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Keywords

online learning, learning outcomes, attention, emotion, instructor presence

Cover Page Footnote

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Experiencing Live Composite Video Lectures: Comparisons with Traditional Lectures and Common Video Lecture Methods

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Video compositing can be used to combine images of the instructor and content, which the instructor can monitor in real time. We evaluated the student experience of this "live composite" format in two carefully designed experiments. Results showed the perceived quality of and student preference for live composite lectures is not different from that of traditional lectures. Results also showed the live composite format is superior to voiceover and picture-in-picture formats in terms of attention, positive emotion, experiential attitude, preference, perceived quality, and instructor social presence. The two experiments had similar patterns of results, suggesting the observed effects are robust. Although we found no differences in short-term learning among lecture formats, the live composite method resulted in a better subjective experience for students. Instructors who use online recordings should consider adopting this approach.

INTRODUCTION

Online learning is now commonplace, as is the use of video lectures as a method of online instruction. Video lectures often form the backbone of distance learning curricula and supplement face-to-face instruction such as in flipped classrooms and other blended learning approaches (Bos, Groeneveld, van Bruggen, & Brand-Gruwel, 2016). Although there is mixed evidence about the benefits of online learning over traditional instruction (Driscoll, Jicha, Hunt, Tichavsky, & Thompson, 2012; Summers, Waigandt, & Whittaker, 2005; Wammes & Smilek, 2017), there is sufficient data to suggest online learning works well when it is designed well.

The format of video lectures when presenting online can affect learning outcomes. (Chen & Wu, 2015; Korving, Hernández, & De Groot, 2016; Wang & Antonenko, 2017). Research in this area often draws on evidence that learning requires attention, and certain lecture formats are more conducive than others to gaining and maintaining attention. It is also important to account for emotional and social processing, which can depend on the choice of video lecture format and affect learning outcomes. The current study assumes this broad conceptual framework and replicates the findings of prior research. It makes a novel contribution by studying certain cognitive, emotional, and social effects of *live composite* video lectures.

Live composite video lectures are not a novel means of delivering content, but few instructors have adopted the technique, which involves the layering of input signals to construct a composite video for instructional purposes. This technique can have high production value and requires little or no post-production. In addition, instructors can apply this technique using software on their own computers, which many instructors regard as essential to e-learning (Witton, 2017). We expect live composite video lectures to have cognitive, emotional, and social effects that are distinct compared to the more common lecture-capture, picture-in-picture, and voiceover recording formats. The current exploratory study examines the effects of video lecture format on knowledge retention, attention, positive emotion, experiential attitude, format preference, perceived quality, and instructor social presence.

Attention, Emotion, and Social Presence

Learning requires memory (Weiss, 2000), or the encoding of new information into existing knowledge structures (Baddeley & Hitch, 1974; Sweller, van Merrienboer, & Paas, 1998). Several factors may affect whether learners remember instructional content. For one, learners need to focus their attention when trying to learn new information. Researchers have studied attentional barriers to learning, finding divided attention—e.g., what occurs during multitasking—limits what information a learner can encode (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996) and may result in memory inaccuracies (Peters et al., 2008; Sahakyan & Malmberg, 2018). In addition, divided attention can amplify the effects of distractions, leading to even poorer memory performance (Weeks & Hasher, 2017). From a cognitive perspective, sustained attention provides a conduit for learning.

Specific features of learning environments can help learners pay attention. In the context of online learning, Robinson and Cook (2018) described the ability of instructional content to hold the interest and attention of learners, which they labeled "stickiness." They argued sustained attention to online content and the absence of distraction gives an indication of that content's stickiness. Things like instructor presence (Wang & Antonenko, 2017) and presentation quality (Lee & Kim, 2015) can make it easier for learners to pay attention, increasing the stickiness of online learning content.

Although the phenomena of attention, memory, and learning are largely cognitive, emotion also plays a supporting role. Research in cognitive neuroscience has shown people attend more to emotionally arousing stimuli (see Phelps, 2006, for a review). Furthermore, there is evidence positive mood broadens attention and negative mood narrows it (Fredrickson, 2001). Mood has similar positive and negative effects on learning performance (Liew & Tang, 2016; Storbeck, 2016).

There are also social factors that can enhance learning. Many studies have documented the effects of social presence, where students have better learning experiences when they feel they are having a real interaction with others in an online learning environment (see Richardson, Maeda, Lv, & Caskurlu, 2017). When learners have these kinds of perceptions about their instructors, they may form a sense of instructor social presence, which reflects beliefs the instructor is helpful and engaging (Wang & Antonenko, 2017). Instructional technologies and techniques can facilitate learning by enhancing instructor social presence (Borup, West, & Graham, 2012; Thomas, West, & Borup, 2017).

Formats and Effects of Online Learning

The format of instruction can also affect the learning process. Although there is evidence video lectures result in mind-wandering over long durations (Wammes & Smilek, 2017) and students prefer traditional lectures (Stephenson, Brown, & Griffin, 2008), video lectures have certain benefits. For example, Borup et al. (2012) found the use of video lectures and asynchronous video feedback supported emotional expression and self-disclosure, which enhanced the social presence of learners and instructors. Understanding the potential drawbacks and benefits of video lectures requires a more nuanced view of the different ways of recording them.

Common video lecture formats include lecture capture, picture-in-picture, and voiceover (see Figure 1, panels A through C). Lecture capture involves video recording a physical lecture. Picture-in-picture combines a full-screen presentation of the slide content with a smaller video recording of the instructor (e.g., as a talking head in a lower corner). In contrast, voiceover combines a full-screen presentation with audio narration by the instructor. Chen and Wu (2015) examined cognitive and affective outcomes of these three video lecture formats. Although there were no differences in positive and negative emotion among the formats, voiceover resulted in the lowest learning performance. The authors explained this finding partly in terms of media richness, where the additional visual cues of lecture capture and picture-in-picture reduce uncertainty. Indeed, Pale, Petrović, and Jeren (2014) found learning performance was greater when a lecture capture included ancillary informational cues, which they described in terms of richness. Consistent with that perspective, Korving et al. (2016) found learners felt more attentive to video lectures when there was a large image of the instructor than when there was a small image or no image at all. They explained being able to see the instructor's face more clearly makes it easier for students to pay attention.

Despite evidence that a large image of an instructor is conducive to learning, there is also research drawing the opposite conclusion. Andrade, Huang, and Bohn (2014) found perceived mental effort and extraneous cognitive load were higher for picture-in-picture than for voiceover. Those findings are consistent with other research showing multimedia instruction can split learners' attention, which increases cognitive demands (Homer, Plass, & Blake, 2008). Further, Pi, Hong, and Yang (2017) found a small video image of the instructor resulted in greater learning performance and learning satisfaction than a large image. Interestingly, they found instructor social presence did not vary as a function of image size.

The current study does not aim to explain the discrepant findings. Those prior studies showed the range of possible outcomes of different video lecture formats. The aim of the current study

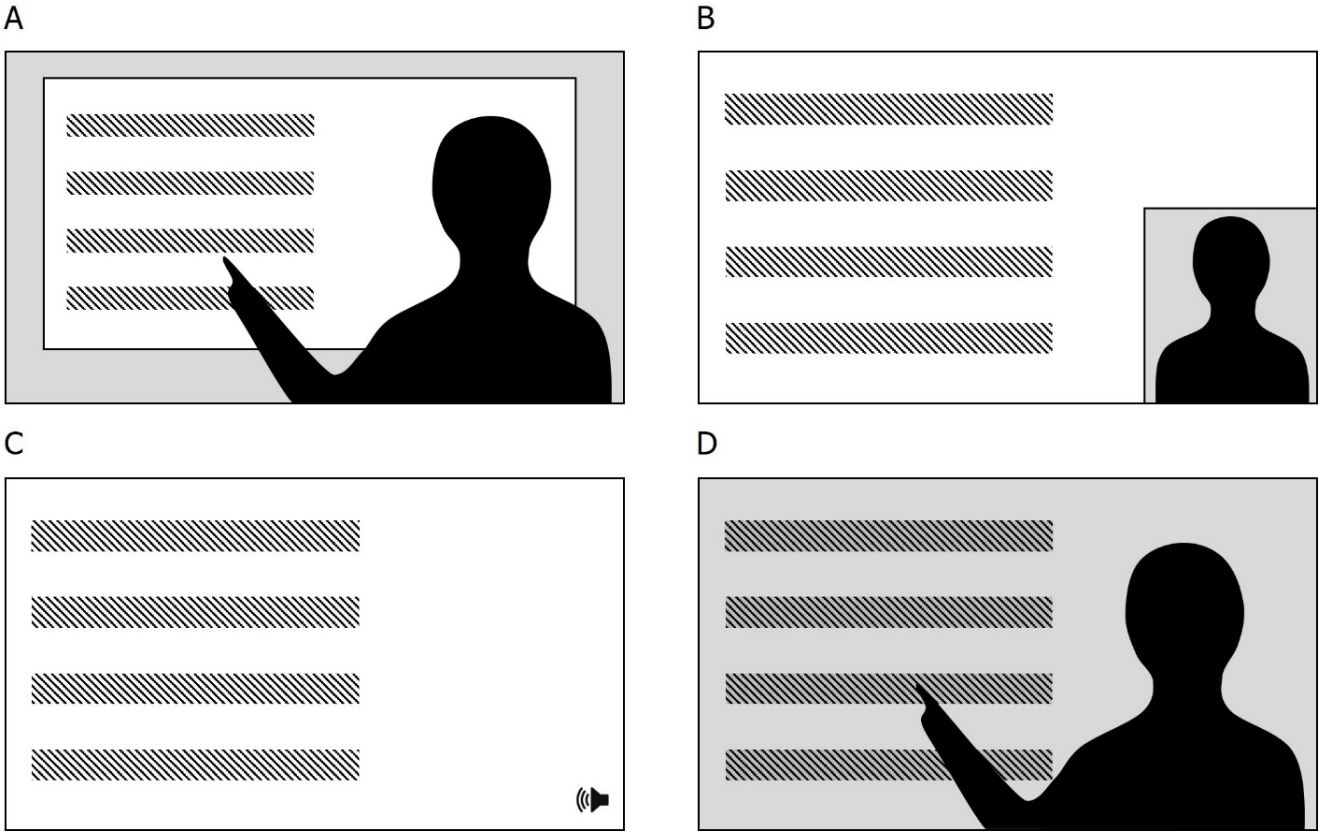

Figure 1. Diagram of video lecture formats: Lecture capture (A), picture-in picture (B), voiceover (C), and live composite (D).

is to extend that prior work by examining a new mode of online learning, which makes use of live composite recordings.

Live Composite Recording

Many video recordings use compositing in post-production. Compositing involves the layering of different visual elements, such as a text-overlay on a moving image, to enhance the presentation of information. Videos that involve green screens use a type of compositing, where green elements are "keyed out" and replaced by other still or moving images. However, there are limitations of compositing. First, it requires creative and technical competences to produce a high-quality video product. Second, it requires time for post-production, which for many instructors is a limited commodity. An additional limitation related to green-screen compositing is it requires a well-lit green backdrop.

Live composite recording uses color keying, like the green screen technique, but requires only a uniform backdrop of any color and does not require post-production. The compositing uses two layers: the video of the instructor and the lecture slides. The lecture slide background is set to a color that approximates the color of the video backdrop. The slide content overlays the video recording and the slide background is keyed out, so the video content is visible through the slide content (see Figure 1, panel D). Instructors can use video hardware or software to achieve this effect. The video compositing software, Open Broadcaster Software (OBS) Studio, is freely available and easy to use for this purpose. Figure 2 shows an example of video compositing in OBS Studio using a dual-screen setup. Instructors can use that setup to create live composite recordings on their own computers, which is an important benefit (Witton, 2017).

Figure 2. Screen capture of dual-monitor setup in OBS Studio. The full-screen slide content (top) and camera video signal are combined in OBS Studio (bottom).

STUDY 1

We first conducted a between-subjects experiment to compare cognitive, emotional, and social outcomes of different video lecture formats with those of a traditional face-to-face lecture. We chose a between-subjects experiment because it simplified the randomization of experimental conditions when one condition involved a traditional lecture versus the other conditions that involved viewing a video lecture on a computer.

Participants

Participants were undergraduate students at a large research university in Singapore. Sampling drew 4,000 emails randomly from the complete list of undergraduate email addresses. Addressees received an invitation to participate in the study, of whom 349 signed up to participate. Of those who signed up, 232 participated. One participant was identified as a straight-liner and was excluded, resulting in a final sample size of $N = 231$. Participants had a median age of 22 ($M = 22.00$, $SD = 1.57$) and were mostly female (61.9%). They indicated their areas of study as humanities, arts, and social sciences (32.0%); business (31.2%); engineering (18.2%); science (15.2%); and other (3.5%).

Materials

The two co-authors of this study each scripted a short lecture on a different topic about which we have expertise. One of the lectures was about strategies for effective learning. The other was about the difference between correlation and causation. We each memorized our lecture and recorded it twice. The first recording used lecture capture, in which we delivered the lecture in a classroom with the slide content projected behind us and to the side. The second recording was a live composite, which took place in a small video recording studio on a hardware configuration. We used video editing software to create two versions of the picture-in-picture recording, each taking the video image from one of the two recordings. Finally, we created two versions of the voiceover, each taking the audio track from one of the two recordings. The lectures about strategies for effective learning ranged in duration from 6:17 to 6:25. The lectures about correlation and causation ranged in duration from 6:46 to 7:09. Figure 3 shows example screen captures of the video lecture formats.

Procedure

The experiment took place 17-20 April 2018 in a university computer lab. The lab has rows of workstations with a lecture console and projector screen at the front of the room. Each day had five experimental sessions with up to 15 participants in each session. Participants could sign up for any session with vacancies. Each session began with an online pretest questionnaire, followed by participants viewing an online video lecture, and finished with an online posttest questionnaire. We randomly selected four of the sessions to deliver face-to-face lectures; we each gave a lecture in two sessions. In the remaining sessions, participants viewed a randomly selected video lecture. The randomization balanced between the two lecture topics and four types of video lectures. A graduate research assistant administered the sessions.

Measurement

Pre-test. There was a pretest and posttest questionnaire. Unless indicated otherwise, we measured all items on 5-point scales and created composite measures as the average of items. All Likert

items ranged from 1 (*strongly disagree*) to 5 *(strongly agree*). The pre-test measured preferences for face-to-face and online learning. We used these measures to check if there were any a priori differences between groups. Two Likert items measured preference for face-to-face learning: "The classroom is the best place for learning" and "I prefer to learn in face-to-face settings." A higher score indicated greater agreement and the measurement had acceptable reliability (*M* = 3.58, *SD* = 1.00, Spearman-Brown coefficient = .74). Three Likert items measured preference for online learning: "I prefer to learn by watching online lectures," "Universities should put more lectures online," and "Watching online lectures is an ideal way to learn." A higher score indicated greater agreement and the measurement had good reliability (*M* = 3.87, *SD* = 0.78, Cronbach's α = .86).

Post-test. The post-test included measures of knowledge retention, attention, positive emotion, experiential attitude, format preference, perceived quality, and instructor social presence. We used these measures to test for effects of lecture format.

Knowledge retention.

We measured knowledge retention with 10 multiple choice questions about the content of the lecture. The questions matched the topic of the lecture a participant viewed, and each question had four response options. Each correct answer was worth one point for a maximum score of 10 points (*M* = 6.64, *SD* = 2.15).

Attention.

We measured attention with seven Likert items: (1) "I was not distracted," (2) "I had a feeling of concentration," (3) "I found my mind wandering," (4) "I was able to block out most distractions," (5) "I was totally absorbed by what was being said," (6) "I had difficulty paying attention," and (7) "my attention was focused." Items 3 and 6 were reverse-coded so a higher score indicated more attention. The measure had good reliability (*M* = 3.32, *SD* = 0.93, Cronbach's α = .91).

Positive emotion.

We measured positive emotion with four Likert items: (1) "I felt contented," (2) "I had a meaningful time," (3) "I really enjoyed what I was doing," and (4) "I had a positive experience." A higher score indicated a more positive emotion. The measure had good reliability (*M* = 3.68, *SD* = 0.78, Cronbach's α = .88).

Experiential attitude.

We measured experiential attitude with six semantic differential items, which had the common stem, "Overall, I found the lecture was:" (1) good/bad, (2) likeable/unlikeable, (3) pleasant/unpleasant, (4) enjoyable/unenjoyable, (5) interesting/uninteresting, and (6) engaging/unengaging. We scored items so that a higher score indicated a more positive attitude. The measure had good reliability (*M* = 3.97, *SD* = 0.78, Cronbach's α = .91).

Format preference.

We measured format preference with four Likert items: (1) "I prefer this kind of lecture," (2) "This is the ideal lecture format," (3) "This is a good way to give lectures," and (4) "I wish more of my lectures were like this." A higher score indicated stronger preference for the format. The measure had good reliability (*M* = 3.76, *SD* = 0.97, Cronbach's α = .93).

Perceived quality.

We measured perceived quality with two Likert items: (1) "I thought the content was high-quality" and (2) "I found the content visually-appealing." A higher score indicated greater perceived

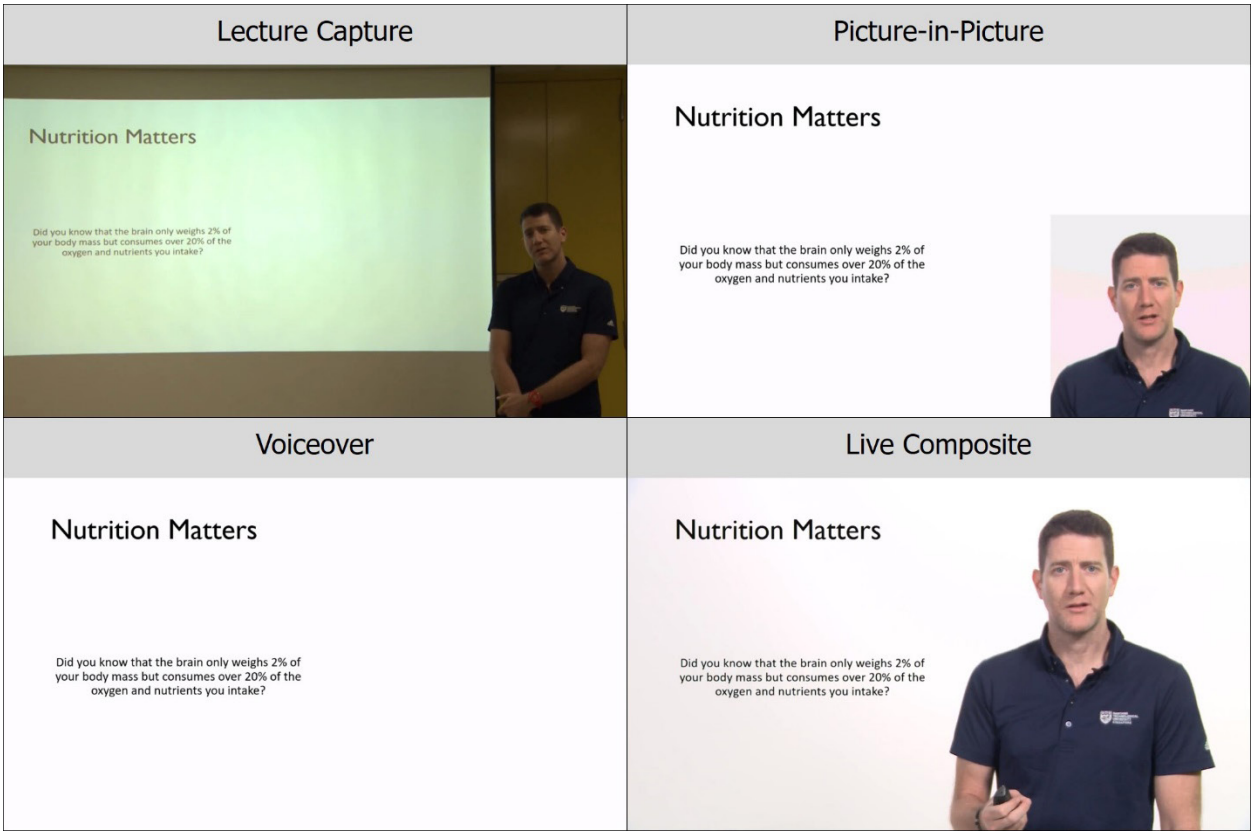

Figure 3. Example screen captures of video lecture formats (Study 1)

quality. The measure had acceptable reliability (M = 3.73, SD = 0.90, Spearman-Brown coefficient = .71).

Instructor social presence.

We measured instructor social presence with three Likert items: (1) "I felt like I was having a real interaction with the lecturer," (2) "I felt like the lecturer was speaking directly to me," and (3) "I felt I had a personal connection with the lecturer." A higher score indicated greater instructor social presence. The measure had good reliability (M = 3.12, SD = 1.02, Cronbach's α = .82).

RESULTS

Pretest by condition.

We used MANOVA in SPSS version 25 to compare the pre-test measures among the five experimental conditions. The multivariate test using Pillai's Trace was not significant, $F(8452) = 1.31$, $p = .234$, suggesting the pretest measures did not differ among the conditions. This finding validates the randomization of groups.

Posttest by condition.

We again used MANOVA to evaluate the effects of lecture format. The multivariate test using Pillai's Trace was significant, $F(28,892) = 2.08$, $p < .001$. The between-subjects tests showed there was not a significant treatment effect on knowledge retention, $F(4,226) = 1.01$, $p = .41$. However, there were significant treatment effects on attention, $F(4,226) = 4.63$, $p = .001$, positive emotion, $F(4,226) = 3.81$, $p = .005$, experiential attitude, $F(4,226) = 3.01$, $p = .019$, format preference, $F(4,226) = 3.08$, $p = .017$, perceived quality, $F(4,226) = 6.82$, $p < .001$, and instructor social presence, $F(4,226) = 2.77$, $p = .028$.

For the significant effects, we conducted pairwise comparisons using Sidak correction and graphed the cell means (see Figure 4). Attention was greater for the face-to-face lecture than for the lecture capture ($p = .015$), voice-over ($p < .001$), and live composite ($p = .044$). Positive emotion was greater for the face-to-face lecture than for the lecture capture ($p = .013$), picture-in-picture ($p = .039$), and voice-over ($p = .011$). Experiential attitude was greater for the face-to-face lecture than for picture-in-picture ($p = .048$), and voice-over ($p = .048$). Format preference was greater for the face-to-face lecture than for the lecture capture ($p < .042$). Perceived quality was greater for the face-to-face lecture than for lecture capture ($p < .001$) and picture-in-picture ($p = .016$). It was also greater for the live composite than for lecture capture ($p < .001$) and picture-in-picture ($p = .011$). Finally, instructor social presence was greater for the face-to-face lecture than for the voiceover lecture ($p = .023$).

DISCUSSION

The first study compared learning outcomes of traditional face-to-face lectures with different formats of video lectures. We found there were no differences in knowledge retention among the lecture formats, which we think this is partly because we measured knowledge shortly after the lecture ended. Shorter delays in measurement improve recall, which may be why there was no difference in knowledge retention among the lecture modes. A longer delay in measurement would better indicate

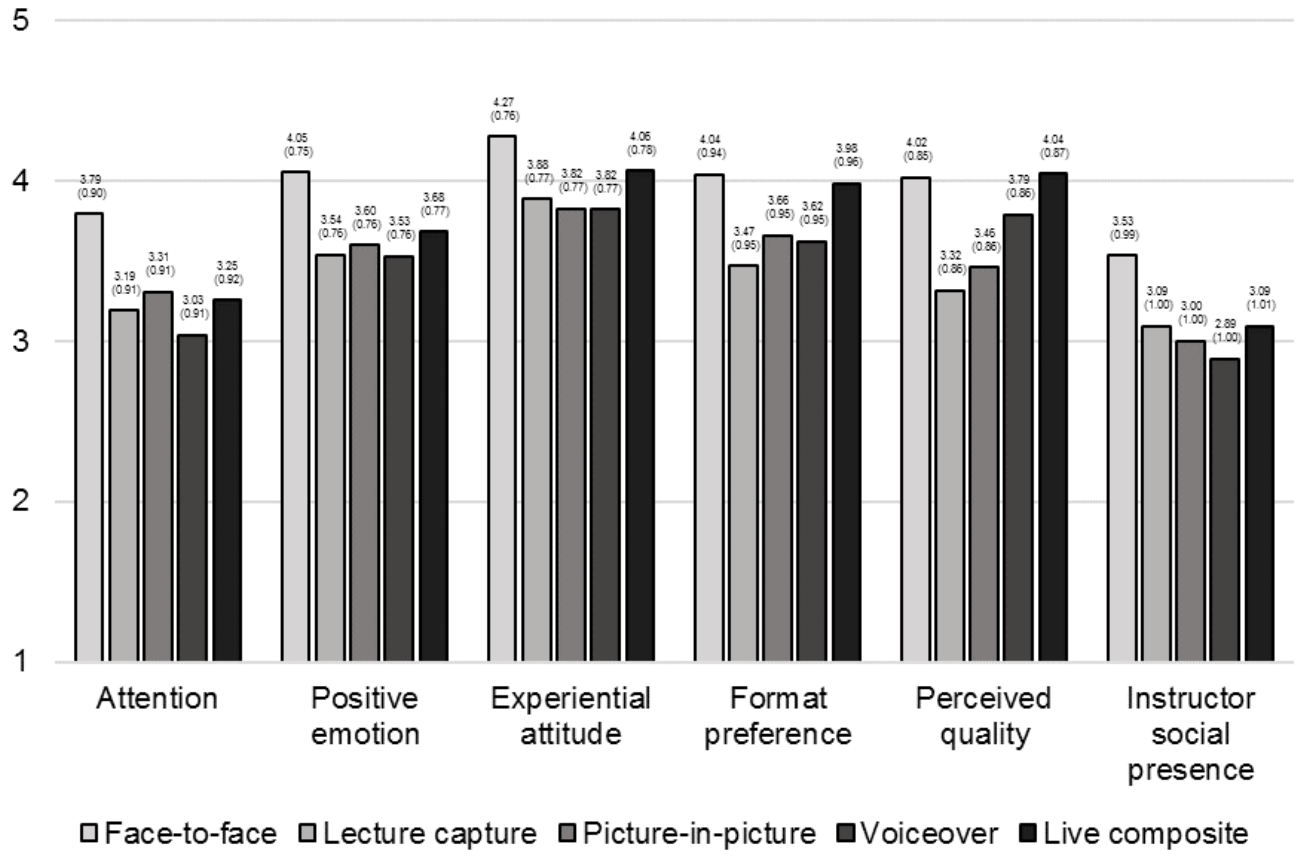

Figure 4. Effects of lecture format on learning outcomes (Study 1).
The numbers above the bars indicate the mean score with the standard deviation in parentheses.

the effectiveness of the different lecture formats with respect to knowledge retention and learning (see Congleton & Rajaram, 2012). It may also be there are no meaningful differences in knowledge retention among formats. Bos et al. (2016) found no differences in assessment scores between students who attended lectures and those who viewed lecture capture recordings. Scores were higher only for students who attended lectures and viewed the recordings as a supplement. Similarly, Rogers and Botnaru (2019) found a marginal improvement in learning performance when a semester-long course used a Lightboard as part of its lecture recordings.

Beyond knowledge retention, this study replicated prior findings showing face-to-face lectures result in a more positive learning experience than do video lectures. We observed this advantage of face-to-face lectures in terms of attention, positive emotion, experiential attitude, format preference, perceived quality, and instructor social presence. The consistent superiority of face-to-face lectures suggests an inherent advantage of that format, which may relate to the immediacy of communication that learners can receive. Other research has shown means of providing immediate communication in online learning environments can improve the learning experience of students (Lee, Srinivasan, Trail, Lewis, & Lopez, 2011).

In comparison to the face-to-face lecture, the worst performing formats were lecture capture and voiceover. The relative disadvantage of lecture capture may simply be that it is a recorded version of a face-to-face lecture. Even if the recording is high-definition, certain qualities of the live experience are lost. This may be an issue of media richness, where a lecture capture is simply poorer format than the real thing. We think media richness also offers a good explanation of the low performance of the voiceover, where the limited number of visual cues restricted the transmission of nonverbal information. This finding contributes to literature showing the image of the instructor enhances the learning experience.

Another interesting finding is perceived quality was not different between the live composite and face-to-face lectures, and it was relatively low for lecture capture and picture-in-picture. We think the relative advantage of the face-to-face lecture and live composite is due to their seamless presentations. With both formats, the instructor and slide content are in the same "space" which has a cohesive visual effect. Lecture capture is a slightly degraded version of the face-to-face lecture and picture-in-picture spatially separates the instructor from the slide content. Overall, face-to-face lectures offer the best format, but live composite lectures have a distinct advantage over other video lecture formats.

STUDY 2

Our second study provided a more focused examination of the live composite format in relation to other video lecture formats. This study used a repeated measures experiment comparing the effects of voiceover, picture-in-picture, and live composite formats. In this experiment, we used students enrolled in a class taught by the lead author. The small sample size necessitated the repeated measures design. One benefit of this design is participants served as their own controls, removing the need to check for a priori differences among conditions.

Participants

We drew participants from one of the lead author's undergraduate classes. The topic of the class is environmental communication. During the semester in which we conducted the study, there were 36 students enrolled of whom 29 participated. One participant completed the study in under three minutes, suggesting inattentiveness. We excluded that participant, resulting in a final sample size of $N = 28$. Participants had a median age of 22 ($M = 21.89$ $SD = 1.40$) and were mostly female (82.1%). Except for one exchange student, all the students were majoring in communication. The age and gender distributions are representative of the population of communication majors at this university.

Materials

The lead author wrote a three-part lecture about environmental sustainability. The lectures were based on the first three chapters from Strange and Bayley (2008). The lead author scripted each lecture and recorded three versions of it: picture-in-picture, voiceover, and live composite. The picture-in-picture recording used a high-quality webcam to capture audio and video; the voiceover recording used a high-quality lapel microphone to capture audio; and the live composite used a DSLR camera to capture video and the lapel microphone to capture audio (see Figure 5 for examples). This resulted in nine video lectures. The first lecture ranged in duration from 12:31 to 14:11 among the three formats. The second lecture ranged in duration from 12:14 to 13:16. The third lecture ranged in duration from 14:04 to 15:36.

Procedure

The experiment took place 22-29 August 2018. Participants received a link to an online survey that embedded the lectures and included survey questions. Participants could complete the study at their leisure and on a web-enabled device, such as a laptop or smartphone. Participants viewed one video lecture for each of the three assigned book chapters. The formats of the video lectures were drawn at random without replacement. As a result, participants viewed three lectures in the order of the

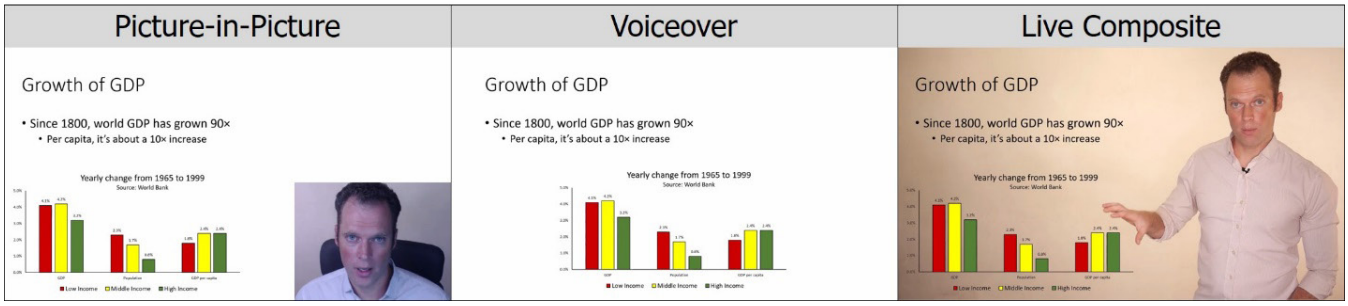

Figure 5. Example screen captures of video lecture formats (Study 2)

chapters, but three recording formats in random order. To be clear, individual participants did not see more than one version of any of the lectures. After viewing each lecture, participants answered survey questions to measure the outcomes of interest.

Measurement

This study employed only post-test measures. We excluded knowledge retention, as we did not expect there to be any significant differences among video formats for the reasons we noted in our earlier discussion. We would have measured knowledge retention later in the semester, but for ethical reasons we had to make all versions of the lectures available to the class immediately after data collection, confounding any subsequent measurement. The ethical issue is the videos were course content and if students preferred one format over the others for studying, it would be unfair to restrict their complete access to it. We replicated all the other measures from study 1.

Attention.

The seven-item measure of attention had good reliability in the picture-in-picture (Cronbach's α = .91), voiceover (α = .95), and live composite (α = .82) conditions.

Positive emotion.

The four-item measure of positive emotion had good reliability in the picture-in-picture (Cronbach's α = .91), voiceover (Cronbach's α = .88), and live composite (Cronbach's α = .90) conditions.

Experiential attitude.

The six-item measure of experiential attitude had good reliability in the picture-in-picture (Cronbach's α = .96), voiceover (Cronbach's α = .93), and live composite (Cronbach's α = .83) conditions.

Format preference.

The four-item measure of format preference had good reliability in the picture-in-picture (Cronbach's α = .96), voiceover (Cronbach's α = .97), and live composite (Cronbach's α = .94) conditions.

Perceived quality.

The two-item measure of perceived quality had variable reliability in the picture-in-picture (Spearman-Brown coefficient = .81), voiceover (Spearman-Brown coefficient = .56), and live composite (Spearman-Brown coefficient = .85) conditions.

Instructor social presence.

The three-item measure of instructor social presence had good reliability in the picture-in-picture (Cronbach's α = .86), voiceover (Cronbach's α = .91), and live composite (Cronbach's α = .87) conditions.

RESULTS

We used repeated measures ANOVA to evaluate the effects of lecture format. Mauchly's test of sphericity was non-significant ($p > .05$) for all tests, supporting the assumption of sphericity. There were significant treatment effects on attention, $F(2,54) = 6.99$, $p = .002$, positive emotion, $F(2,54) = 6.35$, $p = .003$, experiential attitude, $F(2,54) = 13.97$, $p < .001$, format preference, $F(2,54) = 7.94$, p

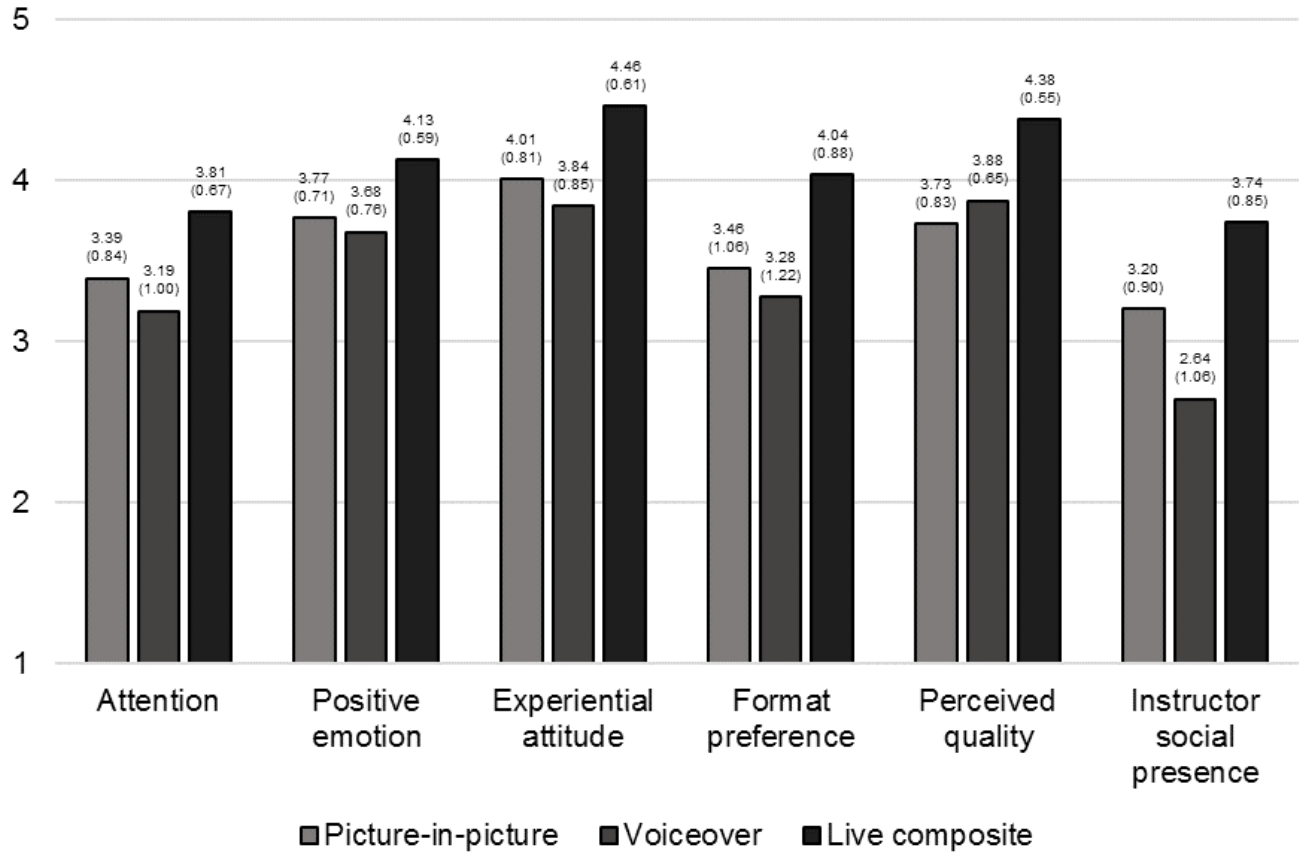

Figure 6. Effects of lecture format on learning outcomes (Study 2).
The numbers above the bars indicate the mean score with the standard deviation in parentheses.

< .001, perceived quality, $F(2,54) = 10.69$, $p < .001$, and instructor social presence, $F(2,54) = 20.26$, $p < .001$.

Next, we conducted pairwise comparisons using Sidak correction and graphed the cell means (see Figure 6). For all the dependent variables, the score was higher for the live composite recording than for picture-in-picture (average $p = .012$) and voiceover (average $p = .005$). Instructor social presence was higher for picture-in-picture than for voiceover ($p = .002$). Otherwise, there were no significant pairwise differences between picture-in-picture and voiceover.

DISCUSSION

The second study compared student learning experiences related to three video lecture formats: picture-in-picture, voiceover, and live composite. Results showed a clear advantage of the live composite format with respect to attention, positive emotion, experiential attitude, format preference, perceived quality, and instructor social presence.

The most pronounced effect was on instructor social presence, which further corroborates the argument that the instructor's image can enrich the medium. Instructor social presence was the lowest for voiceover, which did not show the instructor's image. It was moderate for the picture-in-picture, which included a boxed image of the instructor from the chest up. In contrast, the live composite lecture showed the lecturer from the waist up and could capture large body movements, such as arm gestures. Post hoc analysis showed in the live composite condition instructor social presence was rated significantly above the middle response option, $t(27) = 4.58$, $p < .001$. That is, participants tended to agree they experienced instructor social presence in that condition. This was not the case for the other conditions. This means live composite video lectures create a distinct sense of social connection, which may enhance the overall learning experience.

Finally, it is worth noting the patterns observed in the second study largely mirrored those from the first. Ignoring for a moment the non-significant pairwise comparisons, the pattern of effects in the first study were as follows: (1) scores on positive emotion, experiential attitude, format preference, and instructor social presence were the largest for the live composite lecture and the smallest for the voiceover lecture; and (2) perceived quality was the highest for live composite and the lowest for picture-in-picture. These were exactly the patterns we observed in the second study, where they were all statistically significant. In other words, the second study provided a more powerful test and clarified the equivocal findings from the first study.

GENERAL DISCUSSION

These two studies corroborated the findings of prior research and provided substantial data on the pedagogical value of live composite video lectures. The first study showed the format of video lectures affects several variables related to the student learning experience (Chen & Wu, 2015; Korving et al., 2016; Wang & Antonenko, 2017). Whereas face-to-face lectures resulted in a consistently positive learning experience relative to the video lectures, live composite lectures performed equally well in terms of perceived quality and format preference. As noted in our earlier discussion, by putting the instructor and slide content in the same "space," those visual elements have greater coherence, which may make it easier for students to integrate those different sources of information. We speculate such an effect hinges on attention, but learners may experience it as cognitive challenge. This would be an interesting effect for future research to study.

The second study drew focused comparisons among voiceover, picture-in-picture, and live composite video lectures. The pattern of results mirrored those of the first study and clarified some of the effects. Most notably, we found participants experienced the greatest instructor social presence while viewing live composite videos. Although many factors are important in online instruction, instructor social presence may be especially valuable because it operates at the nexus of social presence and teacher presence (Richardson et al., 2015). Yet, instructor presence is more than the experience of social connection the current study examined. It may also include clarity and immediacy of communication, quality of feedback, and signs of caring (Richardson et al., 2015). Many of these qualities of instructor presence go beyond the lecture and require careful consideration of course design, implementation, and assessment. Do live composite video lectures retain their advantage when instructors employ other techniques to enhance instructor social presence? Perhaps those techniques work synergistically and enhance the learning outcomes of live composite video lectures. It would be interesting for a future study to examine this interaction.

Additional findings of the second study showed an advantage of live composite video lectures in terms of attention, positive emotion, experiential attitude, format preference, and perceived quality. As more online options become available to students who cannot be physically present, it is important to know what formats students find most appealing and may generate the most positive learning experience. As we noted in the literature review, attention (e.g., Weeks & Hasher, 2017), emotion (e.g., Storbeck, 2016), and presentation quality (Lee & Kim, 2015) affect the learning process. Based on the results of these two studies, live composite videos are more effective than other formats at drawing attention, providing an enjoyable emotional experience, and creating a sense of instructional quality.

These results can supplement other lines of research that look at instructor and content characteristics. Wijnker, Bakker, van Gog, and Drijvers (2019) found teenagers expressed more interest in video lectures that posed questions and felt they learned more from informative video lectures with an authoritative instructor. Future research should study if such characteristics interact with video lecture format, especially if live composite lectures enhance their effects.

LIMITATIONS

The two experiments had some limitations. First, participants were undergraduate students from a single university. A more diverse sampling of learners would allow generalization to other kinds of students and may have implications for other types of learners (e.g., in informal learning environments). Second, the fact that both co-authors are White males may have biased the results. Research has shown student evaluations are positively biased for White instructors (Reid, 2010) and male instructors (Laube, Massoni, Sprague, & Ferber, 2007). However, it is unclear how the race or gender of the instructor would moderate the effects we observed. Third, the video and live lectures were short in length, which might have produced distinct effects, particularly with respect to attention. Future research might examine how lecture duration moderates the effects of format. We expect duration would amplify the effects, giving live composite lectures an

even larger advantage, but such assertions require formal testing. Finally, we found no differences in knowledge retention among the lecture formats. Although this is consistent with prior research (Bos et al., 2016), it undercuts the value of this study. If learning is the commitment of knowledge to memory, then our study failed to show effects of format on learning.

CONCLUSION

Instructors who use online instruction, especially those who use video lectures, can benefit from using the live composite format. Instructors can use it to create high-quality lectures with little or no post-production work and, depending on the setup, minimal upfront cost. For these reasons alone, live composite videos are a good option for delivering online instruction. Further, this format has many advantages over other video lecture formats. As the current study showed, learner attention, positive emotion, experiential attitude, preference, perceived quality, and instructor social presence were higher for live composite videos than for other common video lecture formats. Therefore, it is important that providers of online lessons consider using the live composite video format when developing new content.

ADDITIONAL FILES

"Introduction to Live Composite Video Lectures"
https://www.youtube.com/watch?v=Yk7qRCKkoU0

"How-to Guide for Creating Live Composite Video Lectures"
https://www.youtube.com/watch?v=s6TuReOUdpw

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