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Diversity in Video Lectures: Aid or Hindrance?

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Abstract

Media diversity within video lectures has been shown to have an effect on students who participate in both flipped classes as well as online courses. While some research claims that content delivered through multiple sources leads to more learning, contrasting research makes the claim that too much media hinders cognitive processing. The present study investigated the effects of varying levels of instructional media delivered to students (n=110) within a flipped scientific writing course to investigate the relationship between higher levels of media diversity and student performance. Results showed that more diversity led to lower levels of performance. It was also found that higher levels of media diversity correlated with higher levels of students' scanning between different forms of media, possibly contributing to the lower levels of performance. The implications of these results provide insight into the optimal level of media diversity, and on student behavior that can affect learning.

Keywords: flipped learning, Korea, multimedia, scanning, summaries, video lectures

Introduction

Video lectures are a key component to most e-learning environments and the relationship between the effective design of video lectures and other aspects of online environments needs to be examined in order to optimize the effectiveness of online learning. One method instructors have used to improve e-learning experiences is to create more diverse lecture videos that incorporate various types of media (Kim, Kwon, & Cho, 2011; Zhang, Zhao, Zhou, & Nunamaker, 2004). The effects of such diversity on student engagement and learning is a topic worth exploring. This can be done by examining how diversity in the presentation of lecture videos affects germane load, which is widely accepted to contribute to learning through increased comprehension of the course content that the videos present (Cierniak, Scheiter, & Gerjets, 2009; De Jong, 2010; Sweller, 2005; Sweller, van Merriënboer, & Paas, 1998).

Media diversity, which refers to the various audio and visual means of presenting information in online video lectures, influences student perception of video lectures and affects their cognitive processing (Kalyuga et al., 1998; Lowe, 1999; Mayer, 2014; Mayer & Moreno, 2003; Rasch & Schnotz, 2009; Schnotz & Rasch, 2005; Sims & Hegarty, 1997; Sweller, 1999; Sweller et al., 1998; van Merriënboer, 1997). However, this is still a contentious area, as some research suggests that diversity in media presentation increases germane load, while other studies have shown that such diversity can hinder the development of germane load. For instance, some studies claim that presenting the same information several times through diverse forms of media enables students to improve their comprehension of the material (Paivio, 1991; Schmidt-Weigand & Scheiter, 2011), while others claim that doing so causes a redundancy effect, leading to unnecessary cognitive processing (Kalyuga, Chandler, & Sweller, 1999; Mayer & Moreno, 2003) and decreased germane load (Sweller et al., 1998). Further to this, lecture design has been shown to influence whether or not students finish watching a video in an online class (Costley, Hughes, & Lange, 2017; Costley & Lange, 2017a).

The present study quantitatively measures student recall of the content in video lectures that contain varying degrees of media diversity. Additionally, the effect of media diversity on scanning between different media sources is investigated, which may provide more insight on the results of this study. This research differs from extant studies in the literature in that the videos examined herein contain the same lecture by the same lecturer, but with differing levels of media diversity. Tailoring the media diversity in each experimental group while maintaining the content being presented offers a clearer insight into the effects of media diversity in online lecture videos.

Literature Review

The Effects of Visual Diversity on Retention

Studies indicate that the use of visual media is beneficial for student understanding. Images and animations have been shown to facilitate the learning process so students can better comprehend the content (Salomon, 1994; Sweller & Chandler, 1994; van Gog, Ericsson, Rikers, & Paas, 2005). This improved understanding leads to better retention of information and quiz scores. The use of animated text was also shown to benefit the learning process; Luzón and Letón (2015) found that the addition of handwritten animated text to lecture videos was more helpful to the students' learning compared to cases when such text was not included. Chen and Wu (2015) point to Mayer's (2001) cognitive theory of multimedia learning and its claim that visual modalities or animations with verbal explanations have the edge over either text or narration in performance on retention tests.

Videos that show the instructor have also been shown to be more effective. For example, Day, Foley, and Catrambone (2006) found that videos where the instructor was shown led to higher retention of information and greater understanding and ability to apply the principles featured in the lecture compared to the same content presented using either audio and a slide deck created using Microsoft PowerPoint (PPT) or a PPT slide deck with transcription text. The amount of such recall improves depending on the form in which the instructor is presented (Li, Kizilcec, Bailenson, & Ju, 2016). For example, Pi, Hong, and Yang (2017) state that more knowledge is achieved when the image of the instructor is small – in their study, defined as "8.4% of the space of the video lecture" (p. 347).

Some research suggests that instructors should use caution, particularly under certain conditions, when adding visual media such as animation or simulated pictures. While visuals are widely acknowledged to have a facilitating effect (Lowe, 1999; Rasch & Schnotz, 2009; Salomon, 1994; Schnotz & Rasch, 2005; Sims & Hegarty, 1997; Sweller & Chandler, 1994; van Gog et al., 2005), some studies have shown that the inclusion of visuals may not always be beneficial to learning (Rasch & Schnotz, 2009; Schnotz & Rasch, 2005). For instance, it has been stated that the use of images and animations often leads to superfluous cognitive processing for students who are able to comprehend the content without the use of such visuals (Rasch & Schnotz, 2009; Schnotz & Rasch, 2005). Schnotz and Rasch (2005) point out that the use of such visuals can reduce germane load for learners who do not require them to comprehend the information because of unnecessary mental processing.

Abrupt changes within the lecture video can also be problematic, as some have suggested that sudden transitions or scene changes be avoided when creating online lectures (Fanguy, Costley, & Baldwin, 2017; Kim et al., 2014). Other studies have cautioned against the improper use of videos that show the instructor. While Kizilcec, Bailenson, and Gomez (2015) maintain that there are advantages to showing the professor speaking in a lecture video and that students prefer this presence (Kizilcec, Papadopoulos, & Sritanyaratana, 2014), the former state that continuous use of this type of video may actually lead to cognitive overload, as student are forced to over-rely on their working memory while focusing on the instructor, particularly when the instructor directs their attention to particular points in the lecture.

Visual Diversity and Germane Load

Cognitive load theory can provide a framework with which to understand multimedia instruction and its effects on students. According to cognitive load theory, when instruction is unnecessarily complicated or confusing, students may experience extraneous cognitive load, which can impede learning (Leppink, Paas, van der Vleuten, van Gog, & van Merriënboer, 2013; Sweller et al., 1998). Extraneous load can be defined as the amount of cognitive effort required by ineffective instruction that does not help to achieve the learning objective (De Jong, 2010). A key concern when designing multimedia instruction is cognitive overload, which occurs when a learner engages in cognitive processing that exceeds their useable cognitive capacity (Mayer & Moreno, 2003). Ideally, instruction should be designed to increase levels of germane cognitive load in students (Kolfschoten, Lukosch, Verbraeck, Valentin, & Vreede, 2010; Sweller et al., 1998). Germane load contributes to learning directly and reflects the learner's attempt to construct schema to improve comprehension of relevant information. Furthermore, germane load has been shown to strongly influence a student's likelihood to maintain focus within a learning environment (Sweller et al., 1998). To increase the level of germane load, extraneous load must be reduced so that a greater portion of the learner's available cognitive capacity can be devoted to mental processes relevant to the learning task (Cierniak et al., 2009; Leppink et al., 2013; Schmeck, Opfermann, van Gog, Paas, & Leutner, 2015). To do so, instruction should be presented in a format that can be easily understood by learners (Bruner, 2009).

Diversity in the presentation of media influences student perception of video lectures and affects their cognitive processing (Kalyuga et al., 1998; Mayer & Moreno, 2003; Lowe, 1999; Mayer, 2014; Sims & Hegarty, 1997; Rasch & Schnotz, 2009; Schnotz & Rasch, 2005; Sweller, 1999; Sweller et al., 1998; van Merriënboer, 1997). A number of empirical studies add support to the theoretical claims that diverse presentation of visual media increases germane load by enabling greater comprehension of the information being presented. Day et al. (2006) found that more audio and visual diversity in lessons led to increased levels of understanding and recall, as shown in post-test retention scores and indicated levels of comprehension. A study by Kim et al. (2011) indicated that perceived learning increased when students were exposed various integrated media such as images, graphics, audio, and video clips. Other studies claim that presenting the same information several times through diverse forms of media enables students to improve their comprehension of the material (Paivio, 1991; Schmidt-Weigand & Scheiter, 2011). Zhang, Zhou, Briggs, and Nunamaker (2006) provide empirical evidence that germane load increased with the total diversity of media. The results of the study showed that learners who experienced both auditory and visual delivery (PPT slides and video with audio) achieved improved learning outcomes compared to those who received only visual delivery (PPT slides and lecture notes). Cheon and Grant (2012) found that a metaphorical interface containing pictorial form as well as text can enhance germane load and positively affect learning, while Costley and Lange (2017b) found that overall, there was a positive relationship between diversity of media used in lectures and germane load. These results support the idea that total media diversity helps to increase student levels of germane load with regard to information that is presented in e-learning lectures.

Other research suggests that instructors should use caution, particularly under certain conditions, when adding visual media such as animation or simulated pictures. While visuals are widely acknowledged to have a facilitating effect (Lowe, 1999; Sims & Hegarty, 1997; Schnotz & Rasch, 2005; Rasch & Schnotz, 2009; Salomon, 1994; Sweller & Chandler, 1994; van Gog et al., 2005), some studies have shown that the facilitating effect may not always increase levels of germane load (Schnotz & Rasch, 2005; Rasch & Schnotz, 2009). For instance, it has been stated that the use of images and animations often leads to superfluous cognitive processing for students who are able to comprehend the content without the use of such visuals (Rasch & Schnotz, 2009; Schnotz & Rasch, 2005). Other studies claim that repeating the same information through several forms of media causes a redundancy effect, leading to unnecessary cognitive processing (Kalyuga et al., 1999; Mayer & Moreno, 2003) and decreased germane load (Sweller et al., 1998).

Visual Diversity and the Split-Attention Effect

When viewing lecture videos, learners may engage in a number of *lecture behaviors* such as pausing the video, rewinding and rewatching, skipping ahead, increasing video playing speed, averting one's eyes from screen for more careful listening, scanning one's eyes between text and images, and temporarily turning off the sound in order to focus on a visual or text. While these lecture behaviors may seem advantageous, as they enable learners to control the pace and flow of information (Schwan & Riempp, 2004), such forms of control may also impede comprehension. For example, Caspi, Gorsky, and Privman (2005) show that even brief pauses during the viewing of an instructional video disrupted the context of the lecture. In addition, splitting attention between media sources in an instructional video may increase extraneous cognitive processing (Kizilcec, Bailenson, & Gomez, 2015; Mayer & Moreno, 2003). A physical manifestation of attention splitting is scanning one's eyes back and forth between two types of media (e.g., visuals and text).

Research suggests that multimedia instruction is more effective when it contains change-of-pace elements and a variety of visual media (Barker & Benest, 1996; Brecht, 2012). However, instructors must be careful in how they present visual media to avoid overloading the visual channel, which can invoke the *split-attention effect*. The split-attention effect occurs when learners are required to divide their focus among several sources of media in order to understand the learning material (Ayres & Sweller, 2005; Mayer & Moreno, 1998; Sorden, 2005). This splitting of learner attention represents an increase in extraneous load, which impedes learning. For example, Chen and Wu (2015) found that instructional videos that showed lecture slides and the instructor's face in separate windows on the screen caused the split-attention effect, as students mentioned in follow-up interviews that they felt burdened by the need to scan their eyes between the two windows. However, Chen and Wu (2015) did not report a split-attention effect for participants who were shown videos that pictured the lecturer and slides in the same video window. These findings suggest that physical separation of visual content may lead to the split-attention effect, as viewers need to scan their eyes back and forth between media content, which in turn may increase extraneous load.

The Present Study

Previous research has already examined the relationship between media diversity and its effectiveness in learning (Mayer & Moreno, 2003; Mayer 2014; Rasch & Schnotz, 2009; Schnotz & Rasch, 2005; Sweller et al., 1998; van Merriënboer, 1997). However, past studies are inconsistent in findings regarding the diversity of media in lecture videos. Some claim that the diversity actually has a negative effect on germane load at particular parts of the lecture (Chandler & Sweller, 1991; Kizilcec et al., 2015; Mayer & Moreno, 2003; Rasch & Schnotz, 2009; Schnotz & Rasch, 2005; Sweller et al., 1998). However, Costley and Lange (2017b) found that overall, there was a positive relationship between diversity of media used in lectures and germane load. Therefore, it is worthwhile to investigate whether the increase in specific types of media diversity leads to better performance in students, as represented by germane load and quiz scores. Additionally, it would be useful to investigate whether varying levels of media diversity affects levels of students' scanning between different media sources, which may provide more insight into the effects on performance. In particular, this paper examines the effects of four types of media use included with talking-head presentations: on-screen text, visuals (i.e., photographs, figures, and tables), the instructor's handwriting on the screen (also known as "Khan-style"), and summaries given by a guest lecturer. The findings of this study will be useful to instructors in e-learning who want to understand whether specific types of media aid students in learning.

Research Hypotheses

The present study will test the following research hypotheses:

H1: Students in experimental conditions with higher levels of diversity will have higher quiz scores.

H2: Students in experimental conditions with higher levels of diversity will have higher levels of germane load.

H3: Students in experimental conditions with higher levels of diversity will exhibit more scanning behavior.

Methods

Experimental Procedures

In the present study, our goal was to assess how diversity in media presentation in online lecture videos would affect student perceptions and recall in the graduate-level course *Scientific Writing* (CC500) at the Korea Advanced Institute of Science and Technology (KAIST) in Daejeon, South Korea. The course was taught in an "inverted" or "flipped" format; students were required to watch lecture videos and take online quizzes for homework while also meeting with professors and fellow classmates once per week, face-to-face, in a brick-and-mortar classroom. In the present study, we examine five of the 56 total videos that constitute the lecture content of the course. The five videos included in this study were reproduced in four different styles with regard to media diversity, with each style corresponding to one of four treatment groups. In Treatment Group 1, students were provided a video series that was prepared with an instructor delivering a lecture in front of PPT slides featuring a simple black background with white text on the screen; Treatment Group 2 received the same type of lectures but also included the addition of visuals, such as photographs, figures, and tables; Treatment Group 3 also received the same type of lecture as in Treatment Group 2, but this time with the addition of instances of Khan-style writing with a pen on a glass panel in front of the instructor; and finally, for Treatment Group 4, the same type of lecture was given as in Group 3, but each video contained mid and final summaries that were delivered by a "guest" instructor who was also seated in a "coffee shop" environment projected in the background rather than standing in front of PowerPoint slide contents. Screenshots of the aforementioned Treatment Groups can be seen in Figures 1-4 below.

Figure 1. A screenshot of a Treatment Group 1 video featuring a lecturer presenting in front of a slide background showing only text and no other visuals (low diversity).

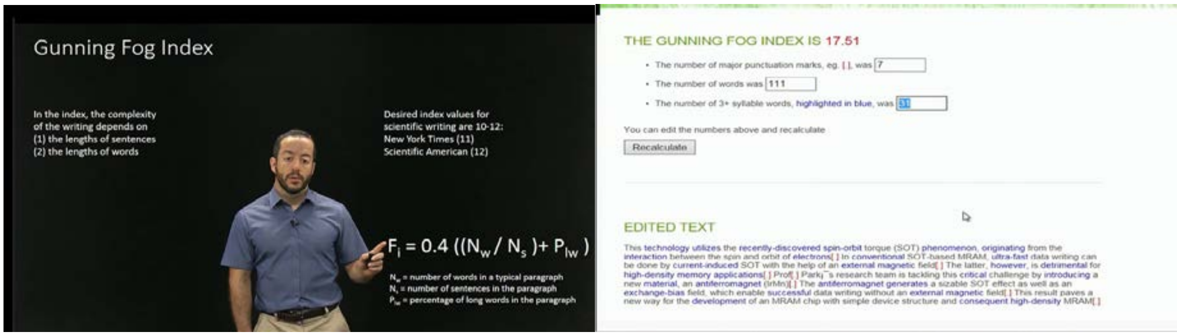

Figure 2. (Left) A still from a Treatment Group 2 video lecture (medium low diversity). (Right) A second still from the same Treatment 2 video featuring an addition visual not shown in Treatment 1.

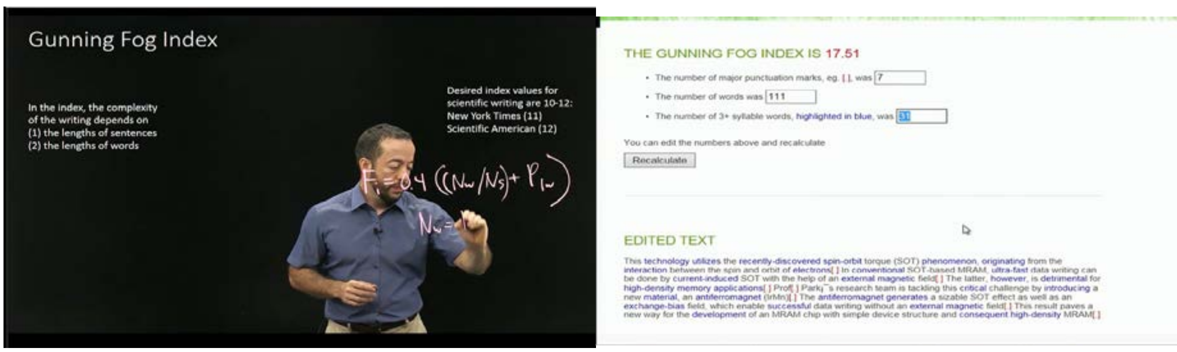

Figure 3. (Left) A still from the Treatment Group 3 video lecture (medium high diversity) that features the same text on the slide background as in the Treatment 1 and 2 versions along with Khan-style writing by the instructor. (Right) The Treatment Group 3 version of the video lecture includes the same visual shown in the Treatment 2 version.

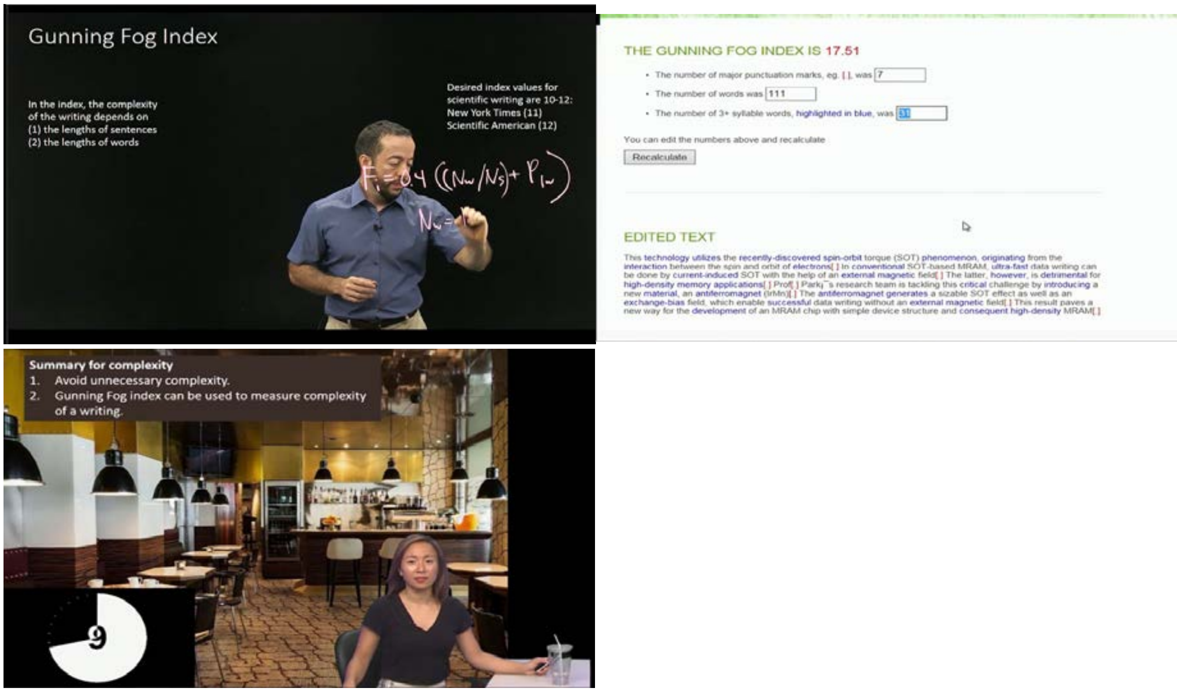

Figure 4. (Upper left) Treatment Group 4 (high diversity) features the same background, Khan-style writing, and (Upper right) visual as in Treatment Group 3. (Lower left) An additional still of a guest lecturer summary included in the Treatment Group 4 version but not in other treatment versions of the video.

A total of 110 students were divided up into four treatment groups, with between 20 and 31 students in each group. The respective videos were posted on the school's learning management system in Week 4 and were available to watch at the students' leisure. Once the videos were viewed, students took a multiple-choice quiz online, which they could access at any time during the seven-day video viewing period. Students were required to complete this test before the next face-to-face, brick-and-mortar classroom meeting day. The quiz was used to measure the students' comprehension and recall of the contents from the videos. During the respective brick-and-mortar classroom meeting, students were asked to fill out a survey that involved a 10-point Likert-type scale to assess the videos. Survey forms were assessed, and quiz data was taken from the online learning management system for the course.

Participants and Context

The present research was conducted at KAIST, a large university located in Daejeon, South Korea. The majority of students at KAIST specialize in STEM fields. As of 2013, the student population of KAIST was 11,175, with 60% of students exclusively at the graduate level (Korea Advanced Institute of Science and Technology [KAIST], 2014b). Most of the students are male (80%), with international students comprising 5% the total student population (KAIST, 2014b). Nearly all courses at KAIST are conducted in English, although the vast majority of KAIST students are non-native English speakers. KAIST provides a variety of online and blended courses, including Massive Open Online Courses (MOOCs) provided through Coursera, institution-level online courses through the CyberKAIST program, as well as the Bridge-Program for prospective freshmen, and global- and institutional-level flipped courses through iPodia and Education 3.0, respectively (Korea Advanced Institute of Science and Technology [KAIST], 2014a).

Participants in the present study were enrolled in classes that were offered as part of KAIST's Education 3.0 program. The Education 3.0 initiative was started in 2012 with the aims of reducing the amount of traditional lecturing in KAIST courses and enabling students to participate in more communicative and interactive learning activities through a flipped classroom environment (Horn, 2014). In 2014, a total of 5% of all classes were given in Education 3.0 format at KAIST, with an objective of increasing the percentage to 30% by 2018 (Horn, 2014).

As a requirement for graduation, graduate students at KAIST must be able to compose articles that are publishable in scientific journals. To assist them in this goal, KAIST offers *Scientific Writing* (CC500), a course that teaches students how to communicate their research in English through writing. The course is given in English, and enrollment is generally capped at 20 student per class. In the present study, eight sections of Scientific Writing were included in the experiment. Of the potential 135 total participants, 25 were removed from the study due to not completing all the requirements for inclusion in the study. This left a total of 110 valid responses, of which 29 were female and 81 were male. The oldest participant was 45, and the youngest was 22, with a mean age of 27. The eight selected sections of Scientific Writing were taught as part of KAIST's Education 3.0 program, and as such, were delivered in a flipped format.

Measures

Student took a quiz that consisted of 20 questions and covered topics given in four video lectures. The quiz was available online, and students could take it at any time during the one-week video viewing period (week 5 of the course). The quiz consisted of multiple-choice questions, with some of the items permitting only one answer choice and others allowing one or more possible answer choices. For the latter, partial credit was given when a correct option was chosen, but no credit was awarded when an incorrect answer option was chosen. All quiz items were written by the course instructors and were aimed at making the students demonstrate that they were able to apply the concepts covered in the lecture videos. For example, if a student viewed a video about how to integrate numbers into their writing, they would see a multiple-choice question asking them to evaluate whether particular instances of writing with numbers were correct. The quiz was worth 5% of the total course grade.

To take a look at the germane load of these students, four items were selected from Leppink et al.'s (2013) research on measuring cognitive load. Specifically, the four items chosen in this study were:

1. The lecture really enhanced my understanding of the topic.
2. The lecture really enhanced my knowledge and understanding of the of the class subject.
3. The lecture really enhanced my understanding of the concepts associated with the class subject.
4. The lecture really enhanced my understanding of concepts and definitions.

However, this research uses slightly different wording than Leppink et al.'s (2013) –this study uses the word "lecture" instead of the original "activity"– in order to focus the items more specifically on the video lectures as they were used. The Cronbach's alpha for the germane load construct was .926 and the Cronbach's alpha for the extraneous load construct was .919, which is acceptable for this type of research. To further understand student behavior while they were watching the videos, the survey described above included one Likert-type item to respond to: “I had to scan my eyes back and forth between the text and the graphs/images in the videos I watched.” This item as with the germane load construct was scored between 1 and 10.

Results

To get an overall picture of the main variables used in this study and the relationships between them, descriptive statistics were calculated and the variables were correlated with each other (Table 1). There were four different categories for the experimental conditions, while *scanning* and *germane load* ranged between 1 and 10. Scanning had a mean of 4.62, and germane load had a mean of 7.52. The *quiz score* variable had a range of 1.76 to 10, with a mean score of 7.43. The experiment condition variable was positively correlated with scanning (.250), but negatively correlated with quiz score (-.295) and germane load (-.231). All of the relationships between the experimental condition and the other variables were statistically significant. Quiz score also had a negative relationship with scanning (-.257), which was statistically significant, though quiz score did not have a statistically significant relationship with germane load (-.018).

Table 1

Descriptive Statistics and Correlations Between the Main Variables

	N	Min	Max	Mean	*SD*	Experiment condition	Scan	Quiz score	Germane load
Experiment condition	110	1	4	NA	NA	1			
Scan	110	0	10	4.62	2.56	.250**	1		
Quiz score	110	1.76	10	7.43	.90	-.295**	-.257**	1	
Germane load	110	1	10	7.52	1.95	-.231*	-.149	-.018	1

Note. * *p* = < .05; ** *p* = <.01

The correlations between the experimental condition and dependent variables give some insight into the effect of the levels of diversity on scanning, quiz score, and germane load. As can be seen in Table 2, for scanning, the low diversity group had the lowest mean (4.06), followed by medium low diversity (4.13), medium high diversity (4.38), with high diversity having the highest mean scanning score (5.90). However, in respect of quiz score and germane load, high diversity had the lowest mean (6.79), followed by medium high diversity (7.23), then medium low diversity (7.54), with low diversity having the highest levels of quiz score (8.40). Germane load followed a similar pattern to quiz score though low diversity and medium low diversity were similar (7.95, 7.96), followed by medium high diversity (7.39), with high diversity having the lowest levels of germane load.

Table 2

Main Variable Means by Experiment Condition

	N	Scanning	Quiz score	Germane load
Low diversity	21	4.06	8.40	7.95
Medium low diversity	32	4.13	7.54	7.96
Medium high diversity	30	4.38	7.23	7.39
High diversity	27	5.90	6.79	6.79

The data from Table 2, is visually represented below in Figure 5. This shows the trends discussed in the preceding paragraph, and shown in Table 2. As the levels of diversity increase from low, to medium low, to medium high, and finally to high, both germane load and quiz score decrease, and scanning increases.

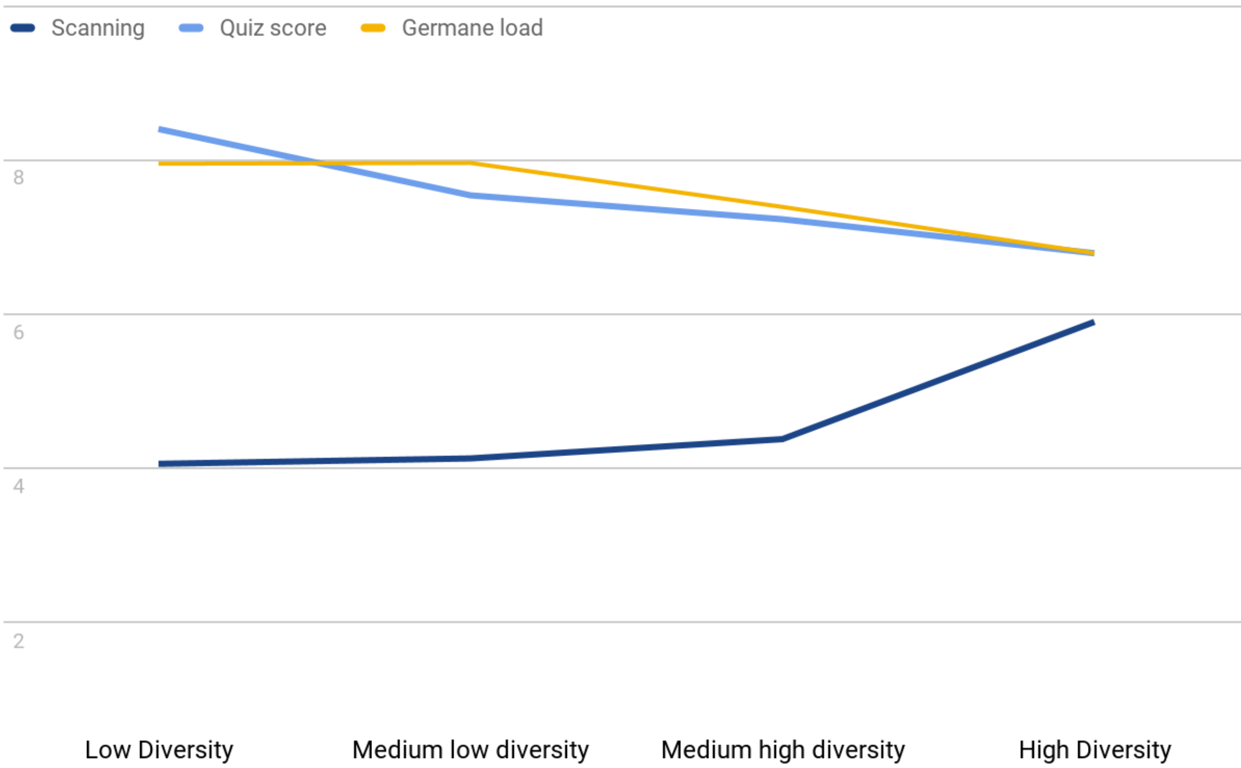

Figure 5. Main variable means by experiment condition.

To establish if the differences in relationships seen in Table 2 are statistically significant, one-way ANOVA was used. As can be seen in Table 3, the between-group difference for both scanning (p = .02) and quiz score (p = .02) were statistically significant. However, the between-group differences for germane load were not statistically significant (p = .09).

Table 3

One-Way ANOVA Results for the Main Variables Used in this Study

		Sum of squares	Mean square	F	Sig.
Scanning	Between groups	60.616	20.205	3.279	.024
	Within groups	653.166	6.162		
	Total	713.782			
Quiz score	Between groups	8.087	2.696	3.593	.016
	Within groups	79.528	.750		
	Total	87.615			
Germane load	Between groups	24.880	8.293	2.269	.085
	Within groups	387.501	3.656		
	Total	412.382			

Discussion

The results of the present study show that as diversity increased from the lowest to the highest level, the rate of students scanning their eyes between contents on the screen increased, while germane load and recall both decreased. Contrary to Hypothesis 1, students' quiz scores showed an inverse relationship with the amount of diversity of media within the lecture videos. These findings are unlike those of Costley and Lange (2017b), who found that lecture videos containing a wider variety of media resulted in students recalling more of the instructional content. However, their study relied upon self-reported levels of recall rather than qualitative analysis, so it is uncertain whether these perceived levels of retention would have been demonstrated in actual test scores. At a glance, the findings of the present study seem to contradict those of Day et al. (2006), who found that increased diversity in lessons resulted in increased comprehension and recall in post-test retention scores and self-reported levels of understanding. However, in Day et al.'s study, there was only one experimental condition (out of a total of four) in which the video showed a lecturer speaking on screen with PPT slides, while all four experimental conditions in the present study contained these features. As Day et al. do not mention Khan-style on-screen handwriting or summaries, it is likely that the most diverse "Video + Audio + PPT" experimental condition in Day et al.'s study was most similar to the low and mid-low diversity conditions in our own study, negating the apparent contradiction.

Likewise, germane load was relatively higher in the low and mid-low diversity groups, at 7.95 and 7.96, respectively, than in the mid-high and high diversity groups, at 7.39 and 6.79, respectively, contrary to our expectation indicated in Hypothesis 2. The present results contradict those of a number of studies that have shown that diversity in lecture videos is beneficial to student learning. For example, the results of Zhang et al., (2006) showed that the learning process is enhanced for learners exposed to both auditory and visual delivery (PPT slides and video with audio) compared to those who viewed only visual delivery (PPT slides and lecture notes). However, this apparent contradiction with the present results can be explained when we consider that the low diversity condition of the present study was already more diverse than the "PPT slide + video and narration condition" since the former showed the instructor speaking while the latter did not. Featuring the instructor in the low diversity condition of the present study is likely to have benefitted student learning, as Kizilcec, Papadopoulos, and Sritanyaratana (2014) indicated the importance of seeing the instructor in such videos, since the instructor can provide social cues and emphasis through gestures and body language. Taking this point into account along with the results of the present study, it may be that online lessons that contain both audio and video represent the lower bound of media diversity for effective online lessons that lead to increased germane load and recall. Other studies have suggested that lecture videos were more effective when containing “strong presentation of relief and change-of-pace elements,” including changes in the video or audio stimulus, modifications to the background or setting, or dramatic transitions between various parts of the video (Brecht, 2012). Barker and Benest (1996) suggested that the inclusion of multimedia contents is beneficial since doing so may prevent students from losing focus. Although such studies indicate that it is beneficial to increase media diversity, they do not identify an upper bound on the level at which diversity is helpful in achieving desirable learning outcomes and improved recall. The results of the present study offer insight into where that upper bound might lie: the most effective experimental condition involved an instructor speaking in front of PPT slides containing text only. In the present study, the addition of images, figures, tables, Khan-style writing, and summaries given by a guest lecturer yielded diminishing returns in terms of germane load and quiz scores. Students in the high diversity experimental condition exhibited the lowest germane load and quiz scores and the highest rate of eye scanning behavior by a significant margin. In addition to the high level of media diversity in this group of videos, the mid- and end-point summaries may have induced the redundancy effect (Sweller et al., 1998), as students were exposed to the same information more than once in a different manner. This redundancy may have led to additional cognitive processing and reduced germane load.

In the most diverse conditions in the present study, students increasingly scanned their eyes back and forth between contents, which was in agreement with our hypothesis. As noted by Sweller et al. (1998), perhaps the split-attention effect that causes this scanning behavior is a sign of cognitive overload, as students were unable to fix their gaze and attention on just one part of the screen while viewing the lecture. As scanning increased with the amount of diversity in the videos, it is plausible that students found the diversity in the videos to overwhelming and unhelpful. This result may help to explain why germane load and quiz scores decreased as media diversity was increased.

Conclusion

As online lecture videos are a major component of flipped and online courses, it is important to consider the most effective ways to deliver content through this medium. Lecture videos should deliver the course contents in a meaningful, memorable, and engaging way that adds to the learning experience of the course. The present results are important in that they contradict the findings of a number of studies that suggest that diversity of media is beneficial in online lecture videos. In the present study, increased diversity led to decreased germane load and recall, and increased instances of students scanning their eyes back and forth between contents on the screen. Based on these results, it seems reasonable to conclude that there is an upper bound to how much diversity is useful and productive in online lecture videos and that above this threshold, diversity may become a detriment to student attention and learning. The present results lead one to consider whether there is a “Goldilocks zone” in the diversity of media in online lecture videos, where content is presented in an engaging way that is beneficial to learning without creating extraneous load or the redundancy effect. Considering that Day et al. (2016) found decreased student performance on recall tests with videos containing relatively less media diversity than our low diversity condition, and that our low diversity condition led to the highest quiz scores and reported levels of germane load, a possible conclusion is that the most effective videos will contain a level of media diversity similar to the low or low-mid diversity conditions, where an instructor speaks in front of slides containing text and possibly a few visuals such as images, figures, and tables. Such findings may be useful to instructors who are designing lecture videos for MOOCs, flipped, or any other type of e-learning environment.

The present study provides a starting point in answering the question, “How much diversity of media is too much in online lecture videos?” The fact that the highest level of diversity examined in this study caused a significant decrease in student germane load and recall, and a significant increase in scanning behavior, should give course designers pause when considering how much media diversity to include in a lecture video. The present work provides a valuable counterexample to numerous studies in the literature that suggest that increased media diversity is beneficial to student learning. In this regard, moderation in media diversity may be a useful guiding principle.

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