
Simple Interactions	Require minimal training within limited control schemes

To develop a more substantial framework, an VR framework must be developed to formally evaluate these principles across various user scenarios. Research questions might include:

- Does the type of collaboration matter? I.e. what effect do symmetric/asymmetric interactions [7] have on learning?
- What kinds of social and non-social interactions work best for users new to VR?

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Figure 1: From left to right, (PC, mobile, HMD) Circles' symmetric object manipulation across multiple VR devices via ray-cast mouse, touch, laser respectively. All rotations/zoom on an X-Y plane interface locked to camera.

4 Prototype Implementation

Our socio-educational framework Circles explores the use of multi-device symmetric interactions (HMD, mobile, and desktop) using basic controls, illustrated in Table 2. Circles is developed using WebVR via A-Frame [11] for multi-device support (see Table 2), and the Networked-Aframe plugin [12] and Mozilla HUBs Janus adapter [13] for multi-user WebRTC communication. Using WebVR allows Circles to more easily be integrated into existing web-based Learning Management Systems (LMSs) used in post-secondary education institutions.

Table 2 : Circles' multi-device Interactions.

Object Interaction	PC	Mobile	HMD
Selection	click	tap	controller trigger
Manipulation	click	tap	controller trigger
Release	click	tap	controller trigger
Snap-turning	keys w/s	Swipe left/right	controller trackpad left/right

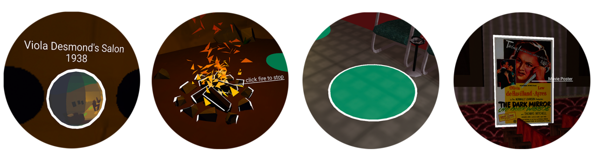

Figure 2: Basic single-click interactions, from left to right: hyperlink portals, click to trigger events, click to teleport to a checkpoint, click to pick-up objects.

HMD support focuses on the low-cost standalone Oculus GO [14], mobile support on Android and iOS devices running Firefox mobile, and PC devices running Desktop Firefox. We are currently in the midst of designing collaborative interactions, so the current focus is on symmetric object interactions that use single click/tap events for ease of use across multiple devices – see Figures 1,2.

In our upcoming formal evaluations, we will measure performance (reaction time, task completion time, accuracy) and preference (qualitative post-experiment questionnaires) for the various inter-device interactions.

5 Conclusion

In this extended abstract, we overview some educational theory to compare with existing VR socio-educational efforts. We find that recent examples often do not take into consideration universal design accessibility and social cognition. We suggest a few design guidelines for designing socio-educational VR experiences for social learning spaces and describe a WIP framework, Circles, working towards incorporating them.

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