Creating and Utilizing Virtual Reality and Video Demonstrations to Support Student Learning and Understanding of Geoscience

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Abstract

The text of the abstract should be maximum of 350 words and written in italicized text, using Arial 10-point. The paragraph should be fully justified. Please leave one blank line after the abstract, then start writing the main text. We examined the impact of geoscience demonstration and virtual reality field trip videos on student assessment confidence, performance, and their overall attitudes towards learning geology using a mixed methods sequential explanatory design. Participants were 111 undergraduate students enrolled in an introductory geology course in one of four consecutive semester offerings. Repeated for 13 videos, students would watch a video and answer select-response questions. Then during a later exam students answered questions specifically associated with the video content while also rating their answer confidence using a ten-point scale. Open-ended student comments were collected from a four-question survey at the end of each semester. Findings of student responses to four of the videos suggest that the use of the demonstration videos and VR field trips had a positive impact on student learning of geological concepts. Qualitative findings affirmed the voice and personalization principles of the Cognitive Theory of Multimedia Learning.

Keywords: *Demonstration, virtual reality, geoscience, Cognitive Theory of Multimedia Learning, learning, confidence, visualization*

Introduction and Background

Video-based educational resources are well suited to explain the dynamic nature of geosciences. Visualizations can increase student control of learning, and serve as a means for self-assessment, that can lead to improved student achievement [1][2][3][4]. For students with limited science backgrounds and experiences, the use of instructional video may raise the students' level and depth of understanding, awareness, and appreciation of geology that a textbook simply cannot do [5][6]. Instructional video may help to positively impact student learning outcomes and performance, as well as self-efficacy and attitudes toward learning geology [7]. Experience with virtual reality to visit significant geologic locations can also provide an increased level of interest, enthusiasm, and appreciation of geology [8][9][10], as well as gains in geological content knowledge [11][12].

The Cognitive Theory of Multimedia Learning outlines video design principles that when implemented tend to lead to better student learning outcomes [13]. Well-developed video resources provide instructors with a flexible tool to assist with instruction. The development of a rich supply of video resources provides another pedagogical tool for instructors engaged in virtual teaching. With in-person instruction, they can support a flipped classroom model and allow instructors to devote class time to explain challenging concepts, check for understanding, and promote active learning environments, all of which can improve student performance [14]. Virtual reality tools provide instructors with an opportunity to customize the learning experience and take students on a tour of locations they might not otherwise be able to visit.

Drawing on the theoretical foundations of the Cognitive Theory of Multimedia Learning, we will share the results of a mixed methods sequential explanatory design that answers the questions:

1. What impact do instructional video demonstrations and virtual field trips in an undergraduate introductory geology class have on student learning and performance,

2. Does the use of videos as a learning tool improve student confidence and attitudes towards learning geology, and why?

Methodology

Participants were 111 undergraduate students enrolled in an introductory geology course in one of four consecutive semester offerings. Repeated for 13 videos, students would watch a video and answer select-response questions. Then during a later exam students answered questions specifically associated with the video content while also rating their answer confidence using a ten-point scale. The results presented here are focused on four of the videos – two instructional demonstrations, "Relative Time Sandwich" and "Milky Way Tectonics" and two VR field trips "Crater Lake" and "Yosemite." Open-ended student comments were collected from a survey at the end of each semester including questions: How does learning from the videos and VR trips compare to reading from a text or viewing a PowerPoint slideshow? Explain; and What were some specific aspects in any one of the videos that appealed to you to assist your learning? Or was there some aspect that was general to the whole slate of videos that appealed to you and assisted your learning?

Video Design

The demonstration and VR field trip videos investigated in this study applied numerous CTML design principles. The demonstration videos were hosted and performed by the course instructor along with multiple student assistants in order to break down the "fourth wall" to talk directly to the intended audience. The VR videos were created using an HTC Vive virtual reality headset and Google Earth VR. The instructor used the tools to narrate a customized tour of geologic features that students would not otherwise be able to visit. In both video styles, the use of human narrators incorporated the embodiment, personalization and voice principles of CTML. The demonstration videos used common everyday items including foods that students are likely to be familiar with as analogies to more complex geologic concepts and processes. Because the narrators in both video styles were discussing the concepts as they were displayed, the CTML principles of modality, temporal contiguity, and to a lesser extent signaling were incorporated in the videos. Both video styles made use of text pop ups to share key vocabulary and definitions as those terms were introduced but did so in a way that still met the CTML design principles of spatial contiguity and redundancy. Finally, the users had the ability to pause or rewind the videos which were also only 7 to 12 minutes in length, which addressed the segmenting principle.

Results

Results from the quantitative data analysis showed that participants' overall performance on the two items from the Relative Time Sandwich video changed very little following their viewing of the demonstration video to taking the exam. There were no statistically significant differences between the video and exam, which we attribute to the high number of students who had already performed well in responding to questions after viewing the video. The same is true for the first Milky Way Tectonics item about the lithosphere-chocolate analogy. However, the exam confidence level mean for both Sandwich items were both rather high (8.5-9.0 out of 10), which are notably higher than the first Milky Way item (about 8.0 out of 10). This confidence mean may have been lower due to the perceived binary choice in responses to the exam item (with either lithosphere or asthenosphere as likely correct choices). The correlation to students' responses about their preference and ease of learning from the videos, being visual learners by watching their instructor perform the demonstration may have assisted in their strong scores in both the video quiz and exam items. Specifically, the inclusion of a human narrator addressed the CTML design principles of embodiment, personalization and voice which likely also contributed to the high student scores.

The second Milky Way item results showed the greatest change in all the questions analyzed for this research, and the change was statistically significant (0.000), with a high confidence level (>8.5/10). Analysis of the qualitative data responses identify the use of analogies (in this instance caramel nougat being the asthenosphere), and using a food students may be familiar with, may have instigated this change.

The two Crater Lake items also showed statistically significant changes from the video quiz to exam, as an increase of 20 students were able to identify Crater Lake as a caldera correctly on the exam, an increase of 12 students were then able to reason that the eruption must have been cataclysmic in nature in order to create such a feature. Their reported confidence levels were reasonably high (~8.5/10) for both Crater Lake exam items. When correlated with students' survey responses, we can infer that the virtual field trip to an actual well-known caldera that students have not seen or visited before, and the exploration of the Crater Lake caldera by flying over and around it using Google Earth, may have helped in their understanding of the feature and process that created it. However, neither of the Yosemite items showed statistically significant changes. Both items had already been highly successful on the video quizzes so a dramatic shift in the number of students answering correctly would be unlikely.

The confidence level of students is also a revealing variable, with the marked drop in confidence levels of students who got the item wrong on the exam, and who had answered the same question correctly after the video quiz. The confidence level mean of this small cohort (right quiz-wrong exam) is always the lowest, in some cases by several points, as with the second Yosemite item about the type of weathering the rocks are experiencing. This lower confidence, combined with the incorrect response, may indicate they did not recollect the information from the video, and thus were unsure of the correct response couple amongst the distractors.

Results from both the quantitative data and quantitative data analysis showed that the use of the demonstration videos and VR field trips had a positive impact on student learning of geological concepts. There was a distinctly overall strong performance and generally high confidence level, especially pronounced after the exam items. Based on the survey results, participants' content knowledge did indicate some significant gains. Thematic analysis and interpretation of student responses showed that participants generally enjoyed their experience using the demonstration videos and VR field trips as a learning instrument, with several reasons as to their positive impact on student confidence levels in understanding geological concepts, and their appreciation of geology by allowing them to see processes and concepts demonstrated and to visit geologically significant locations.

Recommendations

We strongly recommend that geology instructors, or any science instructor, develop their own instructional demonstration videos as a means for improving conceptual understanding amongst their students. Reaching out to a school's digital media center or video production unit can provide instructors the opportunity and assistance to create more dynamic, engaging, and interactive learning experiences that allow students to learn and think critically about different aspects of our Earth, their place in it and how they may affect it. This may lead to increased levels of science literacy, as well as a greater value students place on our planet.

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