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Virtual Reality and Collaborative Learning in Higher Education

A Research Thesis Proposal

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ABSTRACT

For the past forty years, research has revealed many ways in which Computer-Supported Collaborative Learning (CSCL) can be utilized to support and enhance education. Similarly, Virtual Reality (VR) technology has proven promising for different educational purposes. These affordances, however, tend to change when the technology behind them advances; as such, research should continue to examine the effects how these advances affect the pedagogy. With VR technology continuously expanding, its potential for Collaborative Learning (CL) requires further studying. This research project aims to better understand how different aspects of VR can be used to support key dimensions of successful CL. In doing so, the research project hopes to provide guidelines as to how these VR aspects can be implemented to facilitate and enhance collaboration between group members in an educational setting.

KEYWORDS

Virtual Reality, Extended Reality, Computer-Supported Collaborative Learning, Collaborative Learning

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1. Introduction

Since the 1980s, academics have studied how technology can be used to support collaboration in educational settings. Research on Computer-Supported Collaborative Learning (CSCL) has already established numerous affordances for supporting and enhancing education (e.g. Jeong & Hmelo-Silver, 2016; Shawky et al., 2014). These affordances, however, tend to expand, change and evolve whenever the technology behind them do (Ludvigsen & Steier, 2019).

While research into the use of Virtual Reality (VR) in education is nothing new, recent years have seen immersive VR become more technologically advanced, as well as more accessible and affordable. As a result, interest in the use of VR to facilitate learning on different educational levels has been rapidly increasing since (Martín-Gutiérrez et al., 2017). Though prior studies have already studied benefits of applying VR to education (e.g. Concannon et al., 2019; Ferguson et al., 2020) as well as using it for CSCL (e.g. Zheng et al., 2019), shortcomings are apparent. A majority of studies only discusses VR's promise for educational use, yet lacks the guidelines and best practices for adopting and implementing VR into educational settings (Cook et al., 2019; Smith, 2019). Furthermore, most studies discuss the use of "desktop VR", (three-dimensional, virtual environments on a (flat) monitor), whereas the application of Head-Mounted Display (HMD) VR to education has been studied far less frequently despite its potential and immersive qualities (Radianti et al., 2020).

2. Research question

This research intends to acquire a better understanding of how CSCL can benefit from use of VR. Instead of showcasing VR's potential for CSCL, the research aims to examine how different aspects of VR can be used to support key indicators of successful Collaborative Learning (CL). As such, it will focus on answering the following research questions:

How do these three aspects influence CL between group members?

1. How does the visualization of activities inside a virtual environment influence the social modes of co-construction between group members?
2. How do different types of virtual embodiment affect the level of participation of group members?
3. What effect do different levels of control over the virtual environment have on the on-task discourse between group members?

3. Proposed approach

This research will examine the effects of characteristics of VR on dimensions of CL and is based on the work of Weinberger & Fischer (2006) (**Figure 1**).

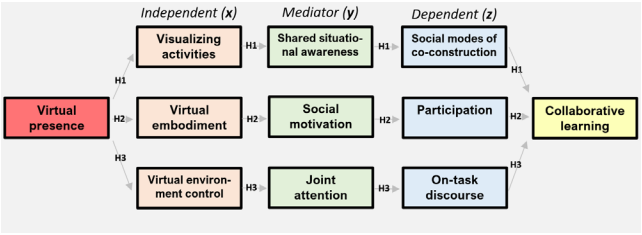

Figure 1: Proposed model for using aspects of (multi-user) VR to support CL

Besides studying the direct effect(s) of the VR aspect (**x**) on the dimension of CL (**z**), the work will study the underlying mechanisms (**y**) that can explain these direct effects. Therefore, the following three hypotheses will be tested to study these mediating mechanisms:

- **H1.** Visualizing users' actions (making them perceptible to each other) (**x**) leads to higher shared situational awareness between them (**y**), in turn providing a higher level of social modes of co-construction (**z**), i.e. a higher level of learners referring to contributions of their learning partners;
- **H2.** Higher virtual embodiment of users (**x**) lead to users having a higher motivation to engage with each other in the virtual (**y**), which in turn leads to higher quantity and heterogeneity in participation (**z**);
- **H3.** When users have a higher control of the virtual environment (both visually and content-wise) (**x**), the shared focus between users (**y**) increases, leading to a higher on-task discourse in the group (**z**);

During the research, a multi-user VR prototype will be developed with which different elements related to CL can be examined. This prototype will be developed in 3 stages, with each stage focusing on testing one of the hypotheses via an experiment. As such, the prototype's framework will revolve around the independent- (**x**), mediator- (**y**) and dependent (**z**) variables depicted in **Figure 1**.

3.1 Visualizing activities and social modes of co-construction

In order to test H1, both a lab trial and an experiment will be performed. The lab trial will use a single-subject study design, focusing on a small group of four members, collaborating remotely within a virtual, three-dimensional environment. The group members will be asked at several points in time to solve (non-domain specific) tasks that do not specifically require collaboration in order to be completed (but might benefit from collaboration nonetheless). During each interaction, different tools for the visualization of activities will be accessible for use to the group members. These tools will include "cones of vision", three-dimensional representations of what is 'seen by the observer's eye' (Astruc et al., 1996) as well as instruments for highlighting points of interest (Horst et al., 2019).

The experiment will expand this approach and apply it to a course in "Forensics Engineering". In both cases, shared situational awareness (**y**) and social modes of co-construction (**z**) will be measured to establish whether visualization of activities (**x**) has effects on the later.

3.2 Virtual embodiment and participation

To test H2, an experiment involving different types of virtual embodiment (**x**) will be performed. These types will range between simplistic, three-dimensional geometrical shapes and realistic, human avatars. The purpose of this experiment is to detect if and to what degree these different forms of virtual embodiment cause social motivation (**y**) amongst group members, as well as to study how this social motivation then influences the level of participation (**z**) between them. The different types of virtual embodiment are expected to also have an impact on the perception of co-players of activities.

3.3 Virtual environment control and on-task discourse

Finally, the third hypothesis (H3) will focus on VR's ability to continuously change users' surroundings to better suit their needs, as well as to scaffold support of and attention towards collaborative tasks and contributions. By allowing users varying levels of control over how their environment is shaped and visualized (**x**), the experiment will revolve around examining how the difference in (control over) the representation of the environment affects group members' joint attention (**y**) and, consequently, their ability to keep communication and collaboration on-task (**z**).

4. Current state of the project

As a first step for this research, a systematic literature review on VR and CL was carried out and the accompanying paper is currently being written. In particular, this review focused on both the educational and technological side of the relationship between VR and CL, as well as how the use of VR for CL purposes has been evaluated in these prior studies. This research proposal is partially conceptualized based on results of this review, focusing in particular on elements that, despite showing promise, have so far not been extensively examined or discussed in prior research, such as the use of HMD-related features like positional tracking and the use of VR controllers to display body language.

5. Expected contributions

Expected contributions to both the field of VR and CL include a better understanding of how recent advancements in the field of VR and the technology behind it affect the dimensions of CL. As the proposed model in **Figure 1** suggests, the focus of this trajectory is not on establishing to what degree VR increases knowledge gain after CL; it primarily focuses on establishing the mechanisms that can explain the effects of certain VR aspects on known dimensions of CL and, in extent, how these influence the CL between group

members. As such, the PhD trajectory is expected to provide guidelines as to how these VR aspects can effectively be implemented to facilitate and enhance these dimensions of collaboration between group members in an educational setting.

6. Next steps

At the time of writing, a paper on a literature review discussing prior research on CL and VR is being written and is expected to have a first draft ready soon. Additionally, the lab-experiment described in paragraph 3.1 is currently being conceptualized. Once both of these are finished, a first version of the prototype discussed in this proposal will be developed so as to use it for the single-subject study.

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