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A Virtual Tour of the Cell: Impact of Virtual Reality on Student Learning and Engagement in the STEM Classroom †

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INTRODUCTION

Virtual reality (VR) is an immersive experience designed for users to explore a digital overlay that is completely independent of their true surroundings. The user is provided with a VR headset (often called a Head Mounted Display [HMD]) providing visual and audio stimuli and multiple sensors that track physical movement in relationship to a virtual world. Virtual reality is widely used in the gaming industry and has steadily extended to a variety of fields, especially the healthcare industry. Virtual reality is now used by patients, including autism and Alzheimer's patients as a form of therapy (1–5). Similarly, VR is also used in the education of healthcare professionals, for example to practice surgeries and dental work (6–9). Virtual reality in healthcare is highly represented in the primary literature. However, there are relatively few publications on VR in the undergraduate STEM classroom (10–13). It is also uncertain how many colleges and universities have begun to use VR in the classroom.

A recent international study indicates that active learning in STEM classrooms is rare compared with the lower-impact traditional lecture (14). An immersive VR experience which allows students a hands-on approach to interacting with the subject matter can provide students with a unique active-learning experience suited to a variety of STEM topics. Cell biology is a challenging course, and this is greatly exacerbated by the fact that the cell is so tiny that the parts cannot be viewed in a typical light microscope. The concepts are therefore abstract and difficult to visualize. Virtual reality gives students the ability to "travel inside the cell" and even "handle" organelles that would only be one micron or less in a real eukaryotic cell. Here we describe the very first in-class use of VR at our university and the educational benefits derived from providing students with the experience as part of a STEM laboratory period.

PROCEDURE

The sophomore-level cell biology class of 65 students participated in a freely available virtual reality experience called "Journey Inside a Cell" created by The Body VR (http://thebodyvr.com/products/) using the HTC Vive platform at The Point (Otterbein's new STEAM Innovation Center). The students were divided into three laboratory sections of 19 to 25 students. Two HMDs were available for student use with the Journey Inside a Cell module, providing a virtual, immersive guided tour of the cell that lasts approximately 12 minutes, including opportunities to interact with the cell and its component organelles. For example students could manipulate cell parts by "handling" them with the controllers, a set of hand-held wands that allow the user to interact wirelessly with the virtual surroundings; and at the end students could "shoot" antibodies at an oncoming "viral assault."

The students followed their VR experience with a timed cell-sorting challenge, working in teams of two to match printed VR cell parts with the correct labels. Each student was rewarded with candy for their participation, and the fastest matching team in each lab section was awarded a "Cell Challenge" trophy made by engineering students at The Point. As students waited for their turn, they worked on computers to design their own concept map of the cell, connecting nodes about the various organelles and their functions (Appendix 1). The use of VR in conjunction with the concept mapping and cell sorting activities was designed to provide a multi-modal, multi-sensory, engaging experience.

A week later, students were asked to complete a voluntary survey administered through Qualtrics survey software. The short survey included yes/no, open-ended, and Likert scale questions asking students to describe their perceived VR experience, cell-sorting challenge activity and whether they felt it had impacted their learning (Appendix 2).

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SAFETY ISSUES

Students were not required to participate in the VR activity, and were told that they could watch a video of the VR journey instead if they felt uncomfortable participating or were unwilling or unable to participate in VR. They were also told that they could stop the VR activity at any time point if they felt motion sickness or had any other sensory issues. This particular program did not have any scary or particularly startling imagery. Students could stand still or even sit, if they preferred. Participating in VR (or watching the 2D film instead) was part of the required laboratory period. This research complies with federal guidelines and received institutional review board approval.

RESULTS AND CONCLUSION

A total of 62 undergraduate students in the sophomore-level cell biology course at Otterbein University completed a survey following the VR lab. The survey was designed to assess the impact of full immersion virtual reality on student attitudes toward cell biology and learning about the cell in a cell biology course. The majority of students had never experienced VR in any form before this lab (43 of 62 students or 70% responded that they had never experienced VR outside of a classroom setting). One student responded that they had experienced VR in a classroom setting before this. When the students were asked "Did virtual reality enhance your learning experience in the cell biology course?," 93% of respondents chose "yes" and only 4 (6%) chose "no" (Fig. 1A). Respondents who chose "yes" were then asked to describe how virtual reality enhanced their learning experience. A complete list of explanations is included in Appendix 3. Most responses could be grouped into the following categories: 1) increased interest, 2) better understanding, and 3) new perspective. Students were also asked to describe in two or three sentences the very similar question of "How did the use of virtual reality reinforce your learning about the cell parts? Students gave similar, but expanded, answers that are included in Appendix 3.

Students responded to a question that addressed the combination of the virtual reality experience followed by the cell-sorting challenge activity. Forty-four students (71%) answered "yes" to the question, "Did the combination of virtual reality and the timed cell-sorting activity improve your understanding of cellular processes?" (Fig. 1B). Extended student responses for this question primarily mentioned that the cell sorting activity helped them to recall, process, and reinforce the VR activity. When asked "Would you recommend this type of virtual reality classroom/lab activity to others?," 55% of students strongly agreed and 37% agreed (Fig. 2A). Only 5% and 3% were neutral or disagreed, respectively. No students strongly disagreed. When asked if the students would recommend the use of innovative learning tools like virtual reality in their other courses, 52% strongly agreed, 43% agreed, and 5% were neutral (Fig. 2B).

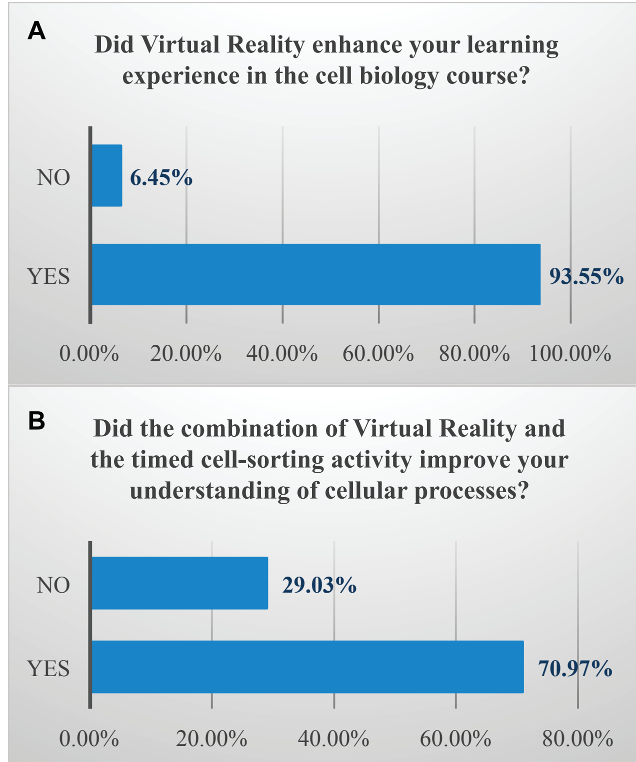

FIGURE 1. Student answers to "yes/no" virtual reality (VR) survey questions. A) Percentage of students who responded "yes" versus "no" when asked whether VR enhanced their learning experience in the cell biology course. B) Response to survey question asking students whether the combination of VR and a timed cell sorting activity improved their understanding of cellular processes.

No students disagreed or strongly disagreed. The positive impact on student perspective, interest, and engagement is readily apparent from the survey. Additionally a perceived impact on ability to better understand the material was widespread. Future assessments will be required to verify this additional outcome as more than a perception.

The described activities can be easily repeated at other institutions. Immersive technologies continue to evolve and the cost for both hardware and software (apps) continues to drop as more companies enter the market. For example the free VR app used in this article is now available for both Samsung Gear VR and Google Daydream, which are more accessible than the HTC Vive that we used.

SUPPLEMENTAL MATERIALS

Appendix 1: Cell concept map assignment
Appendix 2: Student VR assessment survey
Appendix 3: Student survey results

ACKNOWLEDGMENTS

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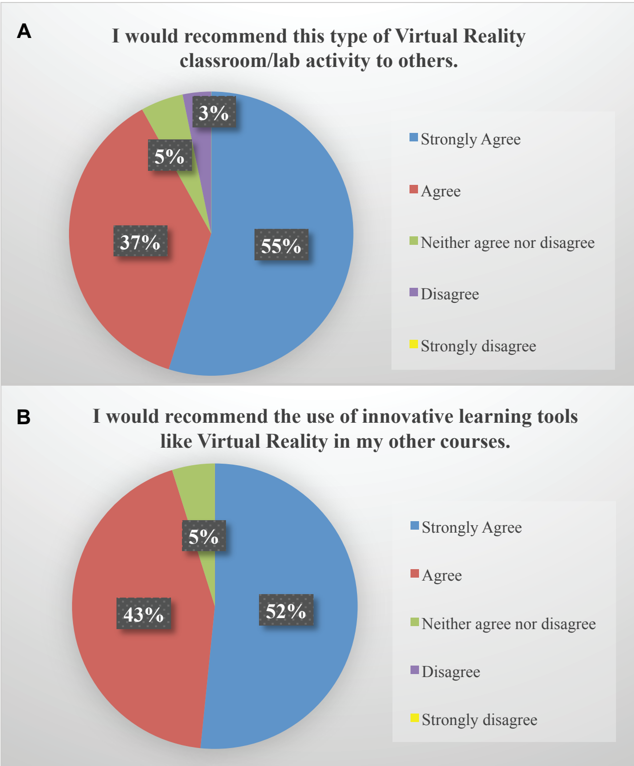

FIGURE 2. Likert scale responses to virtual reality (VR) survey questions. A) Answers to whether students would recommend the VR classroom/lab activity to others. B) Likert responses for whether students would recommend innovative learning tools like VR in their other classes.

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