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Actionable Framework in Producing High-Impact, Low-Cost Instructor-Made-Videos for E-Learning

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Instructor-made-videos (IMVs) are often used to foster learning in higher education. However, there is a dearth of studies on IMVs for any instructor to understand and replicate the success. In response, to better inform practice, the impact of IMVs on learning effectiveness and satisfaction was evaluated. Thereafter, an actionable framework describing the pedagogical innovation was produced. In this study, an experimental research design was employed to determine the impact of IMVs by comparing three lessons on health, ethics, and law; with and without IMVs, followed by a survey questionnaire. This study was conducted with 121 polytechnic students who were randomly assigned to a control group (N=50) or an experimental group (N=71) of five classes. Students exposed to IMVs outperformed the control group on quiz scores when IMVs were used to scaffold learning and were more satisfied. These findings validate the actionable

6Ps IMVs design framework in producing high pedagogical value IMVs in a nimble manner.

Keywords: videos, e-learning, online learning, instructor-made-videos, multimedia

INTRODUCTION

The COVID-19 pandemic has become an unlikely catalyst of change. Committed to advancing education, instructors had to quickly adapt so that education could be effectively delivered remotely (Lee, 2020). Hence, educational institutions around the globe have embraced e-learning, particularly using instructor-made-videos (IMVs) as asynchronous multimedia (Noetel et al., 2021).

A laptop with built-in webcam and movie making software are all that is required to produce IMVs (Rose, 2009). Given the proliferation and advancement of technology, instructors can now record and edit high-definition videos on the move. In effect, with just a smartphone, they can stream such videos on YouTube with closed captioning being automated. As a result, IMVs are deemed as one of the most cost-effective ways of creating multimedia for e-learning (Noetel et al., 2021).

The multimodal nature of IMVs involving the illustration and presentation of key concepts, knowledge, and skills, improves students' comprehension, thereby positively impacting their learning (Pan et al., 2012). Similarly, Horn (2013) suggested that IMVs provide greater autonomy for students, and they reduce stress for slow learners as they can pause, replay, and fast forward through the content, to process information at their own pace. Furthermore, adding videos to existing teaching methods led to strong learning benefits for students of higher education (Noetel et al., 2021). However, IMVs are not inherently effective. For example, Guo, Kim, and Rubin (2014) demonstrated that students often neglect huge segments of IMVs, whereas MacHardy and Pardos (2015) found that some IMVs contribute little to student performance. Johanes and Lagerstrom (2016) opined that IMVs that are high in pedagogical value are a multifaceted endeavour with a plethora of nuances to consider. Specifically, they encapsulate the process of pre-production (e.g., script writing, preparation of visuals), production (e.g., recording and voice over) and post-production (e.g., trimming the video) (Thakore & McMahon, 2006).

While technology supports IMVs production in making the processes relatively easy to design as well as cost effective, thoughtful pedagogical approaches to technology integration are often a neglected aspect of e-learning implementation (Bonk et al. 2018; Johnson & Aragon, 2003). In fact, Margaryan et al. (2015) and Huang and Hung (2020) emphasized pedagogical innovation factors outweigh technological innovation alone since pedagogical design determines how technology supports the design of IMVs. Online instructors too often lack adequate professional preparation or experience in producing IMVs (Lowenthal et al., 2018; Zhu et al.); this lack of experience is particularly problematic when caught off guard by suddenly emerging environmental problems or issues like the COVID-19 pandemic (Lee, 2020).

Moore's and Mayer's theories for learning through and producing IMVs

In Moore's (2013) theory of transactional distance, the learning and teaching context considers the separation between students, and between students and instructors. Transactional distance is defined as a psychological and communication gap between the student-student and lecturer-student formed by physical distance, in e-learning. We use this theory to inform the design of IMVs by ensuring an appropriate balance of three factors, i.e. (1) dialogue, (2) lesson structure and (3) student-autonomy. Dialogue refers to the interaction between student-student, student-instructor and student-content. Studies from Ekwunife-Orakwue and Teng (2014) and Best and Conceição (2017) indicate that student-content interaction (Garrison, Anderson, & Archer, 2001; Rourke, Terry, Randy, & Walter, 1999) has a larger effect on student learning outcomes than other forms of dialogue. Hence, in this study, we focus on only the student-content interaction. A typical IMV, therefore, consists of a real-world problem to trigger prior knowledge, pique interest and drive inquiry (Hake, 1998) for student-content interaction.

The second factor or lesson structure that Moore (2013) described is the level of the lesson flexibility or rigidity. This factor includes facets such as the pedagogical model used (e.g., teacher- vs. student-centred) and the ability of the lesson to cater to students' preferences (Zhang, Zhou, Briggs, & Nunamaker, 2006). In our study, IMVs serve as asynchronous multimedia in which students can customise learning around their other commitments, and are less reliant on stable, high-speed internet connections than needed with videoconferencing (Al-Samarraie, 2019). Also, students could pause, rewind, and repeat the IMVs as many times as they desired, in regulating their cognitive load (Robertson & Flowers, 2020; Noetel et al., 2021) and this is a critical feature for e-learning (Tallent-Runnels et al., 2006).

The third factor or student autonomy, is dependent upon the previous two, in that it refers to the sense of both independence and interdependence perceived by learners as they engage in the lesson. Student autonomy refers to a student's sense of self-directedness, which can be highly affected by the dialogue, the level of rigidity or flexibility inherent in the lesson design and delivery, and the degree to which the student has a sense of control over the learning procedures (Giossos, 2008).

Mayer's (2010) cognitive theory of multimedia learning posits that learning is more effective when information is presented to both auditory and visual channels, as our brains have separate but connected neurological systems for processing verbal and pictorial input. Meta-analyses of multimedia effects on learning validate this postulation, revealing that people learn better when both channels are used, rather than either one of the channels (Mayer, 2010; Rolfe & Gray, 2011). IMVs serve this purpose when students learn through both channels, simultaneously.

Extraneous load is where working memory and attention are 'wasted' on content that is not essential to learning and instruction (van Merriënboer & Sweller, 2005). For instance, interesting animation with sounds and graphics that does not directly relate to the learning outcome can be deemed extraneous and, therefore, can hamper learning. Meta-analyses revealed that interesting but irrelevant content reduces learning because these details use working memory that would otherwise be better focused on the learning outcome i.e., the coherence principle (Mayer, 2010). Likewise, studies have revealed multimedia to be more effective when critical information are highlighted i.e., signalling effect (Mayer, 2010), when speech and visuals are presented simultaneously i.e. temporal contiguity (Mayer, 2010), and as part of the same visual field i.e. spatial contiguity (Mayer, 2010).

However, IMVs appear to lack an actionable framework with pedagogical value (Cooper, 2018; Noetel et. al., 2020). Instructors, on the other hand, need training, to expediently produce impactful IMVs for e-learning (Tallent-Runnels et al., 2006); especially, during the pandemic (Lee, 2020). We attempt to design and test an innovative pedagogical approach to technology integration with IMVs production. The IMVs are designed based on Moore's (2013) theory of transactional distance and Mayer's (2010) cognitive theory of multimedia learning. We intend to test such theories rigorously (Bonk et al., 2018; Johnson & Aragon, 2003) instead of basing our research on a single session/lesson as found in most studies (Robertson & Flowers, 2020). Hence, the aim of this study was (a) to examine the impact of the IMVs on learning effectiveness and satisfaction, and, thereafter, to (b) produce an actionable framework describing the pedagogical innovation to inform practice.

METHOD

This study employed an experimental design to determine the impact of IMVs. A survey questionnaire was used to determine students' attitudes towards IMVs. A total of 121 polytechnic students were recruited in this study. Students were randomly assigned to a control group (N=50) or an experimental group (N=71). Three lessons (Lesson 7, 8, and 9) were part of this study. The lessons were on defensive medicine and end of life issues of Health, Ethics and Law Module, which consists of 13 lessons. An approval was sought from the Institutional Review Board and Ethics Committee of the polytechnic.

Research design

IMVs are defined as pre-recorded multimedia that consists of visuals and speech (e.g. voice-over PowerPoint). By being asynchronous multimedia, the scripts for the IMVs were planned carefully and thoughtfully during the pre-production stage so as to reduce extraneous load by applying a series of multimedia design principles (Mayer, 2010). Such multimedia principles were fundamental when recording took place during the production stage as well. Camtasia software was used for the production and post production stages.

An iterative process was undertaken to develop the IMVs before implementation for this study, and not to be viewed as a linear process (Govindasamy, 2001). Hence, IMVs developed for two lessons (Lesson 1 and 2) were piloted to students undertaking this study. The experiences and insights gathered improved the design of the IMVs for the subsequent three lessons of this study. Further, these IMVs were validated by a review committee of the polytechnic as part of quality assurance.

An e-learning lesson of the module consisted of an asynchronous session and then a synchronous session. IMVs were deployed together with PowerPoint and reading materials for self-directed learning for the asynchronous session, in which this study is focusing on. As for the synchronous session, students were to work in teams to formulate responses or solutions to the given tasks, which they had to present and/or debate. This session was not included in the study so as to lower any lecturer or peer effect, variables that may affect the study outcomes. IMVs served as a scaffold for the experimental group and were structured in the asynchronous session, while for the control group, they were a supplementary resource that were released after the post quiz.

For the three lessons that were studied, all students were to complete a pre-quiz and a post-quiz at the start and end of the asynchronous session, respectively. The purpose of the pre-quiz was to determine the student level of prior knowledge before the lesson began. Given that learning effectiveness was measured by the improvement of students' scores, the post-quiz questions were the same as the pre-quiz questions. A total of 18 quiz questions were designed for the three lessons. These were application-based multiple-choice questions (MCQs), aligned to the lesson outcomes. MCQs as an objective scoring method was chosen due to its high degree of reliability (Haladyna 2002) and often deployed to measure achievement of learning outcomes in testing an intervention for research and education (Considine & Thomas, 2005). The MCQs were also appropriate for students' workload (Long, Logan, & Waugh, 2016).

Automatic grading and speed of feedback (Peel, 1994) were offered to students with these forms of assessment before the synchronous session of e-learning took place, subsequent to the lesson. Each quiz contributed a minor amount toward final grade, and could help them assess their achievement of the learning outcomes (Frydenberg, 2013). The IMVs were embedded in PowerPoints as a Shareable Content Object Reference Model (SCORM) package and hosted by the institution's Learning Management System (LMS).

Data Collection Procedures

Informed consents were received from students after they were clearly briefed on the objective and procedure of the study. Also, student participation was entirely on a voluntary basis and they could withdraw anytime. These second-year students have used the SCORM packages in the LMS system during the preceding semester and they were highly familiar with them. The SCORM packages were released to students two days prior to their lesson day. Each lesson consists of about five bite-sized IMVs, averaging about three minutes each, for the experimental group. Both groups had about 35 slides for each lesson. At the end of the session, students were given post-quizzes. At that time, they were encouraged to complete a survey questionnaire via Google Forms to assess their attitude regarding their learning experiences as well as their associated learning preferences. The survey questionnaires were adapted from Long, Logan, and Waugh (2016) and Kay and Kletskin (2012).

The questionnaires in this study included students' information, such as class, gender and GPA. Students were asked to rate the audio quality, video

quality, length, helpfulness, interactivity, self-directed learning, and ease-of-use of the IMVs in SCORM that facilitated their learning, using a 5-point Likert scale (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5). The open-ended questions asked the students to share their views on what they liked most about the IMVs that helped them learn, and their suggestions for improvement. The survey was administered using Google Forms and completed by students anonymously. These procedures were repeated three times for Lesson 7, 8, and 9 of the module.

DATA ANALYSIS

The IBM Statistical Program for Social Sciences (SPSS) software version 24.0 was used for statistical analysis. For all outcome measures, between-group differences in mean change were analysed by using the non-parametric statistical test - Mann-Whitney U. A Wilcoxon Signed-rank test was used to measure the within-group differences. These non-parametric tests were deployed because the data were not normally distributed. Results were reported as means ± standard deviation (SD) for the descriptive data. Alpha level for all analysis was set as α=.05.

The pre-quiz and post-quiz scores of the three lessons, completed by 109 students (90%) in the experimental and control groups (N_{exp} = 68; N_{ctrl} = 41) were compared using the Mann Whitney U test and Wilcoxon signed rank test. In addition, an attitude survey was answered on a 5-point Likert scale and two open-ended questions by these 109 students (90%). Descriptive analysis was used to describe and summarize the data from the closed-ended questions, coupled with Mann-Whitney U test. As for the open-ended questions, student responses were analysed thematically. Emerging common themes were identified, coded, and categorized independently by two authors before deliberation to ensure credibility (Lincoln & Guba, 2006; Tobin & Begley, 2004).

RESULTS

Quiz scores of the three lessons

Mann Whitney U test revealed that both groups failed to show statistical differences for the pre-quiz scores (U=1360, Z= -.166, p=.868). The

mean rank of the pre-quiz scores of the experimental group and control group were 53.59 and 54.59, respectively. Therefore, homogeneity of prior knowledge for both groups was statistically equivalent.

As for the post-quiz scores, Mann-Whitney U test revealed significant differences for the overall experimental and control groups (U=989.50, Z= -2.531, p=.011). The mean rank of the post-quiz scores of the experimental and control group were 60.29 and 44.99 respectively. Specifically, Lesson 8 showed significant differences for post-quiz scores (U=977.50, Z= -2.848, p=.004). The mean rank of the post-quiz scores of the experimental and control group was 61.96 and 44.72, respectively. As for Lesson 7 and 9, there was no significant difference for post-quiz scores (p>.05).

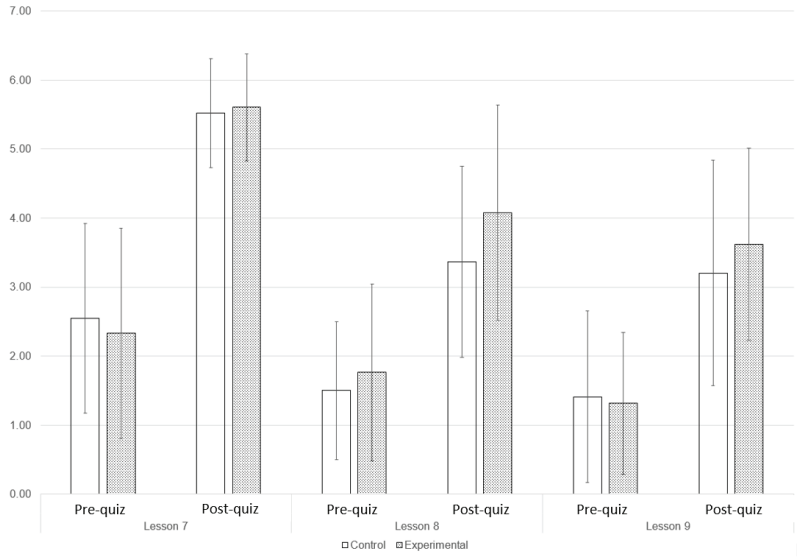

Figure 1. Mean (SD) of Pre-Quiz and Post-Quiz Scores for the Three Lessons.

Overall, improvement in scores was observed for the three lessons and significantly higher in Lesson 8 for the experimental group as compared to the control group (Figure 1).

Wilcoxon Signed Ranks test revealed that there was a significant difference between the pre-quiz and post-quiz scores for Lesson 7, 8 and 9 of the module in both the experimental (Z=-6.64, p=.000); (Z=-5.98, p=.000); (Z=-6.53, p=.000); and control groups (Z= -5.603, p=.000); (Z= -4.918, p=.000); (Z= -4.676, p=.000), respectively, for all three of those lessons.

Such results indicate that students demonstrated learning gains when learning through the SCORM packages, with or without the IMVs.

Overall, as hypothesized, students in the experimental group scored higher (M=4.43) for the post-quiz as compared to the control group (M=4.03). However, the only statistically significant difference was found in Lesson 8 favouring the treatment group (p=.004).

Students' attitude

Figure 2 shows the descriptive analysis for the overall attitudinal data of the three lessons, between the control and experimental groups. In Lesson 7, significant differences between experimental and control groups were revealed for three Items; namely, Item 4 on helpfulness of the IMVs (Z= -2.737, p=.006), Item 5 on length of the IMVs (Z= -2.485, p=.013), Item 7 on easy to learn from IMVs (Z= -2.022, p=.043) with mean rank for all items higher in the experimental group as compared to control group, except for Item 1 on audio quality. As for Lesson 8, there were six Items with significant differences including Item 2 on IMVs quality (Z= -2.009, p=.045), Item 3 on well-explained content (Z= -2.665, p=.008), Item 4 on helpfulness of the IMVs (Z= -2.424, p=.015), Item 5 on length of the IMVs (Z= -2.511, p=.012), Item 8 on interactivity (Z= -2.486, p=.013), Item 9 on achieving learning outcomes (Z= -2.611, p=.009) with mean rank for all items higher in experimental group as compared to control group. As for Lesson 9, two items stood out with significant difference, including Item 5 on length of the video (Z= -2.037, p=.042) and Item 9 on achieving learning outcomes (Z= -2.478, p=.013) with mean rank for all items higher in experimental group as compared to the control group, except for Item 1 on audio quality. Audio quality in Lesson 7 and 9 with mean rank of 54.91 and 51.39 for experimental group and 56.50 and 59.38 for control group, respectively was an area that warranted attention for improvement. There was no difference between groups for Item 1, 2, 6, 7 and 10 (see Figure 2) with $p<.05$.

Overall, five items showed significant differences ($p<.05$) between experimental and control groups. These attitudes were represented by Item 3, 4, 5, 8, and 9 (Figure 2). More specifically, 82.9% (highest) responses from the experimental group agreed that IMVs enabled self-directedness in learning (Item 6). This finding revealed that students had positive attitudes with the IMVs that were designed with appropriate length (Item 5) that scaffolded their learning with clear and concise explanation (Item 3 and 4), coupled with interactivity (Item 8), that helped them to achieve the learning

outcomes (Item 9) in a self-directed manner (Item 6). 8.8% of the responses of the experimental group opined that the audio quality (Item 1) needed improvement.

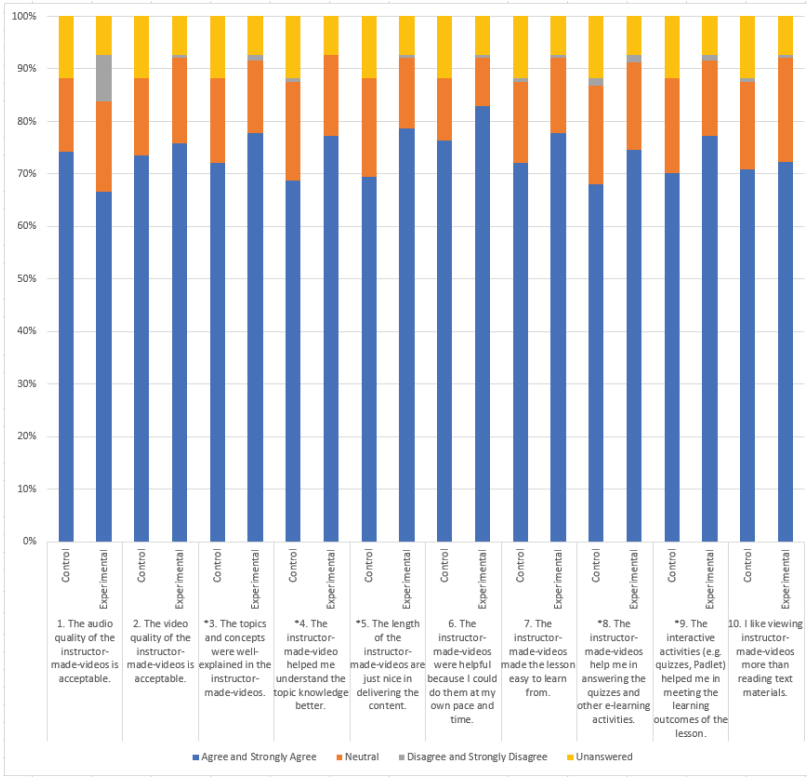

Figure 2. Overall attitudinal data visually, for the three lessons, between the control and experimental group.

Descriptive Statistics

Students' attitude was plotted on a Boxplot graph for visual analysis (see Figure 3). Figure 3 consists of two sets of boxplot graphs, displaying the distribution of students' attitudinal data for both the experimental and control groups with significant differences. The median score for the experimental group was higher than the control group, indicating higher student satisfaction with the IMVs. Boxplot for the experimental group was uniformly distributed. The findings indicate that having pedagogically designed

and purposeful deployment of IMVs as a main resource in the SCORM package was critical for learning.

As for the control group, there were many outliers indicating that IMVs as supplementary resources, released at the end of the asynchronous session yielded very mixed responses. Some students valued the IMVs with high pedagogical value whereas some did not, resulting in the outliers and scattered boxplot.

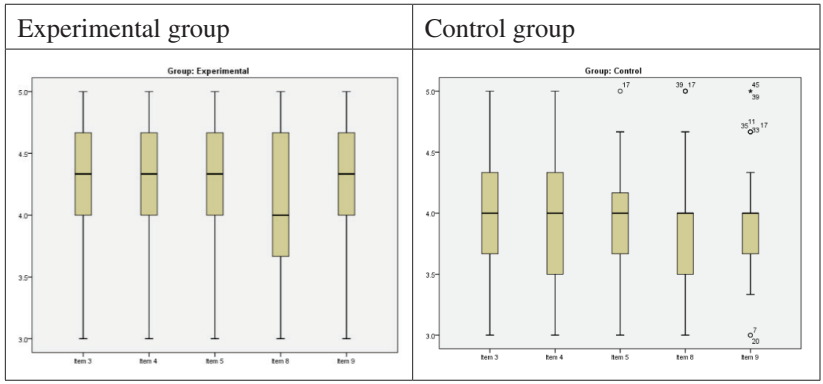

Figure 3. Boxplot graphs displaying the distribution of students' attitudinal data for the items with significant differences.

Thematic analysis

At the end of the survey, students were asked two open-ended questions about what they liked most about the videos and how they could be improved to enhance learning. Students' responses were analysed thematically. The results support the findings from the close-ended questions. The main themes emerged were depicted in Table 1. Slightly over 37% of the responses concerned the theme of 'problem trigger' as concepts were well illustrated through authentic scenarios, making the videos relatable to students while addressing the lesson learning outcomes. Just over 33% of the responses indicated that the students appreciated the 'personalised learning' as they could pause and rewind the bite-sized IMVs when necessary to grasp the concept at their own pace enabling greater self-directedness in learning. In addition, nearly 30% of the responses valued the 'personable engagement' as students found the videos contained clear and concise explanations by a human voice. They also felt the videos mimicked face-to-face experience and were of appropriate length. Areas of improvement sug-

gested were to have a consistent audio quality, with transcript offered in the notes section of the SCORM package and not just rely on closed captions.

Table 1

Thematic analysis of student's attitudes towards the IMVs

Themes	Examples of responses	Three lessons (N=299)
Problem trigger	"I like how it involves a lot of real-life stories that is helpful in terms of relating and understanding better" "it's specifically for the lesson itself and doesn't go off point"	37.12%
Personalised learning	"I can do it at my own pace because I am a slow learner when it comes to theories" "it allows me to understand better from hearing than reading texts" "The use of graphic that was being brought in. It helps me understand better because there is visual"	33.44%
Personable engagement	"I like how it feels like a one-to-one session via the lecturer-made-videos" "the length of the video is just right" "I like that it is not a robot talking"	29.43%

DISCUSSION

The aim of the study was (a) to examine the impact of the IMVs on learning effectiveness and satisfaction and, thereafter, to (b) produce an actionable framework describing the pedagogical innovation to inform practice. The impact of the IMVs was evident from the quiz scores of the three lessons. Students in the experimental group scored higher for the post-quiz as compared to the control group as hypothesized, but only statistically significantly higher in Lesson 8. Attitudinal findings revealed higher satisfaction of the IMVs in the experimental group as it was pedagogically designed; intentionally and purposefully deployed. Findings from the thematic analysis provided deeper insights to inform practice. This result is in ac-

cordance with other studies (Mayer, 2010; Rolfe & Gray, 2011; Robertson & Flower 2020; Noetel et al., 2021) that IMVs augment learning. Arising from the attitudinal findings, an actionable framework describing the pedagogical innovation to inform practice was devised - 6Ps educational video design framework (see Figure 4). There are two segments in the framework i.e., (1) pedagogical innovation denoted by Problem trigger, Personalised learning, and Personable engagement; and (2) technological innovation denoted by Pre-production, Production, and Post-production. The findings were explained using this framework.

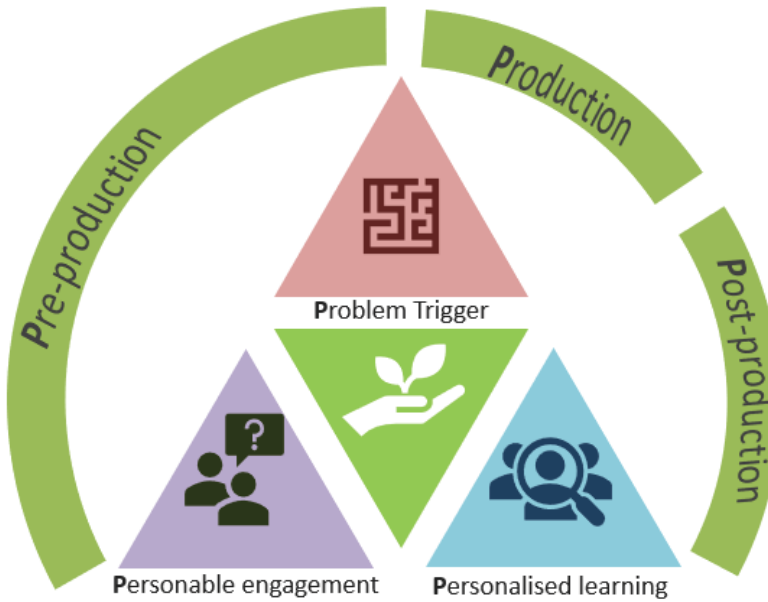

Figure 4. 6Ps Educational Video Design Framework.

Pedagogical innovation: Problem trigger, Personalised learning, Personable engagement

Problem trigger

The result showed that the experimental group rated higher than the control group significantly for four items of the closed-ended questions - helpfulness (Item 4) of the well-explained content (Item 3) which they inter-

acted with (Item 8), helped them to achieve the learning outcomes (Item 9). As for the thematic findings, problem triggers garnered the most responses.

To introduce new concepts in meeting the learning outcomes, an asynchronous session begins with an authentic/real-world problem (Lave, 1996) in the form of IMV, as a trigger. Problems that students could relate to motivate them to research, reason and reflect (Jonassen, Peck, & Wilson, 1999; Noetel et al., 2021) to achieve higher order thinking skill. As the concepts were contextualised, students can learn in a kinesthetics manner (Fleming, 2011) while establishing student-content interaction (Garrison et al., 2001; Rourke et al., 1999).

But the problem trigger should be reasonably scoped such that it is within the capability of learners to find the solutions with the allocated time given. Open-endedness of the problem supports critical thinking whereby there is no standard answer/approach to the problem prescribed, although an explanation was furnished after they attempted the problem trigger. For example, in Lesson 8, in which students significantly outperformed the control group, on end of life issues, the problem trigger was about a terminally-ill-70-year-old woman. Her children kept her unaware of her prognosis as they did not want her to worry unnecessarily. And, with the help of the attending doctor, they proceeded to the doctor's recommendation of having surgery. However, she died shortly after the surgery and did not manage to express her last wishes, if any. Students were asked if the children did the right thing and they shared their individual rationale.

The approach to the problem trigger is often dependent on one's religious belief, local culture, and prevailing medical practice even though that may contradict with Singapore's law which upholds the autonomy principle. This principle is hard to apply in Asian family culture, making it not a straight-forward problem on which students had to justify their decisions. Hence, real-world problems with well-explained concepts in the form of IMVs enhance students' understanding in meeting the learning outcomes (McNeill, 2008).

Personalised learning

A one-size-fits-all method to education will always leave some students behind (George Lucas Foundation, 2016). For instance, not all students can follow along with the pace of an instructor in a face-to-face lesson. With IMVs, lower-achieving students benefited most as they could regulate their cognitive load by pausing to take notes or rewinding and replaying the video on challenging concepts (Costley, Fanguy, Lange, & Baldwin, 2020), there-

by making learning more inclusive. Zhang et al. (2006) found that when students have control over the IMVs whereby they can review or fast forward the IMVs as desired, they achieved greater satisfaction and increased long-term memory with higher retention of lesson content. In effect, they achieved better learning outcomes. This finding could explain why Item 6 "The IMVs were helpful because I could do them at my own pace and time" was the highest rated item by the experimental group from the attitudinal findings. Further, instead of constraining learning by time, it should focus on individual students' progress (Maseleno et. al., 2018). As learning is student-centred with the use of asynchronous IMVs, students are better able to learn at their convenience and in a self-directed manner (Moore, 2013).

Robertson and Flowers (2020) found that students who used a combination of the video and PowerPoint outperformed the students who did not, as evident in our study, with significant difference in Lesson 8. Hence, IMVs augment learning when IMVs were intentionally and purposely deployed (Johanes & Lagerstrom, 2016) together with PowerPoint as a SCORM package and reading materials. The thematic results revealed students' preference of having not just their visual senses being engaged but also audio. Mayer (2010) stated that when audio and visual channels are used to convey information, it enhances students' ability to transfer information than only using one channel (e.g., reading articles alone overloads visual channel thereby impeding learning). Besides, diverse learning styles e.g. visual, aural, read-write, and kinesthetics (Gunawardena & Boverie, 1993) should be considered for an effective design of the IMVs (Drago & Wagner, 2004). Transcripts should be offered in the notes section of the SCORM package and not just having closed captions, as suggested by students. If this suggestion is implemented, students are able to personalise their learning by reading the transcripts if they miss what was said in the IMVs (Adesope & Nesbit, 2012). On the other hand, students can exercise autonomy by turning the closed captioning off if they find it overwhelming, thereby eliminating, or at least limiting, the redundancy effect (Moore & Kearsley, 2012).

Personable engagement

Intuitively, students cannot learn from IMVs if they do not watch them (Brame, 2016). In this study, intentional and purposeful deployment of IMVs as a main resource was critical for consumption as revealed in the attitudinal findings (boxplot) and led to learning (post quiz scores).

The online learning experiences were humanized despite the fact that the lessons were fully digitalized for self-directed learning (Moore & Kearsley, 2012) which often lack human touch, causing students to feel lonely. Evidently, students felt that the IMVs mimicked face-to-face experience. This humanisation was possible as the IMVs were designed around, with, and for humans in an iterative way (Razzouk & Shute, 2012) while adopting a conversational style (Mayer, 2010) and voice principle (human voice) (Mayer, 2010).

The coherence principle (Mayer, 2010) ensured that the content of the IMVs were aligned to the learning outcomes and tended to exclude interesting but irrelevant material, thereby enabling an appropriate IMV length. Each IMV averaged about three minutes (Rey et al., 2019) and were approximately 15 minutes in total, for each lesson that offered content in a clear and concise manner. This explained why Item 5 of the closed-ended questions - the length of the IMVs was just nice was rated significantly higher by the experimental group as compared to the control group. Noetel et al. (2021) reported that IMVs are more time efficient as the same content is reduced into a shorter and more palatable length, in the form of IMVs (e.g., a 1-hour lecture condensed into a 15-minute IMV). Overall, IMVs allow the instructor to customize the content strategically targeted to the learning outcome more humanly, thereby increasing engagement (Brame, 2016).

Technological innovation: Pre-production, Production and Post-production

Overall, our results suggest that IMVs were effective in bridging the transactional distance of online learning whereby dialogue (e.g., interaction with the problem trigger), lesson structure (e.g. IMVs supplemented with PowerPoint and reading materials), and student-autonomy (e.g., pause and rewind video) co-existed (Moore & Kearsley, 2012). However, to inform practice, the process of IMVs development (see green curves in Figure 4) needs elaboration.

Pre-production stage refers to script writing and preparation of visuals which requires a significant amount of time as shown in Figure 4 with the longest green curve. Problem trigger and explanation were written in a script at this stage after conceptualisation using conversational style. For instance, “I” is used to indicate the instructor’s perspective. The use of conversational style rather than formal language for multimedia instruction has been shown to positively impact students’ learning, perhaps because such an

informal style helps students develop a sense of social partnership with the instructor that leads to greater engagement and effort (Mayer, 2010). Words were carefully chosen to convey information in an efficient manner while ensuring the explanation addressed the problem trigger sufficiently. The script helped ensure that nothing was left out during the production stage and that the content was coherently sequenced. In effect, the procedures employed at this stage helped with the effectiveness of the IMVs.

Production stage is where the recording takes place. The corresponding author's voice (Mayer, 2010) was used for the voice-over at this stage. Next, unnecessary parts are trimmed and; volume adjustment and levelling are conducted at the post-production stage. Camtasia software was used for the last two stages. Students had recommended providing higher levels of audio quality, particularly for Lesson 9. This could imply that an external microphone is needed or more robust software.

The IMVs were then uploaded to YouTube for automation of subtitling and streaming. Whenever possible the IMVs were edited during the post-production stage, incorporating feedback from the review committee of the institution as part of quality assurance. However, when it was not possible given substantial change, the three stages were repeated, adopting an iterative approach (Razzouk & Shute, 2012).

LIMITATIONS AND RECOMMENDATIONS

As part of the research protocol, students were repeatedly asked to rely just on the prescribed resources when completing the quizzes. Nevertheless, students likely had access to other resources that were not prescribed in the study. Given this limitation, we suggest future researchers in this area deploy software to restrict internet access and monitor student laptop screens when they are attempting to answer the lesson quizzes. As an additional measure to prevent students from using other devices for communication, eye tracking software can be deployed too. Such approaches will limit the possibilities of interacting with someone knowledgeable about the lessons or using online search tools to determine the answers to the quizzes.

Reflecting on our experience when crafting the content of the lessons, Singapore authorities such as the Ministry of Health were often consulted due to the nature of the highly localised content knowledge. Perhaps students may find Lesson 8 on end of life issues, particularly challenging as they were unfamiliar with concepts such as of euthanasia, do-not-resuscitate (DNR) order and advanced care planning. The concept of euthanasia and

DNR order as depicted in non-local movies that students were exposed to, were not the same in Singapore practice. In Singapore, euthanasia is illegal and DNR order is a medical decision made by the attending doctor in the best interest of the patient.

This anecdotal experience could offer insight as to why students performed significantly better in Lesson 8 as compared to Lesson 7 and 9. Hence, future study could focus on content difficulty for IMV to be an effective scaffold (Vygotsky, 1978). Finally, we also acknowledged that the uneven number of students in the experimental group and control group might have affected the result.

CONCLUSION

In this study, students performed better when IMVs were used to scaffold learning, supplemented by written materials. These students were also more satisfied with the learning context. The 6Ps educational video design framework based on the attitudinal findings explained the learning gains and served as an actionable framework describing the pedagogical innovation to inform practice. The 6Ps educational video design framework will be tested across a wide variety of modules or disciplines to validate the universality of the findings and to shed further light on this novel pedagogical innovation.

Disclosure statement

No potential competing interest was reported by the authors.

References

Adesope, O. O., & Nesbit, J. C. (2012). Verbal redundancy in multimedia learning environments: A meta-analysis. *Journal of Educational Psychology*, *104*(1), 250–263. https://doi.org/10.1037/a0026147

Al-Samarraie, H. (2019). A scoping review of videoconferencing systems in Higher Education. *The International Review of Research in Open and Distributed Learning*, *20*(3). https://doi.org/10.19173/irrodl.v20i4.4037

Best, B., & Conceição, S. C. O. (2017). Transactional distance dialogic interactions and student satisfaction in a multi-institutional blended learning environment. *European Journal of Open, Distance and E-Learning*, *20*(1), 139–153. https://doi.org/10.1515/eurodl-2017-0009

Bonk, C. J., Zhu, M., Kim, M., Xu, S., Sabir, N., & Sari, A. R. (2018). Pushing toward a more personalized MOOC: Exploring instructor selected activities, resources, and technologies for MOOC design and implementation. *The International Review of Research in Open and Distributed Learning, 19*(4). https://doi.org/10.19173/irrodl.v19i4.3439

Brame, C. J. (2016). Effective educational videos: Principles and guidelines for maximizing student learning from video content. *CBE—Life Sciences Education*, *15*(4). https://doi.org/10.1187/cbe.16-03-0125

Considine, J., Botti, M., & Thomas, S. (2005). Design, format, validity and reliability of multiple-choice questions for use in nursing research and Education. *Collegian*, *12*(1), 19–24. https://doi.org/10.1016/s1322-7696(08)60478-3

Cooper, M., Jian Z., Chidansh B., & David A. (2018). Using Recommendation to Explore Educational Video. *ACM International Conference on Multimedia Retrieval (ICMR 2018)*. https://www.jeffjianzhao.com/papers/recedu.pdf

Costley, J., Fanguy, M., Lange, C., & Baldwin, M. (2020). The effects of video lecture viewing strategies on cognitive load. *Journal of Computing in Higher Education*, *33*(1), 19–38. https://doi.org/10.1007/s12528-020-09254-y

Drago, W. A., & Wagner, R. J. (2004). Vark preferred learning styles and online education. *Management Research News*, *27*(7), 1–13. https://doi.org/10.1108/01409170410784211

Ekwunife-Orakwue, K. C. V., & Teng, T.-L. (2014). The impact of transactional distance dialogic interactions on student learning outcomes in online and blended environments. *Computers & Education*, *78*, 414–427. https://doi.org/10.1016/j.compedu.2014.06.011

Fleming, N. D. (2011). *Teaching and learning styles: Vark Strategies*. Christchurch, New Zealand: Neil D. Fleming.

Frydenberg, M. (2013). Flipping Excel. *Information Systems Education Journal 11*, (1): 63–73. https://doi.org/http://isedj.org/2013-11/.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education*, *15*(1), 7–23. https://doi.org/10.1080/08923640109527071

George Lucas Educational Foundation. (2016, July 20). *Multiple intelligences: What does the research say?* Edutopia. https://www.edutopia.org/multiple-intelligences-research

Giossos, Y. K. (2008). Reconsidering Moore's transactional distance theory. *European Journal of Open, Distance and E-Learning*. Retrieved from https://eric.ed.gov/?id=EJ911768

Govindasamy, T. (2001). Successful implementation of e-learning. *The Internet and Higher Education*, *4*(3-4), 287–299. https://doi.org/10.1016/s1096-7516(01)00071-9

Gunawardena, C. N., & Boverie, P. E. (1993). World Conference of the International Council of Distance Education (16th Bangkok). *Impact of learning styles on instructional design for Distance Education*. Springfield, VA: Eric Document Reproduction Service.

Guo, P. J., Kim, J., & Rubin, R. (2014). How Video Production Affects Student Engagement. *Proceedings of the first ACM conference on Learning @ scale conference: 41–50*. https://doi.org/10.1145/2556325.2566239

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of Mechanics Test Data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Haladyna, T. M., Downing, S. M., & Rodriguez, M. C. (2002). A review of multiple-choice item-writing guidelines for classroom assessment. *Applied Measurement in Education*, *15*(3), 309–333. https://doi.org/10.1207/s15324818ame1503_5

Horn, M. B. (2013). The transformational potential of flipped classrooms. *Education Next*. https://www.educationnext.org/the-transformational-potential-of-flipped-classrooms/

Huang, J., & Hung, D. (2020). *Tackling 3 Obstacles to Digital Transformation in Education*. National Institute of Education. https://nie.edu.sg/about-us/news-events/news/news-detail/trackling-3-obstacles-to-digital-transformation-in-education.

Johanes, P., & Lagerstrom, L. (2016). Online videos: What every instructor should know. *2016 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/p.25832

Johnson, S. D., & Aragon, S. R. (2003). An Instructional Strategy Framework for Online Learning Environments. *New Directions for Adult and Continuing Education 100 (2003)*: 31-43.

Jonassen, D. H., Peck, K. L., & Wilson, B. G. (1999). *Learning with technology: A Constructivist perspective*. Merrill.

Kay, R., & Kletskin, I. (2012). Evaluating the use of problem-based video podcasts to teach mathematics in higher education. *Computers & Education*, *59*(2), 619–627. https://doi.org/10.1016/j.compedu.2012.03.007

Lave, J. (1996). *Understanding practice: Perspectives on activity and context*. Cambridge University Press.

Lee, K. (2020, March 10). Coronavirus: Universities are shifting classes online – but it's not as easy as it sounds. *The Conversation*. http://theconversation.com/coronavirus-universities-are-shifting-classes-online-but-its-not-as-easy-as-it-sounds-133030

Lincoln, Y. S., & Guba, E. G. (2006). *Naturalistic inquiry*. Sage Publication.

Long, T., Logan, J., & Waugh, M. (2016). Students' perceptions of the value of using videos as a pre-class learning experience in the flipped classroom. *TechTrends*, *60*(3), 245–252. https://doi.org/10.1007/s11528-016-0045-4

Lowenthal, P., Snelson, C., & Perkins, R. (2018). Teaching massive, open, online, courses (MOOCs): Tales from the front line. *The International Review of Research in Open and Distributed Learning*, *19*(3). https://doi.org/10.19173/irrodl.v19i3.3505

MacHardy, Z., & Pardos, Z. A. (2015). Toward the evaluation of educational videos using Bayesian Knowledge Tracing and big data. *Proceedings of the Second (2015) ACM Conference on Learning @ Scale*. https://doi.org/10.1145/2724660.2728690

Maseleno, A., Sabani, N., Huda, M., Ahmad, R., Azmi Jasmi, K., & Basiron, B. (2018). Demystifying learning analytics in personalised learning. *International Journal of Engineering & Technology*, *7*(3), 1124. https://doi.org/10.14419/ijet.v7i3.9789

Mayer, R. E., (2010). Applying the science of learning to medical education. *Medical Education 44*, (6): 543–49. https://doi.org/10.1111/j.1365-2923.2010.03624.x

McNeill, K. L. (2008). *Inquiry and Scientific Explanations: Helping students use evidence and reasoning*. http://www.katherinelmcneill.com/uploads/1/6/8/7/1687518/mcneillmartin_nsta2010_rd.pdf

Moore, M. G. (2013). The theory of transactional distance. In The *Handbook of Distance Education* (3rd ed., pp. 66–84). New York: Routledge.

Moore, M. G., & Kearsley, G. (2012). *Distance education: A systems view of online learning*. Wadsworth Cengage Learning.

Noetel, M., Griffith, S., Delaney, O., Sanders, T., Parker, P., del Pozo Cruz, B., & Lonsdale, C. (2021). Video improves learning in higher education: A systematic review. *Review of Educational Research*, *91*(2), 204–236. https://doi.org/10.3102/0034654321990713

Pan, G., Sandipan S., Starrett C., Bonk C.J., Rodgers M. T., & Powell (2012). Instructor-made videos as a learner scaffolding tool. *MERLOT Journal of Online Learning and Teaching 8,* (4): 298-33. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.297.4017&rep=rep1&type=pdf

Peel, A. (1994, December 1). *Computer aided assessment through hypermedia*. Kent Academic Repository. https://kar.kent.ac.uk/21159/

Razzouk, R., & Shute, V. (2012). What is design thinking and why is it important? *Review of Educational Research*, *82*(3), 330–348. https://doi.org/10.3102/0034654312457429

Rey, G. D., Beege, M., Nebel, S., Wirzberger, M., Schmitt, T. H., & Schneider, S. (2019). A meta-analysis of the segmenting effect. *Educational Psychology Review*, *31*(2), 389–419. https://doi.org/10.1007/s10648-018-9456-4

Robertson, B., & Flowers, M. J. (2020). Determining the impact of lecture videos on student outcomes. *Learning and Teaching*, *13*(2), 25–40. https://doi.org/10.3167/latiss.2020.130203

Rolfe, V. E., & Gray, D. (2011). Are multimedia resources effective in life science education? A meta-analysis. *Bioscience Education*, *18*(1), 1–14. https://doi.org/10.3108/beej.18.5

Rourke, L., Terry A., D. Randy G., & Walter A. (1999). Assessing social presence in asynchronous text-based computer conferencing. *The Journal of Distance Education/Revue de l'ducation Distance* 14, (2), 50-71. http://www.ijede.ca/index.php/jde/article/view/153/341

Rose, K. K. (2009). Student Perceptions of the Use of Instructor-Made Videos in Online and Face-to-Face Classes. *MERLOT Journal of Online Learning and Teaching 5*(3), 487–495. https://jolt.merlot.org/vol5no3/rose_0909.pdf

Tallent-Runnels, M. K., Thomas, J. A., Lan, W. Y., Cooper, S., Ahern, T. C., Shaw, S. M., & Liu, X. (2006). Teaching courses online: A review of the research. *Review of Educational Research*, *76*(1), 93–135. https://doi.org/10.3102/00346543076001093

Thakore, H., & McMahon, T. (2006). Virtually there: E-learning in medical education. *The Clinical Teacher*, *3*(4), 225–228. https://doi.org/10.1111/j.1743-498x.2006.00114.x

Tobin, G. A., & Begley, C. M. (2004). Methodological rigour within a qualitative framework. *Journal of Advanced Nursing*, *48*(4), 388–396. https://doi.org/10.1111/j.1365-2648.2004.03207.x

van Merriënboer, J. J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and Future Directions. *Educational Psychology Review*, *17*(2), 147–177. https://doi.org/10.1007/s10648-005-3951-0

Vygotsky, L. (1978) Interaction between learning and development. *Readings on the Development of Children* 23, (3): 34-41.

Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker, J. F. (2006). Instructional video in e-learning: Assessing the impact of interactive video on Learning Effectiveness. *Information & Management*, *43*(1), 15–27. https://doi.org/10.1016/j.im.2005.01.004

Zhu, M., Bonk C. J., & Annisa R. S., (2018). Instructor experiences designing MOOCs in higher education: Pedagogical, resource, and logistical considerations and challenges. *Online Learning 22*, (4): 203-241

Annex A: Attitude survey items

1. The audio quality of the instructor-made-video is acceptable.
2. The video quality of the instructor-made-video is acceptable.
3. The topics and concepts were well-explained in the instructor-made-video.
4. The instructor-made-video helped me understand the topic knowledge better.
5. The length of the instructor-made-video are just nice in delivering the content.
6. The instructor-made-video were helpful because I could do them at my own pace and time.
7. The instructor-made-video made the lesson easy to learn from personable
8. The instructor-made-video helped me in answering the quizzes and other e-learning activities.
9. The interactive activities (e.g. quizzes, Padlet) helped me in meeting the learning outcomes of the lesson.
10. I like viewing instructor-made-video more than reading text materials.
11. What do you like most about the instructor-made-video?
12. How can the interactive instructor-made-video be improved to enhance your learning?

Annex B: Sample of IMVs

Pilot run IMVs (prototypes) for Lesson 1 and 2	
Lesson 1 – Introduction to Singapore Law	
Problem trigger	https://youtu.be/W-HKAbmaDrI (2min)
Explanation	https://www.youtube.com/watch?v=OsG3_ofduWw (3min)
Lesson 2 – Medical Negligence	
3 Problem triggers and Explanations	https://www.youtube.com/watch?v=dNRbKiFMQ9o (10 min)
Sample IMVs evaluated in this present study	
Lesson 7 – The Practice of Defensive Medicine	
Problem trigger	https://www.youtube.com/watch?v=rnpGnP8Otq4 (3 min)
Explanation	https://www.youtube.com/watch?v=GDRX7Y7l864 (2 min)
Lesson 8 – End of Life Issues and Euthanasia	
Problem trigger	https://www.youtube.com/watch?v=yjm5gHnOA4s (1 min)
Explanation	https://www.youtube.com/watch?v=bnsadn1iiKs (2 min)

Annex C: Attitudinal data for the three lesson, respectively, of the control and experimental group

	Agree and Strongly Agree			Neutral			Disagree and Strongly Disagree			Unanswered		
Lesson	7	8	9	7	8	9	7	8	9	7	8	9
1. The audio quality of the instructor-made-videos is acceptable.												
Control	70.9%	77.1%	75.0%	14.6%	14.6%	12.5%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	70.8%	72.2%	56.9%	22.2%	16.7%	12.5%	2.8%	1.4%	22.2%	4.2%	9.7%	8.3%
2. The video quality of the instructor-made-videos is acceptable.												
Control	68.8%	79.2%	72.9%	16.7%	12.5%	14.6%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	77.8%	76.4%	73.6%	18.1%	12.5%	18.1%	0.0%	1.4%	0.0%	4.2%	9.7%	8.3%
*3. The topics and concepts were well-explained in the instructor-made-videos.												
Control	68.8%	72.9%	75.0%	16.7%	18.8%	12.5%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	**83.3%**	76.4%	73.6%	12.5%	12.5%	16.7%	0.0%	1.4%	1.4%	4.2%	9.7%	8.3%
*4. The instructor-made-video helped me understand the topic knowledge better.												
Control	62.5%	72.9%	70.9%	22.9%	16.7%	16.7%	0.0%	2.1%	0.0%	14.6%	8.3%	12.5%
Experimental	**83.3%**	76.4%	72.2%	12.5%	13.9%	19.4%	0.0%	0.0%	0.0%	4.2%	9.7%	8.3%
*5. The length of the instructor-made-videos are just nice in delivering the content.												
Control	68.8%	70.9%	68.8%	16.7%	20.8%	18.8%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	**84.7%**	76.4%	75.0%	11.1%	13.9%	15.3%	0.0%	0.0%	1.4%	4.2%	9.7%	8.3%
6. The instructor-made-videos were helpful because I could do them at my own pace and time.												
Control	73.0%	79.2%	77.1%	12.5%	12.5%	10.4%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	**86.1%**	**84.7%**	77.8%	8.3%	5.6%	13.9%	1.4%	0.0%	0.0%	4.2%	9.7%	8.3%
7. The instructor-made-videos made the lesson easy to learn from.												
Control	68.8%	75.0%	72.9%	14.6%	16.7%	14.6%	2.1%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	**82.0%**	76.4%	75.0%	12.5%	13.9%	16.7%	1.4%	0.0%	0.0%	4.2%	9.7%	8.3%
*8. The instructor-made-videos help me in answering the quizzes and other e-learning activities.												
Control	66.7%	70.9%	66.7%	14.6%	20.8%	20.8%	4.2%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	79.1%	75.0%	69.4%	13.9%	15.3%	20.8%	2.8%	0.0%	1.4%	4.2%	9.7%	8.3%
*9. The interactive activities (e.g. quizzes, Padlet) helped me in meeting the learning outcomes of the lesson.												
Control	75.0%	70.9%	64.6%	10.4%	20.8%	22.9%	0.0%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	76.4%	77.8%	77.7%	18.1%	11.1%	13.9%	1.4%	1.4%	0.0%	4.2%	9.7%	8.3%
10. I like viewing instructor-made-videos more than reading text materials.												
Control	66.7%	75.0%	70.9%	16.7%	16.7%	16.7%	2.1%	0.0%	0.0%	14.6%	8.3%	12.5%
Experimental	76.4%	70.9%	69.4%	18.1%	19.4%	22.2%	1.4%	0.0%	0.0%	4.2%	9.7%	8.3%

Percentage of students answering the survey using Likert scale. Item above 80% rating is in **bold**.

*Significant difference between 2 groups at $p < 0.05$