Potential Of Virtual Reality For Teaching And Learning:
an Interdisciplinary Content Analysis

Andrea Adams
James Madison University, adamsah@jmu.edu

Yonghua Feng
School of Education, Henan University, Kaifeng, China
henufyh@163.com and feng2yx@jmu.edu

Juhong Christie Liu
James Madison University, liujc@jmu.edu

Eric Stauffer
James Madison University, stauffem@jmu.edu

Abstract: Virtual reality (VR) brings simulations and immersive interaction that can possibly enable innovative teaching and learning. Its potential for teaching and learning comes along with its complexity and emerging nature. Therefore, an intentional literature review of the types of technology and the initial application can provide a pre-analysis of practices from multiple disciplines, which can lay a solid stage for further applied educational design research. This study has performed an interdisciplinary content analysis of published literature and whitepapers related to VR in teaching and learning in various disciplinary fields. Results are presented with practical suggestions and forward-thinking visions with forward-thinking.

Keywords: Virtual Reality (VR), technology in teaching and learning, Activity System, content analysis

Introduction

Virtual Reality (VR) as a subset of immersive environment, holds the promise to enrich the context of teaching and learning and brings new perspectives. The close-to-real VR settings equipped with facility invent new learning settings through advancements in optical, sensory, and networked technology. These VR applications have been envisioned and piloted to create more engaged learning opportunities and experiences with interdisciplinary, collaborative, and multi-sensory participation (Hsu, 2011; Monahan, McArdle, & Bertolotto, 2008). Studies have also used scenarios where VR has provided a very precise representation of reality for learning and support learners to discover knowledge, and improves learners’ motivation and attention (Alfalahl, 2018; Alhalabi, 2016; Hwang & Hu, 2013). Not only in cognitive development and learning settings, VR has also been used in behavioral science and rehabilitation experiments and studied for its physiological implications (Annerstedt, et al, 2013; Larson, Feigon, Gagliardo, & Dvorkin, 2014; Levinson, Weaver, Garside, McGinn, & Norman, 2007).
VR may be an additional avenue to reach students with the simulative and immersive attributes, but research on design and implementation is lacking. This for-intervention user-inspired applied research (McKenney & Reeves, 2019) is to search answers to the question, What are the potentials of VR to teaching and learning? A content analysis, following a systematic literature search, was performed through stages of preparation, organization and categorization with themes and thematic keywords, and report with contextualized interpretation (Elo & Kyngäs, 2008; Patton, 2005). A thematic analysis was performed (Guest, MacQueen, & Namey, 2011). Along with the content analysis, the authors also conducted the analysis and exploration as part of design-based research of the emerging facilities and applications of VR (McKenney & Reeves, 2019). The results of content analysis and design-based research include the recommendations of key elements for instructional design, the relationships of these elements, and the practical application of these elements for instructors and instructional designers.

**Literature Search**

This study has undertaken a transdisciplinary content analysis of literature on teaching and learning with VR technologies. A series of keyword sets were formulated by practice with emerging VR technologies and interdisciplinary knowledge by a group of researchers, evaluators, and faculty members in the fields of educational evaluation, instructional design, and educational technologies.

Several major scholarly search engines were adopted in this research, including but not limited to ebscohost, Scopus, PsychNet, and Google Scholar, for the interdisciplinary and cross-database searches. Searches were limited within peer-reviewed journals. Since the focus of this research is on the application of VR technology in education and teaching, with an emerging nature, the timeframe of publication inclusion in the search was limited to papers that were published since January 1, 2010.

The searching strategies also included the discrete, combined and recombined set of keywords with the key phrases of “Virtual reality AND online learning”, “Virtual reality AND education”, “Virtual reality AND psychophysiology”, “Virtual reality AND sickness”, “Virtual reality AND cognitive”, and "Virtual reality AND activity system". The search also included the literature on the basis of relevance to the subject areas associated to existing curriculum. The initial iteration of search resulted in a total of 149 published papers.

Since this study was aimed at the potential application of VR technology in teaching and learning, a second filtering was performed by categorizing all the selected papers with their corresponding journals and published keywords in a Microsoft Office spreadsheets. The sorting of journals of their relevance to teaching and learning excluded those paper with loose relevance to the research question. After this secondary filtering, a third-round of quick reading of the papers excluded irrelevant papers based on the following criteria:

1. The paper must include a research study on applications of virtual reality or VR.
2. The paper must report researches on education, learning, teaching, training.

After three iterations of literature search, filtering, screening, and selection, 26 papers resulted in a close-up content analysis. The content analysis was conducted based on the user-inspired
applied research literature analysis (McKenney & Reeves, 2019), with the foci on purpose including main focus, problem statement or research hypothesis, research design and methods, including research context, sample, and data collection methods, research scopes, theoretical framework if there is any, subject areas, VR technologies and key findings.

Thematic Analysis

An applied thematic analysis was conducted by combining coding keywords, themes, and subject areas of the 25 identified VR research papers in a Google Sheet workbook for collaborative identification of patterns and themes (Guest, MacQueen, & Namey, 2011). The researchers paraphrased the patterns of these research studies with a coding table using the applied educational design research key structure components (McKenney & Reeves, 2019). The close review of these papers based on the key structure of applied educational research (McKenney & Reeves, 2019) resulted in the following findings:

Focus

The selected literature focused on several main themes, which include the effective use of VR in instructional design, utilizing VR for knowledge and skill proficiency, and the use of VR to create effective collaboration and communication opportunities. Effective use of VR in instructional design was explored in 11 of the selected articles and focused on aspects such as motivation, interactivity, presence, content/activity design. Six of the selected articles focused on utilizing VR for knowledge and skill proficiency. Literature with this focus explored if and how VR enhances learning. Additional topics reviewed that didn’t align with the main themes and were present in only one article include the comparison of two-dimensional and three-dimensional learning opportunities (Passig, Tzuriel & Eshel-Kedmi, 2016), as well as a review of pedagogies related to gender and VR (Makransky, Wismer, & Mayer, 2019).

Subject Areas

The selected articles mainly focused on multi-disciplinary research and had a general focus. For example, one study focused on the utilization of signaling to transition from a learning management system to a virtual reality activity in an online course (Dodd & Antonenko, 2012). There were fewer articles focused on specific disciplines. Eight of the selected articles included studies or reviews of literature focused on, physical education, science education, medical training, language learning, career and technical education and educational tourism.

VR Technologies

Virtual reality technologies are referred to in various ways throughout the selected literature. Terms that described virtual reality technology include virtual environments (VE), virtual learning environments (VLE), desktop 3D, head mounted devices (HMD), and virtual worlds. Even though there are many ways to describe VR, the two aspects that create diverse learning environments are immersive environments, such as HMD which provides the individual experiencing VR feel as if they are physically in the environment and desktop 3D, which is simulated through a computer monitor and does not immerse the individual’s senses into the learning experience.
Research Design & Methods
Research design and methods found throughout the selected literature primarily focus on 1) action research and 2) literature reviews. The review of literature included a variety of frameworks and learning theories. Frameworks and theories that explored include Flow Theory (Kartiko, Kavakli & Cheng, 2010), Cognitive Theory of Multimedia Learning (CTML) (Dodd & Antonenko, 2012), Mediated Learning Experience (MLE) (Passig, Tzuriel, & Eshel-Kedmi, 2016), Immersion concept (Fowler, 2015; Hedberg & Alexander, 1994), and constructivism (Huang, Rauch, & Liaw, 2010; Lee, Wong, & Fung, 2010).

Key Findings
Overall key findings from the selected literature generally indicate that virtual reality is an effective learning tool. VR can provide opportunities for students to engage in creativity, active learning, communication and group work. Literature also indicates that VR enhances learning outcomes and creates an experiential learning experience, especially for learning instances that cannot actually be experienced by the learner or experiences that would otherwise be unsafe. In addition, several barriers to integrating VR in the learning experience were identified, including a need for higher level technical skills for both students and instructors, cost of equipment and software, high amount of development time, and cybersickness.

Conclusion, Discussion, and Recommendations
Educational application of this unique type of emerging technologies needs to take a transdisciplinary perspective, treat the technology and its message with artifacts in an Activity System, and find the foundation in cognitive science with an understanding of complexity in design (Engestrom, 2000; McKenney & Reeves, 2019). Instructors, learners, learning objectives, outcomes, learning content, VR scenes with respective messages and artifacts, and feedback constitute indispensable factors for the possible creation of emerging learning Activity System. However, reservations on VR sickness, return on cost of facility, infrastructure setup, and physiological implications may hinder VR integration in teaching and learning.

Although the key findings suggest that VR may be an effective learning tool, practical factors continue to be significant barriers to adoption that may prevent the full realization of this type of technology for the purpose of instruction without breakthroughs in the ability to develop and host instructional content. Contributing to this barrier is the lack of a standardized VR platform, or VR learning environment, created for the express purpose of instruction. Generally speaking, access to these platforms is confined to a handful of platforms and each needs it respective proprietary hardware that uses software often purchased through a third-party store. In some instance, VR experiences have been achieved with headsets that utilize smartphones as the conduit for the experience although the developmental or socio-economic level of the student may in many cases create insurmountable barriers for its application.

If the cost and or availability were not factors, a majority of VR content today continues to primarily focus on non-educational content such as games or video experiences that may or may not have instructional value. While new content is continually being developed, educators are still exploring methods to create their own content like the more conventional multimedia of instructional video and digital interactive presentations. Many instructors will remain unsatisfied
as they discover that the development of VR is beyond the technical skills and the lack of a background in the development of immersive and interactive VR settings. Currently, to develop VR content requires not only coding experience but in many cases a team of developers to create even simple learning experience in much less a full simulation. In some cases, faculty may be open to working in an easier form of VR such as 360 photography or videography, but the interaction with the materials may seem to some as not too different from the interaction with 2D still images or video.

Hardware and content concerns aside, in a VR-facilitated learning environment, the decisions and choices made by teachers will be critically instrumental to learning experience (Levinson, Weaver, Garside, McGinn, & Norman, 2007). As instructors conceptualize how students might construct meaning in VR in online courses, a reimagining of interaction will be needed to scaffold experiences within an environment that offers a close-to-real immersive environment which allows learners to learn through interactions with virtual worlds, which may be otherwise impossible (Huang & Liaw, 2018). Feedback can imply merits as well as challenges with VR-enabled interactive mechanism. The dialogue between instructor and learner or learner to learner constitutes the source of meaning creation in the immersive situation of VR. These all invite a reexamination of interaction within these environments.

Future infrastructure of VR-facilitated learning environment and related support can be designed from an Activity System perspective. As illustrated in Figure 1, VR facilitates immersive structure, perception, and experience, based on mediated artifacts, in a learning environment which is an Activity System (Engestrom, 2000; Liu, 2018). There are rules and division of labors to be reformulated in a VR world, for instance, safety concerns in the physical environment because students are fully immersed in the VR space, potential neural and physiological impact to users and alternative solutions to ensure ethical and inclusive applications. There are also the forward-looking aspects related to community-building and alignment with learning outcomes. For instance, reaching, communicating, and collaborating with other users in a VR environment through network connection still remains a to-be-solved issue, restriction of bandwidth, and differentiation between measuring outcomes in traditional classes vs. immersive virtual classes. Content and culture creation, support and training to instructors and students, and cost-benefit analysis concerns community-building, division of labors, and rules in the Activity System. However, the framework helps decision-makers, teachers, researchers, practitioner, and supportive personnel to explore the potential of this emerging and engaging technology in a systemic (not chaotic) way.
Figure 1. VR in Learning Environment as an Activity System (based on Engestrom, 2000)

References:


