The Impact of XR-Immersive Labs on Student Motivation to Learn Kinesiology

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***Abstract*— Kinesiology is an inherently spatial discipline, both physically and visually. The use of Extended Reality-immersive lab activities can enhance student motivation to learn by providing opportunities to deeply interact with visually rich kinesiology content and concepts. Using the instrumental case study method, this paper assesses the use of extended reality immersion across three semesters of an upper division kinesiology course focused on motor control.**

Keywords*— *augmented and virtual reality, games, improving classroom teaching, interdisciplinary projects, pedagogical issues

I. Introduction

Extended Reality (XR) refers to all real-and-virtual combined environments generated by computer technology and wearables, and includes Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR). In other words, XR is the umbrella that brings together these various environments in the reality continuum under one term. Immersive reality, within this continuum, are changing how we learn and experience the world.

XR immersive education is considered a field with massive potential and has evolved from "concept phase" to "implementation phase", that for which pragmatic application is now being used in a variety of contexts. Compared with traditional education, XR immersive education has obvious advantages in teaching theoretical knowledge as well as practical skills training. Not only can students immerse themselves inside these simulations, but they also get immediate feedback on any interactions they may have with the environment. The ability to design complex environments makes XR immersion ideal for providing experiential, constructivist learning experiences [1]. The capacity of visitors to navigate these spaces at their own pace and ability makes them mastery-oriented and student-centered environments in which the instructor is more of a facilitator than a distributor of knowledge. The ability to practice real-world scenarios in student-centered environments empowers students to develop mastery of the content without risk, thus enabling students to engage in both mastery learning and deliberate practice [2, 3]. Through this deliberate and iterative practice, students can attain an enduring understanding of the content. Heighten competence builds student confidence, which is shown to be key component of student motivation to learn [4]. Despite some efforts of utilizing XR immersion in K-12 education, research on XR immersion in the postsecondary environment is very limited [5]. The *Movement in eXtended Reality Lab* was developed at California State University San Marcos to help motivate students and experience hands-on scenarios otherwise limited or impossible in a traditional learning environment.

The theoretical framework utilized in this study was the Attention, Relevance, Confidence and Satisfaction (ARCS) model of student motivation [4]. Student motivation to learn is a critical component of engaging students in the learning process. John Keller's ARCS model asserts that motivation to learn is comprised of the degree to which the learner becomes engaged in the learning experience through elements of attention, relevance, confidence, and satisfaction. To measure those four constructs of the ARCS model, Keller [6] developed the Instructional Materials Motivation Survey (IMMS). The purpose for this study was to determine the extent to which XR-immersive labs would change the students' perception and motivation toward learning in an undergraduate Motor Control and Learning course. Specifically, the aim of the study was to determine attention, satisfaction, relevance, and confidence of the undergraduate students using the XR-immersive labs. Instrumental case study methodology was employed to help identify, understand, and refine how the undergraduate students experienced the XR-immersive labs, and to what extent the XR-immersive labs influence students' motivation to learn kinesiology.

II. Methodology

A. Participants

A total of 135 participants were solicited from an upper division undergraduate course entitled Kinesiology 301: Motor Control and Learning at California State University San Marcos across three semesters.

B. Kinesiology 301

The overall objective of Kinesiology 301 is to develop student understanding of how humans make effective movements. Understanding involves consideration of the requirements for making movements and the factors that make human movement inherently complex. This includes the physics of segmented systems, the muscles involved in various human movement, the physiological properties of muscle, and the nervous system processes necessary to enable and constrain movement.

C. Study Design

The Kinesiology 301 motor control labs were taught in a traditional lab setting. In Spring 2018 pilot testing of the XR immersion occurred with two XR-immersive lab activities. The motor control courses in which XR-immersive labs were implemented included Fall 2018, Spring 2019, and Fall 2019. Table 1 highlights the process of integration of XR-immersive labs by each semester, including the pilot. The immersive motor labs were delivered via the following XR technologies: HTC Vive, Oculus Rift, Microsoft Hololens, Virtualizer Locomotion Platform for VR, and Wii Balance Board.

D. Data Collection

After the final immersive lab content of the semester, the students were asked to write a reflection in response to probing questions about use of XR-immersion in the labs. Additionally, they were asked to anonymously complete an online version of Keller's IMMS [7] in order to assess the students' motivation to learn.

TABLE I. XR IMMERSION IN KINE 301 LABS

XR Immersion	**Semesters**			
	Spring 2018	***Fall 2018***	***Spring 2019***	***Fall 2019***
Addition of XR-immersive labs	1.Intro to VR 2.Balance	1.Intro to VR 2.Balance 3.Upper-body mobility	1.Intro to VR 2.Balance I 3.Balance II 4.Upper-body mobility I 5.Upper-body mobility II	1.Intro to VR 2.Balance I 3.Balance II 4.Upper-body mobility I 5.Upper-body mobility II 6. Learning and memory
Modification to existing XR labs	N/A	N/A	1.Added additional experimental VR conditions to balance lab 2.Added AR/VR comparison in the upper-body mobility lab 3.Increased the activity time for each student 4.Included additional parameters	1.Added additional experimental VR conditions balance lab 2.Added new experimental VR group to upper-body mobility lab
Instructional Materials Motivation Survey	N/A	Collected	Collected	Collected
Student Reflection	N/A	Collected	N/A	N/A

E. Data Analyses

For the IMMS, question ratings in each construct were averaged for a construct score. Mean of four construct scores was used for the overall score. Kruskal-Wallis test was used to compare IMMS scores across semesters. Post-hoc analysis was completed using Dunn's multiple comparisons test, and $p < 0.05$ was considered significant.

Regarding the reflexive analysis of the qualitative data, provenances were used to track the source location of each datum. The tracking of the data was important to ensure integrity and trustworthiness of the qualitative assertions being reported. A quasi-inductive approach [8] was used, which allowed the selection of IMMS constructs as pre-determined themes before the sampling and coding process. The data analysis consisted of open and selective coding. First, data were transcribed and initial labeling of data occurred (i.e., open coding). The second step of the qualitative analysis included rereading the transcripts to confirm, reject, or modify the initial themes and assertions (i.e., selective coding). In addition, during the selective coding step, transcripts with the themes/assertions were read by another higher education colleague (i.e., peer debrief) to ensure the confirmability of the coding/analysis process.

III. Results

Findings from the IMMS and student reflections suggest that XR-immersive labs increase students' motivation to learn compared with traditional instructional heavy methods.

A. Student Motivation to Learn

Table 2 exhibits mean, minimum, and maximum scores for the four IMMS constructs as well as the overall score. The results showed statistically significant improvements on confidence and relevance mean scores. There was also a statistically significant difference in overall learner motivation as measured by the survey across semesters.

B. Students' Attitudes Towards XR-Immersive Labs

Complementary to the findings from the IMMS, analyses of the student reflections revealed students' attention, satisfaction, content-relevance, and confidence with the course material was perceived as enhanced with the use of XR in Kinesiology 301. Students generally said that XR-immersive labs were "more engaging", "more fun", and "enhancing their learning". For example, one student wrote:

> "I have found that I learn the material much better [*attention*], because I enjoy doing the VR labs [*satisfaction*]. Since I enjoy doing the VR labs this makes me more motivated to learn the material presented in both lab and lecture [*relevance*]. In regards to my future, I can definitely integrate some form of VR into my career [*confidence*]." (Q2, S9)

IV. Discussion

In this study, we integrated XR-immersive labs to a kinesiology course: Kinesiology 301 Motor Control and Learning. Over the four semesters, we increased the number of lab modules that include XR content and pedagogy, and modified the existing ones based on student and instructor feedback. We found overall increase in students' motivation to learn in the Fall 2019 compared to Fall 2018. Additionally, three of four individual construct scores (attention, relevance, and satisfaction) and the overall score from the final semester were higher than 4.0 indicating that the XR-immersive labs are motivating students to learn kinesiology [9]. Students' reflections supported the survey findings. Altogether, this study supports the claims about the effectiveness of XR-immersive education on students' motivation to learn [10] and refutes the notion of immersive experiences distracting students from the learning task [11].

A. Challenges Encountered

One of the challenges we faced during XR-immersion was the limited XR equipment available in our labs. Insufficient quantity of virtual reality headsets resulted in high waiting times for students. Over the semesters we were able to increase the amount of equipment in our labs. Additionally, we started to divide the students into groups of four, and giving separate roles to each student within the group (e.g. spotting the person wearing the headset, recording data, assisting in completion of the task by providing verbal feedback to VR user, etc.). These strategies solved the problem by reducing inactive time of students and enabled them to be engaged with the experiments even outside of the XR activity.

Another challenge we ran into was the lack of available content in XR for kinesiology education. We adapted commercially available games into experimental procedures and developed our own applications over the last year. As developing content is very time and labor intensive, we see this as one of the biggest obstacles in promoting the use of XR currently in kinesiology education.

B. Limitations

One limitation of this study is the lack of data on student motivation for kinesiology learning in Kinesiology 301 course without the XR immersion. Even though we are able to see the improvements in student motivation from minimal implementation in the first semester to the final semester, the claims made in the study could have been stronger with inclusion of pre-XR-immersion survey data, or of a control group.

C. Conclusions

This study demonstrates improvement in students' motivation to learn in response to XR-immersive labs in a Motor Control and Learning course in Kinesiology, and therefore proposes adaptation of XR-immersive labs as a viable alternative to traditional labs within this field. Finally, our work adds to the exchange of processes for adoption of XR immersion in higher education within the Kinesiology field. Finally, higher mean scores across all dimensions of the IMMS in Fall 2019 may suggest that instructor experience using XR-immersive labs may also positively impact overall efficacy and student motivation to learn.

TABLE II. INSTRUCTIONAL MATERIALS MOTIVATION SURVEY SCORES

IMMS Scores	Semesters		
	Fall 2018	*Spring 2019*	*Fall 2019*
Overall[a]			
Mean ± SD	3.87 ± 0.64	4.11 ± 0.48	**4.23 ± 0.51**[b]
Minimum	2.67	2.91	2.94
Maximum	4.94	4.94	4.94
Confidence[a]			
Mean ± SD	3.53 ± 0.68	3.88 ± 0.54	3.91 ± 0.57
Minimum	2.11	2.67	2.67
Maximum	4.89	4.89	5.00
Attention			
Mean ± SD	4.05 ± 0.79	4.31 ± 0.49	4.43 ± 0.54
Minimum	2.91	2.82	3.08
Maximum	5.00	5.00	5.00
Satisfaction			
Mean ± SD	4.06 ± 0.80	4.15 ± 0.55	**4.39 ± 0.64**[c]
Minimum	2.33	3.17	2.17
Maximum	5.00	5.00	5.00
Relevance[a]			
Mean ± SD	3.86 ± 0.58	4.04 ± 0.60	**4.21 ± 0.58**[b]
Minimum	2.89	2.78	2.89
Maximum	4.89	5.00	5.00

a. p,0.05, Kruskal-Wallis test

b. p<0.05 compared to Fall2018, Dunn's Multiple Comparison test

c. p<0.05 compared to Spring2019, Dunn's Multiple Comparison test

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