Geoscience Videos and their Role in Student Learning

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Manuscript accepted by Journal of College Science Teaching, January 2017

Introduction

Blended and Flipped Classrooms

Blended learning environments attempt to integrate online instruction and in-class lessons into a cohesive student learning experience. These environments have the potential to eliminate time, place and situational barriers to learning while enabling significant interactions between students and online resources (Kanuka, Brooks and Saranchuck, 2009). Specifically, blended courses have the potential to offer students a greater range of opportunities that enhance the learning experience beyond that of either online or face-to-face techniques alone and can offer experiences that are not available in traditional classrooms and that the combination of these different experiences promotes learning (Ramsden 2003; Oliver and Trigwell 2005).

The flipped classroom can be defined as an education technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom (Bishop and Verleger, 2013). Essentially, it represents a type of blended learning environment where students take responsibility for learning some basic content prior to class (Gross et al., 2015). This allows instructors to present some content before class so that class time can focus on challenging concepts or more sophisticated learning processes (e.g., synthesizing, analyzing) that would traditionally be presented as homework (Bliuc, Goodyear, and Ellis, 2007; Jeffrey et al. 2014). This instructional model prompts students to review material earlier and more often than in the standard note-taking
method characteristic of traditional lecture-style courses. Gross et al. (2015) reported that students approached a flipped course differently, they were more engaged with course material, persisted in their learning through more timely and accurate preparation, and, performed better on homework assignments and exams. Further, by moving part of the instruction outside the classroom, it provides instructors with time in class to incorporate active learning strategies that have been shown to decrease attrition and improve student performance (Handelsman et al., 2004; Manduca et al., 2010; Singer et al., 2012; Tewksbury et al., 2013; Freeman et al., 2014).

Effective videos employ a mix of visual, audio, and temporal cues to transmit information that may be otherwise difficult to convey through a textbook (Tantrarungoroj, 2008). The use of appropriate video resources has the potential to increase students’ attention and engagement (e.g. Green, et al., 2003; Zhang et al., 2006), increase motivation and self-efficacy (Bennett & Glover, 2008) and improve comprehension (e.g. Choi & Johnson, 2005; Reisslein, Seeling & Reisslein, 2005; Zhang et al., 2006; Gross et al., 2015).

Geoscience courses have largely relied on static images (e.g., diagrams, graphs, maps, cross-sections) presented in textbooks, papers or slides to communicate ideas to students. However, students often lack what Hegarty (2011) termed the *representational competence* to fully understand the information contained in these images and associated text. The novice learner may overlook critical details in these representations as they struggle to decipher images or are distracted by irrelevant details (Hegarty, 2011; Singer et al., 2012). Faculty stand to benefit from the addition of video-resources that can be posted online for students to explore at their convenience. Instructors can increase time in class for active learning by introducing some content prior to lecture with interactive videos and related assignments (Moravec et al., 2010). Access to video lessons outside of class can provide students with autonomy and control in the
study process and may avoid expertise reversal effects as students with more conceptual understanding can skip over scaffolds intended for more novice learners (Kalyuga et al., 2003). Additionally these resources are especially valuable when teaching students with diverse backgrounds and skills, including non-native English speakers and those with learning differences (Zhang et al., 2006).

A series of geoscience videos were created to support student learning in an introductory geology course. In this study, we seek to discover if the incorporation of multimedia resources (text, audio and video), such as short video-based resources, improved student performance and confidence on related assessment questions compared to paper-based resources (text and static images).

**Methods**

*Geoscience Videos*

Videos are typically 5-7 minutes long and have a relatively standard format that includes some combination of the following: learning objectives, basic content topics, brief text coupled with images (e.g., maps, graphs, geological features, models) and/or video clips (e.g., demonstrations, real world analogs), a formative assessment, a summary reflection activity, and narration (also available as closed captions). During the creation of the videos we considered aspects of effective multimedia design (e.g., spatial and temporal contiguity, modality, coherence) that have been shown to enhance student learning (see Mayer and Moreno, 2003; Mayer, 2011). While the videos were created for use in a university class, we shared them via a YouTube channel, to make them available to a wider audience. For this study, we utilized the video-based resources covering the topics of magma viscosity and the classification of faults.

*Methods: Video vs. Text Study*
The study was broken into two parts (control and treatment groups) and took place in the Spring 2015 (IRB 5267, Assurance Number: FWA00003429). Participants were undergraduates (n=60) drawn from an introductory geology course and incentivized with $10.00 gift cards to participate in the study. Of the 60 undergraduates, 33 were female and 27 were male. Participants represented a range of majors and academic ranks. For both topics, we developed multiple-choice, true/false, short answer and labeling assessments featuring knowledge, comprehension and application questions to compare student learning for both the control (textbook) and treatment (video) conditions. Both quizzes consisted of six questions. Students in both control and treatment groups were given the same assessment questions, at the beginning and end of each session.

In addition to student performance, we also examined the impact of the resources on students’ confidence in their performance. Students made predictions of their performance in the form of confidence judgments for each individual quiz question. Each question was followed by a horizontal line with the left side of the line labeled “Not at all confident in my answer” and the right end labeled “Very confident in my answer.” Students placed a mark at a position along the line to indicate their confidence in their response to each question. We measured the position of the mark and normalized its location on a scale from 0 (not at all confident) to 1 (very confident). We then derived the confidence interval score based on estimates of students’ calibration from their confidence judgments to determine individual levels of monitoring accuracy and over- and under-confidence (Nietfeld et al. 2005; Schraw 2009). Calibration has been defined as the degree of fit between a person’s judgment of their performance and their actual performance (Nietfeld et al. 2005; Boi and Douglas, 2012). Each calibration value represents the absolute value of the difference between a student’s confidence judgment and their performance on the question (a
correct answer was represented by a 1 and an incorrect answer was represented by a 0) (Nietfeld et al. 2005). For example, if a student placed a mark 87% of the way along the line (0.87) and scored a correct answer on the question, their calibration score would be 0.13 (i.e., 1.0 - 0.87).

The control and treatment groups reviewed text- or video-based resources covering the topics of magma viscosity and the classification of faults. These materials were appropriate for the course but would be presented later in the semester to ensure that students would have little prior experience with each topic. The video-based resource on faults was 5 minutes and 16 seconds long and divided into 15 scenes, while magma viscosity was 6 minutes and 46 seconds long and divided into 8 scenes. Each scene represents one or more images and/or video clips with synchronized text and narration. The videos can be controlled by the student (pause, play, rewind, and position). The text presentation consisted of material on the same topics from two popular introductory geology textbooks. The content was equivalent to the material covered in the video-based resources. Three Physical Geology lecturers reviewed and matched sections of text that corresponded to the learning objectives presented in the video-based resources to confirm that the text was equivalent to video content. For each textbook unit, the material was printed in color, the information on Magma Viscosity was two pages and contained four figures and the information on Faults was two pages and contained fourteen figures.

Students were randomly assigned to the two groups, completing either a video-based resource module (n=30 students) or textbook module (n=30 students). Random assignment of participants was accomplished by alternating the assignment of each session between video- or text-based resources. Thus, participants would not know which resource they would be receiving and each individual had an equal chance of being assigned to either group. Each session lasted up to 30 minutes, consisted of a single lesson and started with a pre-test assessment. After the
completion of the pre-test, the lesson began with either (A) students in the video-based resource group sitting at a computer to review the video presentation or (B) students in the text-based resource group sitting at a desk with a textbook and reading the delineated passage. Students were asked to watch the video (headphones were provided but were optional) or read through the indicated text. Participants were instructed to take as much time as needed and to watch the video or read the text several times if desired. Students took between 10-15 minutes, regardless of the resource, to complete this task. After the video has been viewed and the textbook material has been read, both groups were given a post-test assessment. The post-test was identical to the pre-test. Participants could not refer back to the video or textbook resources to answer the post-test questions.

**Student Interviews**

At the end of each session, each student participated in an interview and was asked to reflect on aspects of his or her learning process. Interviews were digitally recorded and later transcribed. The interviews were semi-structured in nature, providing students with open-ended questions that allowed student-identified themes to emerge that would suggest follow up questions for the interviewer. We report on three questions from the interview that focused on students’ experiences with video or text-based resources. Each student was asked the same series of questions:

1. What could be done to help you learn more from the section of text you read or video that you watched?
2. How do you think learning from reading a textbook compares to learning from watching videos?
3. If you watch videos, what types of videos do you like or dislike?

Following the interview, the interviewer created memos that summarized nonverbal observations of the students, identified emerging ideas and themes, and compared interview notes to data in
previous interviews and memos.

**Results**

**Text vs. Video Data Performance Comparison**

Pre-quiz scores were not significantly different (p>0.05) for students who received the video-based resources versus those that received text-based resources for either the Faults or Magma Viscosity materials (Figure 1). Analyses of the post-quiz data for both topics reveals that students who received the video-based resources scored significantly higher (Faults p=0.0485 and Magma Viscosity p=0.0024) than those who had received the text-based resources (Figure 1). Cohen’s effect size values were high (Magma Viscosity $d = 1.44$ and Faults $d = 0.74$), indicating a practical significance in performances between student groups receiving video-based resources versus text-based resources.
Figure 1: Graph of pre- and post quiz scores on the topic of Faults and Magma Viscosity for 60 undergraduate students. Analyses of the post-quiz data for both topics reveals that students who received the video-based resources scored significantly higher (Faults p=0.0485 and Magma Viscosity p=0.0024). (Faults Pre-Mean score: Video = 40, s.d.= 19; Text = 38, s.d.= 18, Post-Mean score = Video = 90, s.d.= 14 and Text = 76, s.d.= 23 and Magma Viscosity Pre-Mean score: Video = 49, s.d.= 14, Text = 42, s.d.= 18, Post-Mean score: Video = 95, s.d.= 8, Text = 73, s.d.= 20).

Text vs. Video Data Confidence Interval Comparison

Similar to the pre- and post-test performance data, regardless of the subject matter, pre-quiz confidence intervals were not significantly different (p>0.05) for students who received the video-based resources versus those that received text-based resources (Figure 2). Analyses of the post-confidence interval data for faults and magma viscosity topics reveal that students who received the video-based resources had significantly higher confidence (Faults p=0.0013 and Magma Viscosity p=0.0002) in their performance than those who had received the text-based resources. Further, Cohen’s effect size values were high (Magma Viscosity $d = 1.02$ and Faults $d = 0.82$).
Figure 2: Graph of pre- and post student confidence scores on the topic of Faults and Magma Viscosity for 60 undergraduate students. Analyses of the post-confidence interval data for faults and magma viscosity topics reveal that students who received the video-based resources had significantly higher confidence (Faults p=0.0013 and Magma Viscosity p=0.0002). (Faults Pre-Mean score: Video = 42, s.d.= 20, Text = 38, s.d.= 25, Post-Mean score: Video = 89, s.d.= 10, Text = 78, s.d.= 16 and Magma Viscosity Pre-Mean score: Video = 34, s.d.= 20, Text = 33, s.d.= 20, Post-Mean score: Video = 84, s.d.= 8, Text = 73, s.d.= 13).

Text vs. Video Calibration Data

Similar to the pre- and post-quiz performance and confidence interval data, regardless of the subject matter, pre-quiz calibration data were not significantly different (p>0.05) for students who received the video-based resources versus those that received text-based resources. A
summary of the data can be found in Table 1. The average pre-test calibration value for Faults was 0.34 for text-based resources and 0.37 video-based resources. For Magma Viscosity the average pre-test calibration for text-based resources was 0.41 and 0.45 for video-based resources. In each case, most students could not accurately predict whether their answers were correct and students earning equivalent grades on each quiz had similar levels of confidence regardless of whether they were in the control or treatment groups. Analyses of the post-calibration data reveal that students who received the video-based resources significantly improved (Faults p=0.0096 and Magma Viscosity p=0.0006) their calibration scores in comparison to those who had received the text-based resources. Average post-quiz calibration values were reduced to 0.18 (Faults) and 0.23 (Magma Viscosity) for students who viewed the videos. In contrast, average post-quiz calibration values for text showed smaller changes (0.29, 0.37, respectively) for students using text-based resources.

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Table 1: Table of pre- and post student confidence calibration scores (minimum, maximum and average) on the topic of Faults and Magma Viscosity for 60 undergraduate students.

*Student Interviews*

Student interviews were coded to identify trends and patterns in student responses and comments. Overall, 83% of students stated that they watch videos to help them understand course material. Specifically, 63% of all students mentioned searching out their own videos in addition to using the textbook to help them comprehend course material, while 25% stated that
they only watched videos that were assigned during the class (note, these values don’t add to 83% as a few students watched assigned videos but also searched for other video resources).

When asked, “How do you think learning from reading a textbook compares to learning from watching videos”, many students mentioned that it was beneficial to see and hear the information at the same time. Students provided statements such as: “I like videos because I get to hear and see what’s going on” and “I think a video is more involved, actually, just because you’re getting the information given to you, then also getting pictures and text, well, and audio, all at the same time kind of thing”.

Additionally, we asked students, “what could be done to help you learn more from the section of text you read or video that you watched?” Students provided feedback such as: “I feel like watching a video is better because it goes through numerous examples, and it explains it to you in real time, instead of you having to maybe say, go to Figure 5.3 on page two – you have to flip back and forth to see the comparisons, whereas a video just shows it in real time. It makes more sense to me doing it that way” and “by having the pictures move – say we were learning boundaries, for example. When you can see how the boundaries are moving instead of just a static image you understand it better”.

Of those students who watched videos, when asked, “If you watch videos, what types of videos do you like or dislike?” They reported using search engines such as Google and YouTube and selecting videos that they interpreted to have been created by professionals and experts (i.e. – college professor, Khan Academy, Bill Nye the Science Guy or National Geographic Society). Additionally students reported sorting videos on YouTube based on views and provided feedback such as “I look for some videos and search based on topic and then look for ones that have higher views”. Additionally, more than two-thirds (71%) of students mentioned specific
qualities of video design that they look for when selecting and watching videos. Specifically, participants stated that they preferred shorter videos with demonstrations, animated effects, progressive illustrations, step-by-step problem solving and examples.

Conclusions

Our post-assessment results revealed that students who received the video-based resources scored significantly higher than those who had received the text-based resources, suggesting that having access to well-crafted video-based resources can improve student comprehension of the material. In addition, students who received the video-based resources were more confident in their performance than those who had received the text-based resources. Additionally, a consistent pattern emerges from the confidence calibration data showing that students who received video-based resources are more accurate in their predictions of their learning than those who read the text. These results suggest that we are improving students’ calibration of their knowledge as a result of using video-based resources.

Student interview responses echo these findings. Students report a stronger connection between their comprehension and confidence when using video-based resources versus text-based resources. Examples of students responses regardless of the topic included statements such as: “I benefit more from learning from a video because it’s almost like somebody’s reading the material to me. Plus the person in the video knows what they are talking about. When I read a book, I don’t necessarily know what I’m talking about.”

As we advance into a future that will be characterized by increasing volumes of online resources, short online videos have the potential to enhance student learning by 1) replacing and/or supplementing text-based resources; and, 2) providing a mechanism to support content
delivery for instructors seeking to enhance the value and engagement of classroom meetings by adding active learning strategies.

References


