BOARD # 17: Students Learning Experiences in VR Laboratories

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Deborah Moyaki is a doctoral candidate in the Engineering Education and Transformative Practice program at the University of Georgia. She holds a bachelor's degree in Educational Technology and is excited about the possibilities technology offers to the learning experience beyond the formal classroom setting. Her research focuses on improving the educational experience of engineering students using merging technologies such as virtual reality and artificial intelligence.

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Nathaniel Hunsu is an assistant professor of Engineering Education. He is affiliated with the Engineering Education Transformational Institute and the school of electrical and computer engineering at the university. His interest is at the nexus of the res

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Dr. May serves as a Professor for Technical Education and Engineering Education Research at the School of Mechanical Engineering and Safety Engineering at University of Wuppertal. His work revolves around generating both fundamental and practical knowledge that defines, informs, and enhances the education of engineers.

His primary research thrust centers around the development, implementation, practical utilization, and pedagogical value of online laboratories. These laboratories span a range of formats, including remote, virtual, and cross-reality platforms. Dr. May's scholarly pursuits extend into the sphere of online experimentation, particularly within the context of engineering and technical education. Prior to his role at the University of Wuppertal, Dr. May held the position of Assistant Professor within the Engineering Education Transformations Institute at the University of Georgia (Athens, GA, USA).

Central to Dr. May's scholarly endeavors is his commitment to formulating comprehensive educational strategies for Technical and Engineering Education. His work contributes to the establishment of an evidence-based foundation that guides the continual transformation of Technical and Engineering Education. Additionally, Dr. May is actively involved in shaping instructional concepts tailored to immerse students in international study contexts. This approach fosters intercultural collaboration, empowering students to cultivate essential competencies that transcend cultural boundaries.

Beyond his academic role, Dr. May assumes the position of President at the ”International Association of Online Engineering (IAOE),” a nonprofit organization with a global mandate to advocate for the broader advancement, distribution, and practical application of Online Engineering (OE) technologies. His leadership underscores his commitment to leveraging technological innovation for societal progress. Furthermore, he serves as the Editor-in-Chief for the ”International Journal of Emerging Technologies in Learning (iJET),” a role that facilitates interdisciplinary discussions among engineers, educators, and engineering education researchers. These discussions revolve around the interplay of technology, instruction, and research, fostering a holistic understanding of their synergies.

Dr. May is an active member of the national and international scientific community in Engineering Education Research. He has also organized several international conferences himself – such as the annual ”International Conference on Smart Technologies & Education (STE)” – and serves as a board member for further conferences in this domain and for several Divisions within the American Society for Engineering Education.

Dr. Cheryl T Gomillion, University of Georgia

Dr. Cheryl Gomillion is Associate Professor in the School of Chemical, Materials, & Biomedical Engineering, part of the College of Engineering at the University of Georgia (UGA). She received her B.S. in Biosystems Engineering with an emphasis in Applied Biotechnology from Clemson University, and she completed both her Master's and Ph.D. in Bioengineering also at Clemson University. Dr. Gomillion's long-standing research interests are in tissue engineering and regenerative medicine. Specifically, the work of her research group focuses on three general areas: (1) design and evaluation of biomaterials for therapeutic purposes; (2) application of materials for engineering tissue systems; and (3) advanced engineering strategies for developing in vitro models and culture systems. Dr. Gomillion is committed to the integration of her biomedical interests with education research endeavors, with a specific focus on evaluating classroom innovations for improving biomedical engineering student learning and exploring factors that facilitate success for diverse graduate students.

WIP: Students' Learning Experiences in VR Laboratories

Introduction

Virtual Reality (VR) laboratories are digital representations of physical laboratories that provide the opportunity to experience life-like scenarios of experimental procedures without requiring physical presence. VR laboratories are particularly effective in fostering student comprehension of complex concepts, validation of knowledge, confidence, and overall engagement through the allowance for multiple practices [1, 2]. Within biomedical engineering education, VR laboratories have been reported to provide students with holistic learning experiences in the absence of physical laboratories.

There have been limited investigations into the impact of VR labs on students' unique learning experiences beyond understanding lab concepts and skill development. Investigations into the influence of VR laboratories on student learning have predominantly centered on comparison studies with physical labs, emphasizing the efficacy of virtual experiences for knowledge acquisition through their accessibility and ability to emulate traditional settings [3]. Furthermore, these investigations are rarely grounded in theory, resulting in a lack of advancement in knowledge on technology usage in improving educational outcomes [4-6]. Similarly, students' perception and beliefs of the utility of tasks within a learning environment greatly influence how and what they perceive, interpret, and gain from the learning environment [7]. Thus, there is a need for theory-grounded studies that investigate the influence of VR laboratories on learners' experiences beyond technical evaluations and comparison studies. Our study addresses this gap by evaluating students' experiences in VR laboratories through the experiential learning theory (ELT) lens. In adopting a theory-driven approach, we aim to uncover insights and strategies for implementing VR laboratories for optimal student outcomes toward adequately preparing students for workplace careers. We adopt a qualitative methodology to answer our research question: "What are students’ experiences when using VR labs for learning?"

We adopted ELT as it provided a framework for assessing VR laboratories as environments that allow for active learner roles through its emphasis on knowledge transformation in addition to knowledge acquisition. This is reiterated in Koretsky and Magana [8] argument for technologies such as VR labs as learning environments that support engaged learning beyond replications of “pallid” traditional environments. ELT defines learning as “the process whereby knowledge is created through experience transformation. The combination of grasping and transforming experience results in knowledge” [9]. The theory posits that optimal learning occurs when learners engage in a four-stage learning model: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE).

Course Description: The Tissue Engineering (TE) course is an elective undergraduate course that provides foundational knowledge for designing and developing replacement tissues for body tissues and organs. The course enables students to connect and apply general sciences (e.g., biology, chemistry, and physics) and engineering concepts they have learned throughout their degree program. Students generally take the course in their third—and fourth-year undergraduate studies.

Laboratory Description: Five of Labster’s commercially available 3D desktop VR labs, cell culture, gene regulation, CRISPR-Cas, tissue engineering, and flow cytometry, were used in this study. In the cell culture VR lab, participants learned to apply good laboratory practices for maintaining a healthy cell culture in a TE lab environment. During the VR laboratory, they worked in a biosafety cabinet and prepared reagents and samples to test the viability of the cell culture and go through the freezing protocol. Unlike a real lab setting, the students could observe the cells' growth in a shorter time. This lab was administered to address the basic concepts of cell culture prevalent in the TE field. We described activities undertaken in these VR labs and their relevance to the course in Moyaki, et al. [10].

Data Collection: The VR labs were administered as a part of the TE course curriculum in the Fall of 2023. The instructor introduced concepts related to the VR labs in alignment with the course objectives during the regular class period. Students were assigned the VR lab, a post-module activity sheet, and an online survey link to gather their feedback on the experience. The survey was designed to collect quantitative ratings and open-ended responses about students' experiences in the VR labs. In the second survey, we included a question asking students to volunteer to participate in interviews to share their experiences and improve future course implementations. We received approval from our institution's Institutional Review Board (IRB) before conducting this research. This WIP focuses on the interview data. We began conducting interviews after administering the fourth VR lab and continued until a week after student usage of the fifth VR lab. We conducted a one-on-one 60-minute semi-structured interview over Zoom or in a physical room at the college, depending on the student's preference. Each interview was audio recorded. The interview protocol included prompts designed using the four-stage learning model of ELT to guide the conversation and garner insights into learners' experiences. For example, under AC, a question such as "*Tell me about the opportunities for peer discussions in the cell culture virtual lab*" was asked.

Participants: Study participants were BME students enrolled in the TE course at a public research university in a southeastern state of the U.S. in Fall 2023. The interview data in this study are based on responses from six out of twenty-six students who volunteered to participate. These students had different levels of experience, ranging from no prior laboratory experience to working as research assistants in biomedical labs. This range of experiences reflects the experience level of the cohort, offering us a representative sample for understanding student experiences. Furthermore, our article focuses on depth rather than breadth, encouraging a thorough exploration and understanding of learners' experiences.

Data Analysis: We use a hybrid approach for our analysis, in which we conduct deductive and inductive analyses. We transcribed the audio recordings of our interview using Otter.ai and cleaned the data to ensure correctness and logical flow. We used the four-stage learning model of ELT as overarching themes for the deductive analysis. Under these themes, we intend to generate codes that capture precise insights into learners' experiences in the VR labs. During our inductive analysis, we will do an open-ended coding to identify overarching themes and recurring codes for learning experiences that do not fit into the ELT learning stages. Data analysis was carried out by the first author. Upon completion of the analysis, inter-rater reliability will be conducted by one additional researcher.

Preliminary Results: We have begun a thematic analysis of our interview data and are currently in the coding phase. At each stage of the ELT learning model, we present a high-level overview of preliminary findings on students' experiences in the VR labs. The sample quotes presented are from different students.

Concrete Experience (CE). This refers to a learner's first encounter with an experience. It is often where fundamental concepts are introduced to learners alongside an opportunity to apply theory actively. We observed learners' descriptions of the VR labs as environments that provide adequate background to concepts, offering them more understanding of the theoretical meanings behind experiments. Majorly, learners' experiences within this stage centered around understanding the why through background information and explanations provided in the VR labs. Thus, in carrying out the experiments, they felt better informed about the theoretical application of concepts. For example, a learner commented, *"So for the cell culture, I feel like what I really took away from it was a kind of a step by step process. And also like, why we were using certain compounds like, then kind of like the reasoning behind each of those processes."*

Reflective Observation (RO). This refers to the stage where activities to spur reflection and discussion among students on concepts from CE are introduced. The goal is to get learners to reflect on their learning experiences to foster more profound reflection. We expected that learners' engagement with experiments would spur conversations in and out of the classroom with peers and the instructor. However, most learners experienced the VR labs as isolated learning environments that allowed for limited reflections and discussions with others. We thus deduced that the individualized nature of the VR lab influenced learners' ability and perceived need for further reflection through peer discussions. Although multiple-choice questions within the VR labs were intended to serve the purpose of reflection, learners failed to experience it. Instead, they saw the questions as a task to get done to engage with other experiments. For example, a learner commented,

"And that's, I think, maybe like, one thing it might have been one thing it might have been like, lacking, because I feel like I just did them all on my own. Like, a lot of my friends are the same. Like you just like sit down at home and like, kind of work through them. "

Abstract Conceptualization (AC). This refers to learners' engagement in creating representations of process flows using real-life scenarios. The goal is to enable learners to connect mentally with concepts learned, activities engaged in, and their real-life application. The visualizations within the VR labs allowed learners to make complete mental connections between concepts as they experienced the theoretical and practical applications of laboratory experiments and procedures. Learners often seemed to skip RO, the second stage in the learning model, to experience AC. They repeatedly discussed moving from awareness of fundamental concepts to visualization of concepts in real-world scenarios. The VR labs situated experiments in real-life cases to enable learners to apply concepts and connect concepts with the real world. Some learners who registered for the course due to its relevance to their future career goals reported having more awareness of the real-world applicability of course concepts. For example, a learner commented,

"And then kind of like showed you the fundamentals of tissue engineering. And then like, how that scaffold, will eventually be used in a patient."

Active Experimentation (AE). This is where learners can apply knowledge learned to the world around them to bring the mental connections made in AC to life. The VR labs mainly focused on teaching experimental processes and procedures and did not allow learners to apply knowledge to the external world. However, assignments and exams allowed learners to apply concepts learned to address real-life case studies.

Future Work

We will conduct in-depth data analysis to gain additional insights into students' learning experiences. In addition to experiences in the VR labs at each stage of the ELT learning model, we hope to generate additional themes that elucidate our understanding of factors, activities, and perceptions that influence student learning experiences in VR lab environments. Upon completing our analysis, we hope to provide findings on the relevance of ELT in describing learning experiences within VR labs while providing extensions to the theory. Open-ended responses would be analysed as part of our future analysis. We focus more on the physical interview data, as the protocol was designed using ELT, and our study uses ELT as a lens to interpret experiences. Data from the post-activity questionnaire, which includes the students' grades, would be used upon completion of the data analysis to explore how student performance relates to experiences.

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