

# **Toward Meaningful Integration of VR in STEM Teaching and Learning: An Ethnographic Case Study**

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## **Abstract**

Virtual reality (VR) has gained increased implementation in higher education with reported benefits of enhancing student learning and engagement. However, there is a lack of qualitative research devoted to understanding the prolonged use of VR, and the social process of how instructor's and students' behavior and perception toward VR develop and evolve. This research conducted an ethnographic case study of a semester-long VR-integrated neuroanatomy course. By triangulating data from classroom observation, student focus group, and faculty interview, the research results suggested that instructional design of VR was heavily influenced by the instructor's personal and educational backgrounds, and their technology self-efficacy. The quality of instruction affected students' perceived value of VR activities and dictated their lived experience in the VR-integrated course.

**Keywords:** VR integration, STEM classroom, instructional design, learning outcomes, student experience, negotiation

## **Introduction and Theoretical Framework**

Virtual reality (VR) has gained increased adoption and implementation in the higher education space with reported benefits for enhancing student learning and engagement (Cromley et al., 2023; Radianti et al., 2020). Researchers were exploring the effect of VR integration in various disciplines (Cromley et al., 2023), however, mostly in a short intervention format (Radianti et al., 2020). Prolonged and persistent use of VR in standard academic semester/quarter systems is rarely documented, indicating a knowledge gap that prevents extensive and institutionalized use of VR across higher education curricula.

### ***Faculty as Change Agents***

The adoption and use of technology innovation such as VR in curricula and professional activities requires substantial investment of time, money, equipment, and most of all, the instructors' personal commitment and courage to try new things (ISTE, 2008). Instructors are change agents in higher education to shift the paradigm and promote more extensive use of VR in STEM classrooms (Kluge et al., 2022; Yang et al., 2020), if they are prepared with appropriate professional development to attain integral knowledge and skills in their professional repertoire (Angers & Machtmes, 2005; Honey et al., 2020).

### ***Integral Knowledge and Skills Required for Teaching STEM with VR***

As suggested by Radianti et al. (2020), many research studies in the literature were conducting course redesign in an experimental setting where VR applications were temporarily or even haphazardly introduced as interventions to explore the educational affordances and impacts of VR. In these scenarios, instructors' engagement in and students' exposure to VR were limited to short intervals with one or multiple sessions. Emphasis has been predominantly on exploring new use cases or seeking preliminary empirical quantitative evidence of VR's impacts through pre- and post-intervention comparisons (Radianti et al., 2020). Very little research, especially qualitative research, has been done with little attention paid to

understand “why” and “how” instructors’ knowledge and skills with VR, the learning contents, and corresponding pedagogical design could affect meaningful learning experience and outcomes, missing evaluation data obtained from prolonged observations where VR was intentionally integrated and consistently used in the curriculum (Angers & Machtmes, 2005).

While the technological, pedagogical, and content knowledge (TPACK) model offers a promising framework to identify the complex, multifaceted, and situated nature of knowledge required by instructors for teaching with technology (Mishra & Koehler, 2006), the actual attainment and realization of such integral knowledge and skills by instructors will take time and persistence, and an iterative process full of progresses and setbacks (Chiu, 2022). Limited empirical evidence and qualitative research has been done in the field of applying TPACK in VR integration. This knowledge gap warrants the investigation conducted by this research study, which aims to unravel the subtlety of changing behaviors of instructors and students by employing an ethnographic case study to interpret a process that is highly complex, and to determine patterns of behavior and cultural themes in the use of VR in the classroom with the goal to provide scenarios of classroom VR integration practices that other instructors may emulate and replicate.

### **Research Purpose and Objectives**

This study explores meaningful and consistent VR integration practices in STEM classrooms based on data from a semester-long lab course in which students explored neuroanatomy concepts and conducted hands-on case studies in a fully immersive VR application. Using an ethnographic case study approach, this research unravels critical roles played by the instructor in technology-driven curriculum innovation and enriches the understanding of how pedagogical design and technological factors impact students’ perceptions and lived experience in the VR constructed learning space. The research urges that meaningful VR integration necessitates the collaboration and negotiation between the instructor and students for learning expectations and outcomes alignment.

The following Research Questions (RQ) guided the investigation:

- **RQ1** (about the designer/instructor): What factors might influence instructors' design during the semester-long VR-integrated course delivery?
- **RQ2** (about the students): What were the experiences from the students during the semester-long VR-integrated lab?
- **RQ3** (about the interactions): How do the dynamics between instructors and students show the factors that contribute to meaningful VR integration in classroom teaching and learning?

### **Method**

#### ***Modes of Inquiry***

An *ethnographic case study* was used in this qualitative research. Ethnographic designs are qualitative research procedures for “the description and interpretation of a culture or social group” (Holloway et al., 2010); and it is “an in-depth study of a culture and studies everyday behavior of participants” (Creswell, 2012). According to Stake (1995), a case study is a unique and in-depth exploration of a bounded system over time. Thus, this method guides the investigation to explore individual STEM faculty’s experiences in integrating and delivering XR into their teaching practices. To conduct the ethnographic case study, we conceptualize individual STEM faculty and their XR integration experience as a bounded system, i.e., the case.

### **Context**

The context of this was a semester-long VR integration in an undergraduate neuroanatomy course at a public school in central California. This is an elective course for undergraduates enrolled in the College of Science and Mathematics majoring in biology, chemistry, health sciences and other related fields of study. The semester-long lab courses included an individual part where students were expected to use a VR application, SyGlass, to learn the gross anatomy of brain structures; and a teamwork part where students collaborated (two to three students per team) on a case study of brain function-related diseases with the goal to understand functional components of the brain, including different pathways and sensory output. The deliverable of the teamwork were narrated case studies in the SyGlass VR environment that could be used as tutorials for future students. 19 students participated in the lab sections. **Figure 1** shows the interface and the user interactions in SyGlass. The participants of this study were the lab instructor and the students in the lab sections in the Spring 2024 semester.

[INSERT FIGURE 1 HERE]

### **Data Collection and Data Analysis**

IRB approval was obtained prior to the study. Multiple streams of data were collected in this research (**Figure 2**). Field observation in the classroom took place in 2024 Spring Semester. Two researchers conducted eight in-person observations of the lab sections. The student focus group, consisting of a total of six students (three from each lab section) was conducted in person with audio recording. The semi-structured faculty interview was conducted online via Zoom for about one hour. Both the interview and focus group audio recordings were transcribed and imported into ATLAS.ti for preliminary open coding. Each observer preliminarily conducted open coding to the field report, and compared the codes through ATLAS.ti, and then the research team conducted thematic analysis (Braun & Clarke, 2006) through axial coding, selective coding and comparative analysis (Glaser et al., 1968; Strauss & Corbin, 1990) following best practices recommended by Saldaña (2021). Three thematic assertions were developed from the data analysis. These assertions are summarized and presented below as results to the research questions.

[INSERT FIGURE 2 HERE]

### **Results**

***Assertion 1: Instructor's belief and self-efficacy in VR, how VR integration related to their prior personal and professional experience with technology, and the support and resources they felt receiving collectively contributed to instructional design (or limited design).***

Through the analysis of the observation and interviews, the theme of personal experiences and beliefs towards VR integration dictated how she set expectations on the VR integration and made assumptions on how students should respond to and perform in the VR-integrated course experience. The instructor had an elite educational background in the subject matter, “*my background is biophysics. So, I had got my bachelor's and master's degree in biophysics, and then I got my PhD in the behavioral neurosciences,*” and cultivated a strong disposition toward technology when growing up observing family members practicing technology, when she shared that “*I always have been there, my dad (was) a nuclear physicist, so I have seen him building lots of things as a kid, I think it's just, I was exposed to that type of lifestyle when I was a kid, so maybe that's why I am like that.*” She had a strong belief in the prospects of technology in higher education, “*I (have) always thought that ... technology is becoming much more involved in our life than we have expected,*” and she was ready to embrace it. The instructor's self-efficacy in technology, and the ability to relate VR integration with her prior experience with technology in teaching and research, e.g., “*I (have)*

*always combined different type of technologies in, enrich and enhance my research,” made the decision to integrate VR autonomous and focused, e.g., “So as you can see, just I always try to enhance the classes with technology or newer ways,” as well as, “I am not using it because it sounds fancy, I use it, it's gonna be useful.” She was confident in and felt proud of what she was trying to do with VR, e.g., “I haven't seen anybody use the VR, in the way that I have done.” Another contributing factor for her determination to integrate XR was the support she felt received, e.g., “I was trying everything to make this happen. We now have the laptops, the license of the app (SyGlass) with a huge discount!”*

***Assertion 2: Student experiences were largely shaped by the extent of reconciliation between their course expectancy/perceived value of VR, and the instructions and expectations from the instructor.***

Compared with the instructor’s passion for VR integration and optimistic expectations on students’ natural acceptance of new technology, analysis of the data from the classroom observation and the student focus group indicated that the lived experiences of students with this lab course and VR technology were convoluted. In a nutshell, there seemed to be a tension or discrepancy between students’ expectancy and perceived value of the lab course (as a required companion of the lecture course), and the imposed effort expectations from the instructor for them to perform tasks in this lab with a new technology they were not familiar with. Students found the lab course description misleading in the amount of VR usage, as their expectation was more dissection and models like a traditional neuroanatomy course, e.g., “So I kind of expected I mean, like everybody else, I kind of expected more dissections,” and “I honestly would have liked if we continued with the I feel like the when we were dissecting it was only the first couple of weeks and then we've fully switched to VR.” This “surprising” emphasis on VR immediately created a sense of mismatch, as students complained, “I feel like the lab did not at all correlate with lecture... it was so different from the lecture. It just didn't really correlate as much, even though it was brain related.”

***Assertion 3: Beyond learning contents and technology, meaningful VR integration needs negotiation and reconciliation between the instructor and students to align instructional design with students’ perceived value of tasks/activities and expectancy for academic success.***

To further dive into the inquiry of what constitutes as meaningful VR integration, insights was extracted from reflection by both the instructor and students, pivoting on the central matter of significance: ***how can expectations from the instructor and students be reconciled and aligned, so the instructional design can scaffold and support the delivery of the negotiated outcomes?*** From students’ perspective, they recognized the potential of technology, with firsthand experience in the VR application that improved their cognitive and hands-on learning. Their frustrations were multifold but mostly centered on the unexpected level of VR usage on tasks that they could not relate to. From an expectancy-value theory (Rachmatullah et al., 2021) perspective, neither students were able to perceive the value from the VR activities, nor did they have the expectancy to perform well with VR, in the absence of clear and sufficient instructions.

## **Discussion and Significance**

The ethnographic data obtained from this semester-long VR experience provided important insights into how technology innovation could be meaningful in STEM classrooms, for both the instructor and the students. The dynamics among stakeholders and the human-technology interaction collective constructed the ecosystem of a new modality or genre of learning and teaching that higher education is starting to witness. A few additional observations maybe worth future research endeavors are shared below:

- Given the instructor’s expertise in the subject matter and proficiency with technology, there is little or limited pedagogical design observed, which largely shaped the students’ experience and their

perceived value from the VR integration, making such integration less “meaningful” for them. Will applying the TPACK framework, especially emphasizing on the technological-pedagogical knowledge (TPK) and pedagogical-content knowledge (PCK) knowledge, in future faculty professional development help improve the integration?

- Despite the deficiency and frustration felt by both instructor and students, there was an interesting consensus that learning objectives were still mostly achieved. This interesting departure between students’ perceived experience (mostly negative) and instructor’s assessment of student outcomes (quite positive) led to some possible future research question: Should we care only about academic outcomes when integrating technology innovation such as VR? Or, to what extent do non-academic outcomes, e.g., engagement, sense of belonging, and career aspiration matter or contribute to meaningful VR integration in higher education?

In all, results and findings from this semester-long study on VR embedded learning environment contributed to a better understanding of the instructor’s decision in adopting and implementing VR, which was heavily influenced by personal, educational, and cultural backgrounds, and self-efficacy in technology. The results also revealed the students’ experience with VR, although suffered from technical challenges, was largely dictated by the quality of instruction received, as well as the degree of alignment between instructor’s expectation and the perceived value by students from performing the VR tasks. A major contribution of this research was the evidence and insights based on direct field observation of the prolonged and extensive use of VR, which provided the desired volume and granularity of actionable information to facilitate a possible negotiation between instructors and students for a common ground to align their expectations on learning experience and outcomes.

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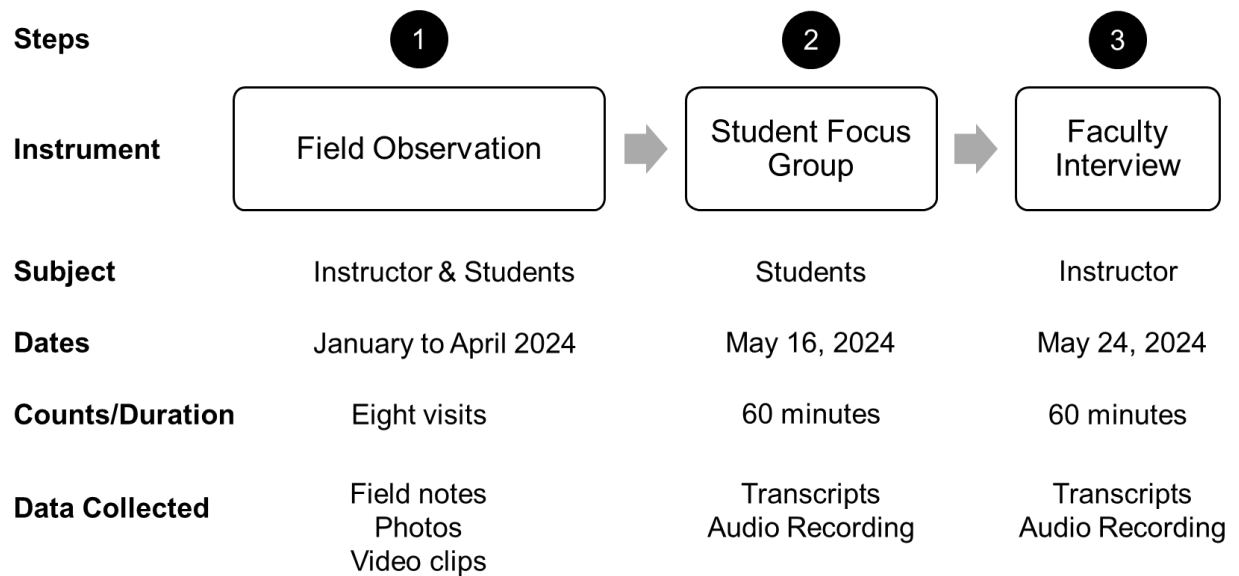
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## Appendix



**Figure 1.** The user interface of SyGlass (left) and a student working in SyGlass with Oculus Quest 2 (right).



**Figure 2.** Ethnographic case study data collection procedures.