Research in Engineering Education Symposium &
Australasian Association for Engineering Education Conference
5 – 8 December, 2021 - Perth, WA

Evaluation of H5P interactive videos in enhanced e-learning of an environmental engineering course during COVID-19 pandemic

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ABSTRACT

CONTEXT

In the autumn session of 2020, COVID-19 outbreak forced the transition of teaching and learning from face-to-face mode into remote delivery in Australian universities. Over this unplanned, unprepared, and rapid move to remote delivery for lecturers and online learning for students, many strategies, designs, and technologies were applied to replace conventional classes, tutorials, laboratory classes, project assignments, and assessments.

PURPOSE OR GOAL

This study investigated the design, use and impact of videos for lectures, tutorials, and laboratory experiments for a combined undergraduate and postgraduate Environmental Engineering course during the COVID-19 pandemic in 2020. The course was delivered through both face-to-face and online delivery modes, which we employed conventional video recordings and H5P interactive videos to support e-learning on the Moodle platform.

APPROACH OR METHODOLOGY/METHODS

H5P interactive videos, slides and quizzes were also used to design the pre-lab and recorded lab experiments, as our labs were closed due to social distancing requirements. Students' performance was evaluated through their marks of weekly quizzes; and their engagement was analyzed using Moodle activity logs and anonymous surveys through teacher evaluation and polling in Zoom meetings.

ACTUAL OR ANTICIPATED OUTCOMES

The attendance to online Zoom lecture and tutorials ranged from 70-87%. These data collectively demonstrate a high level of student engagement and satisfaction under the COVID-19 impacted teaching and learning environment compared to rate of lecture attendance at traditional lectures. H5P interactive videos helped students to achieve higher marks, compared to conventional videos. Student has watched the video more than once to obtain enough information to write the lab class report.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

It was shown that H5P interactive videos had higher views than conventional videos, which subsequently led to higher marks in weekly quizzes. The tutorials were delivered using Zoom meetings, supplemented with pre-recorded videos which supported students who could not attend the tutorial or for their revisions. The virtual laboratory experiments enabled with H5P provided adequate data and information for students to write their lab reports comparable to the requirements of a real-life lab class. Different approaches of video design and their limitations and improvements are discussed for the future development of e-learning in the post-COVID era.

KEYWORDS

H5P; interactive video; online delivery; e-learning

1 Introduction

In the autumn session of 2020, COVID-19 outbreak forced the transition of teaching and learning from face-to-face mode into remote delivery in Australian universities. The transition was unexpected and quick, and many lecturers and students were unprepared to go down the path of complete e-learning. On the bright side, nearly everyone used internet and video conferences for their studies, work, and daily life long before the COVID-19 pandemic. Based on existing technologies, it became possible to deliver university subjects remotely. Over this unplanned, unprepared, and rapid move to remote delivery for lecturers and online learning for students, many strategies, designs, and technologies were applied to replace, within a short period, conventional classes, tutorials, laboratory classes, project assignments, and assessments (Dietrich et al., 2020).

Online learning and using multimedia have been widely reported for the engineering education in universities (K. Martin, Cupples, & Taherzadeh, 2020; Vial, Nikolic, Ros, Stirling, & Doulai, 2015; Xiao, Cai, Su, & Shen, 2020). Especially, video-based e-learning has been regarded as a formidable frontier of education, offering many benefits to teachers, students, and educational administrators. However, most current university subjects are still delivered in conventional face-to-face mode with supplementary online e-learning to enhance teaching and learning experience. It is due to COVID-19 that forced nearly all teaching and learning into online delivery mode; therefore, it offers a unique opportunity to investigate students' satisfaction, benefits, and the usefulness of different online delivery approaches.

This paper will provide a detailed evaluation of the design and outcome of the remote delivery of a core subject for the Environmental Engineering degrees at the University of Wollongong, Australia. The subject (Membrane Science & Technology) contents were delivered using lectures, tutorials, laboratory experiments, and a design project. The students' performance is assessed through weekly online quizzes, tutorial participation quizzes, assignment reports, mid-session and final exams. In the 2020 autumn session, this subject was initially delivered through face-to-face teaching for the first three weeks. Following the COVID-19 outbreak in Australia, the subject was switched to online delivery for the rest of the teaching session. This provided an opportunity to compare the different teaching modes, based on student engagement, experience, and achievements for the same subject in the same teaching session. Video-based learning is believed to offer sensory learning environment with a touch of face-to-face human texture that can support students to understand more and recall information better (Fern, Givan, & Siskind, 2011). Thus, for online delivery, we adopted conventional video recordings and H5P interactive video clips for both lectures and tutorials in different weeks. A comparison of these two different approaches was also conducted to understand how remote delivery can be carried out to achieve satisfactory learning outcomes. For lab classes during the COVID-19, it was impossible to conduct in-person experiments due to social distancing restrictions. H5P was used to establish a pre-lab and interactive pre-recorded videos of different experiments.

2 Research methods

2.1 Student cohorts

Two classes of students, one undergraduate and one postgraduate class, taught by the same lecturers and tutors in the same session (2020 autumn) were involved in this study. The students were studying this subject towards their Bachelor or Master of Environmental Engineering degrees. Students had in-person teaching of lectures, tutorials, lab classes and group design projects, and access to online resources organized on a subject Moodle site. The teaching lasted 13 weeks and included a lecture and a tutorial (each of two hours duration) each week, in addition to separate weeks for lab classes and field trip. The first three weeks were delivered in the normal face-to-face teaching mode, followed by online delivery for the rest of the session.

https://doi.org/10.52202/066488-0055

2.2 Moodle subject site structure

The Moodle site for this Environmental Engineering subject is divided into different sections, including subject outlines, lecture notes, tutorials, lab classes, field trips, group design assignment and online examination. This site structure on the Moodle has been developed and evolved from previous teaching sessions before the COVID-19 pandemic. When remote delivery was implemented, a few key changes were implemented. The subject outline section was supplemented with a remote delivery guideline (details in Section 2.3), which was developed to give clear instructions to students how lectures and tutorials would be delivered online. We also gave some technical step-by-step instructions, including how to create PDF using mobile phone and attend Zoom meetings. In addition, two video sections were added to provide pre-recorded videos for lectures and tutorials, respectively. A few Zoom meeting links were created for recurring online lecture and tutorials. Most importantly, an online examination section was created for the mid-session and final exams.

2.3 Design of the remote delivery of the subject

Some previous studies showed e-learning can achieve similar or better learning outcomes than face-to-face teaching (Anwar, Lindsay, & Sarukkalige, 2011; Park, Kim, Cha, & Nam, 2014; Willis, Kestell, Grainger, & Missingham, 2013). This encouraged the transition to remote delivery. Prerecorded videos of lectures, either in the format of simple videos or as H5P enabled interactive videos, were made available weekly, four days in advance of the scheduled lecture. Students were expected to view the videos, answer the quizzes (embedded in the H5P interactive videos, mostly non-compulsory) and take necessary notes. During the normal weekly lecture time on the timetable, the lecture became a ZOOM meeting with all students, through a link available on the Moodle site. During the Zoom lecture time, the lecturer provided discussions on the weekly lecture contents based on student queries, and quizzes embedded in video lectures. Also, there were ample opportunities for Q & A related to the teaching materials of that week. It has been shown that a conversational style is better than a formal style for learning (Mayer, 2001) so the Zoom Lecture Q and A sessions were well received by students.

For tutorials, questions were made available weekly, four days in advance of the scheduled tutorial. Students were expected to attempt the tutorial questions for preparedness. Tutors were holding tutorials (for the entire class) via Zoom. Opportunities were created using Zoom breakout rooms for students to work in groups (like the design assignment in Week 9). Prerecorded video tutorials were provided after the live online tutorials to assist self-paced learning. For the tutorial participation quizzes, students needed to download the participation quiz question from Moodle and complete the quiz within 30 minutes using A4 size papers and in handwriting. They then uploaded the completed quiz after scanning into a PDF file.

2.4 H5P interactive lecture videos

The first three weeks of the subject was delivered in the face-to-face mode. We then divide the following typical teaching weeks (lecture + tutorial) into three weeks of teaching based on conventional prerecorded videos and three weeks based on H5P interactive videos. The videos were cut into clips from full-length lecture videos. The different teaching approaches allow a comprehensive evaluation of the experience and performance of e-learning in comparison to face-to-face learning.

Each 2-hour lecture is divided into 6-8 sections according to the teaching contents so that each section can be recorded in a single video clip which is usually less than 15 min. The lecture video was recorded using Microsoft PowerPoint with a small window of the lecturer overlapped on the slides. The “talking head” lectures (images of the lecturer’s face and shoulders) can add a sense of in-person communication to the video(Young & Asensio, 2002). Research shows that all learning requires both visual and auditory stimulus to promote the cognitive processing. We adopted the multimedia principle, contiguity principle,

https://doi.org/10.52202/066488-0055

modality principle, and signaling principle by Mayer (2001) when designing the PPT slides and recording the lecture videos. Pictures, sketches, flow charts, animations, and technical videos were incorporated with text on the PPT slides.

For each H5P interactive lecture video clip, we added some H5P interactions including single- or multiple-choice questions, true/false questions, fill-in-the-blanks questions, drag and drop questions etc., as well as a summary task at the end of the video (Fig. 1). The embedded questions can be displayed as a push button or poster on top of the video, thus having the flexibility to make questions compulsory or voluntary for students, in combination to the option to pause the video for those interactions. The interactions allow students to digest parts of the lecture and quickly identify what they may not have understood. The H5P interactions on the Moodle site allow the answers of students being recorded in the Grader report (not accounted in the final grade), where the lecturer can review the answers and monitor the learning outcome. Carefully designed interactions can further divide the video clips into smaller durations, thus allow better concentration and enhanced learning.

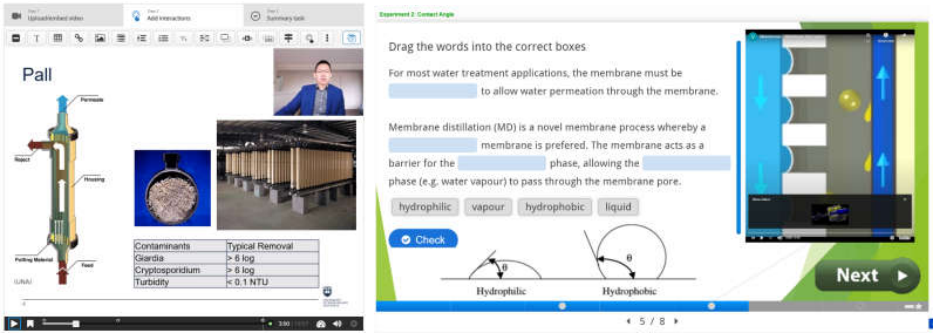

Figure 1. Moodle interface of editing a H5P interactive video (left); Pre-lab slides using embedded video and drag-and-drop questions, compiled with H5P on Moodle (right).

2.5 H5P laboratory classes

The subject has four experiments that need to be completed in one teaching week. To deliver the laboratory classes online, we provided an experimental step-by-step manual, H5P enabled slides as a pre-laboratory and finally, prerecorded videos of experiments with H5P interactions. It is important that students start the experiments as prepared as possible to maximise their learning potential. It was reported that students who watch the pre-laboratory videos increase their preparedness and also increase their assessment mark (Rodgers et al., 2020). The pre-laboratory H5P slides shown below (Fig. 1) combine videos (local or linked from YouTube or Vimeo etc.) and other interactions as discussed in section 2.3. The purpose is to prepare students with more in-depth knowledge and theory related to the four experiments, that would enable them to understand most observations of those experiments.

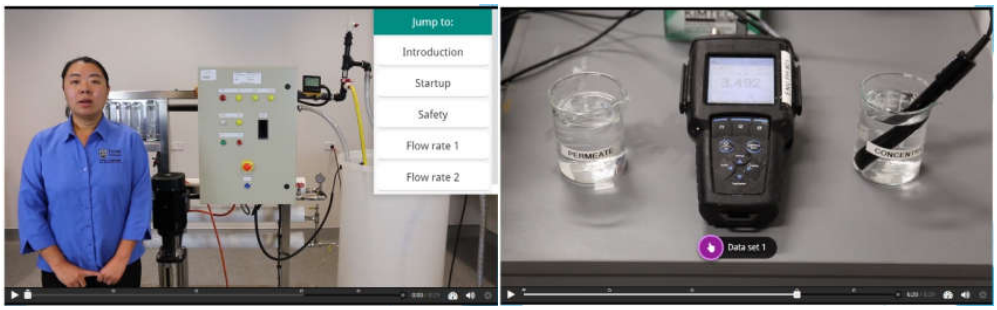

Figure 2. The navigation menu embedded in the video (left and push buttons reminding students to take readings for experiments (right.

The pre-recorded videos of experiments have a navigation menu which was designed

https://doi.org/10.52202/066488-0055

according to the experimental manual so students can easily locate and revisit specific parts of videos. There are some push buttons embedded in the video, which serve as a reminder to students for noting down the equipment readings. Those numbers are essential for them to write up the lab class report. The students were required to watch the video, answer the questions (some are compulsory for the video to continue) and record observations and datasets from the video. Students then undertook relevant calculations, plotted graphs, answered questions and wrote a typed laboratory report. Interactivity and engagement were the principles at the forefront of the design process of these videos. However, these virtual experiments have inherent limitations and may only be used as an auxiliary of real-life experiments in the future.

2.6 Data sources and limitations

The online delivery was conducted on the Moodle platform, which has comprehensive activity logs and study analytics. Ethics approval (protocol number 2020/439 at University of Wollongong) was granted for the use of the Moodle log files and grades of all students enrolled in the subject in 2020 Autumn session. The primary data on the number of video views were extracted from the Moodle activity logs. A limitation of the research is that the video access logs do not show if students quitted in the middle or finished the whole video. The H5P interactive videos have checkpoints like submission and summary pages so it would allow checking the engagement with videos from the answers submitted by students.

3 Results and discussion

3.1 Overall subject feedback

The subject Moodle site provides a combination of traditional learning materials (PowerPoint slides, tutorial questions and solutions in PDF format) and interactive items like online quizzes, discussion forum and H5P videos. The well-structured learning materials and delivery ensured an overall good student achievement and satisfaction. The average final mark and pass rate were comparable to previous years. At the end of the teaching session, the lecturer conducted a formal teacher evaluation through the university teaching evaluation unit to collect feedback from the students.

In total, 18 out of 30 students responded to the teacher evaluation survey. Some students also took the opportunity and provided optional comments. A few students commented that the subject was “extremely well organized, delivers information clearly”, “teaches at a good pace” and “concise learning material provided is quite helpful”. Specifically, one comment pointed out that “I enjoyed the interactive prerecorded lectures put up by the teacher, the questions within the lecture helped with learning and understanding the material”. The comment also resonates with the in-class polling results using Zoom, which shows that 84% of students have watched the lecture videos before the summary lecture, and 42% watched all videos of that week. Among them, 74% of students have tried the embedded interactions and quizzes in H5P lecture videos and they found it helpful and like them. The Moodle log files show a range of 63-83% engagement with interactive lecture videos. The attendance to online Zoom lecture and tutorials ranged from 70-87%. These data collectively demonstrate a high level of student engagement and satisfaction under the COVID-19 impacted teaching and learning environment compared to rate of lecture attendance at traditional lectures (Purcell, 2007).

3.2 Lecture video views and weekly quiz marks

When the student achievement was assessed by the weekly quizzes, face-to-face teaching led to the highest mark (Fig. 4A). In comparison, remote delivery weeks using either conventional or H5P interactive video achieved lower marks, for both undergraduate and postgraduate students. However, H5P interactive videos helped students to achieve higher

https://doi.org/10.52202/066488-0055

marks, compared to conventional videos. This is likely due to the higher views of the lecture videos with H5P interactions (Fig. 4B). It is also interesting to note that undergraduate students tend to prefer the H5P lecture videos than postgraduate students, evidenced by 1.0 vs 0.6 views/video per student. The conventional lecture videos received around 0.34 views/video per student, which is much lower than the H5P lecture videos. It is clear that H5P lecture videos can greatly enhance the student engagement during remote delivery, which subsequently led to higher student achievements. Postgraduate students were less promoted by H5P interactive lecture videos, from 0.33 to 0.6 views/video per student. This implies that some more advanced interactions (different sets of quiz questions designed specifically for PG students) might be needed to enhance their interests in using lecture videos.

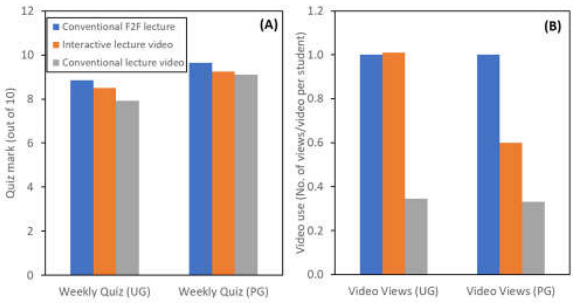

Figure 3. The marks of weekly quizzes for different weeks delivered through face-to-face lectures, H5P interactive lecture videos or conventional lecture videos (A); and the video use comparison for undergraduate and postgraduate students (B).

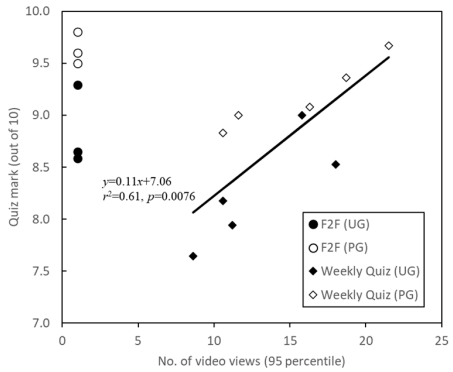

Figure 4. The correlation between the video views and marks of weekly quizzes.

There is a strong correlation (correlation coefficient r=0.8388) between the 95% of views of lecture videos and marks of weekly quizzes. This positive correlation, as shown in Fig. 5, indicates that increased video views can increase the student performance. Those students who had high video views achieved comparable quiz marks to face-to-face teaching. This correlation shows the importance to enhance the student engagement with lecture videos. The use of H5P interactions is obviously one way to increase the video views.

To further understand how the increase of video views influenced quiz mark, the students were divided into different groups according to the percentile of video views, i.e., low (<40%), medium (40-70%), and high (>70%), as shown in Fig. 6. This demonstrates that for UG students, the improvement mainly happens for those with medium video views, with slight improvements for students with high or low video views. In combination with above observations, H5P interactive video attracts mainly those students have relatively good levels of engagement. For students already actively engaged, its room of improvement is very limited. Also, for those students with very low engagement level (at risk students), other measures should be taken to identify the actual issue. Through contacting students at risk, it

https://doi.org/10.52202/066488-0055

was found those students missed the first few weeks and was not motivated to follow the teaching schedule. For PG students, the improvement is consistent across all the range of video view groups and the overall engagement is higher than UG students.

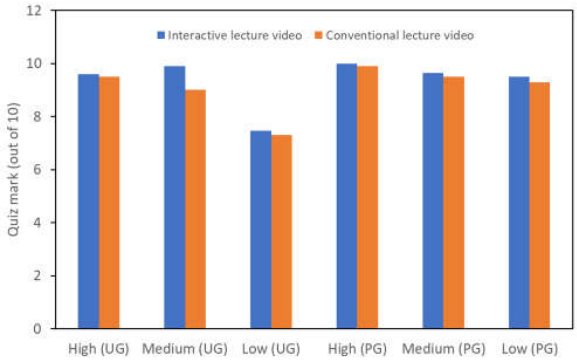

Figure 5. The improvement on weekly quiz mark for different group of students who had low, medium and high video views.

With the ubiquitous video recording capacity nowadays, there is no doubt that university lecturers can easily develop video-based digital teaching materials (Gillie, Dahli, Saunders, & Gibson, 2017). Some studies have found that in conventional teaching and learning, lecture or tutorial videos were mainly used by students for revision or supplementary to face-to-face lectures. Students tend to like short, focused videos more than longer ones (Gillie et al., 2017). However, video-based learning is not always attractive, as it is well-known that linear video may become a passive experience due to superficial learning and insufficient viability of the learning effect, what is called the "couch-potato-attitude"(Ertelt, Renkl, & Spada, 2006). Therefore, there has been a sharp increase of research in employing interactive video for learning in recent years (Palaigeorgiou, Papadopoulou, & Kazanidis, 2019). With interactive videos, students can answer questions, click on interactive items or regions of the video, choose how the video story develops, click on external links, access extra information, etc. It is clear that the functional and cognitive interactivity of educational interactive videos can greatly enhance the learning effectiveness through improved engagement.

3.3 Tutorial and laboratory class videos

For the tutorial classes, PDF documents of tutorial questions and solutions were provided on the Moodle site. The views of solution document were 3.2-3.6 per student. Although a short demonstration video was provided, the views were only 0.4-0.6 per student. This indicates that students tend to use the written document to help them in understanding the solution. It appears that only on rare occasions, they would turn to the demonstration videos for help. Overall, the tutorial videos still find some use likely for those difficult questions. Previous studies also reported the use of video tutorials to improve student learning experiences and student satisfaction (Anwar et al., 2011; Turan & Cetintas, 2020; Wong, Oladinrin, Ho, Guilbert, & Kam, 2018). In the future, maybe we can choose to only provide key problem videos to enhance its use (P. A. Martin, 2016).

Laboratory classes are an essential part of the education of undergraduate and postgraduate engineering students. Laboratories provide the opportunity to acquire a range of hands-on technical skills, active learning experiences and practical knowledge that are not available through other avenues (Feisel & Rosa, 2005; Restivo, de Fátima Chouzal, Abreu, & Zvacek, 2019). Some previous studies have explored different ways of delivering laboratory classes using online mode. Live internet-based bench-top shake-table experiments were developed using real-time video monitoring, control, and execution systems (Elgamal, Fraser, & Zonta, 2005). Another study reported an electronic experiment using real hardware and under real test conditions that can be remotely conducted by engineering students and other interested

https://doi.org/10.52202/066488-0055

individuals in the world via the Internet and with the capability of live video streaming from the test site (Axaopoulos, Moutsopoulos, & Theodoridis, 2012). However, this type of remote labs or experiments would need time and effort to achieve the design and transformation. For the remote delivery of this subject, we opted to use pre-recorded video-based virtual experiments considering the short transition time due to the COVID-19 pandemic.

There were four laboratory class experiments, which were delivered using H5P interactive videos. Each video had some compulsory questions to ensure students record datasets by carefully reading numbers on equipment in the video. The average views per laboratory class video was 2.2 per student. It indicates student has watched the video more than once to obtain enough information to write the lab class report. Also, the H5P prelab videos and quizzes provide background knowledge for the discussion in lab reports.

4 Conclusions

The COVID-19 pandemic has created unprecedented challenges to the teaching and learning in universities, but also offer an opportunity to pursue changes that possibly have enduring effects to future higher education. This study demonstrated that H5P lecture videos obtained higher views than conventional videos, which enhanced student performance in understanding the teaching information. Students achieved similar marks in comparison to face-to-face teaching. H5P was also employed in delivering the laboratory classes using prerecorded videos. Short, focused and interactive video clips are more appealing and functional to students. Overall, the student gave positive feedback on the learning experiences in this subject.

This study shows that interactivity in teaching and learning is essential to maintain the much-needed engagement during the remote delivery over the COVID-19 pandemic period. Although current technology allows high definition of videos being adopted in developing a replacement of face-to-face teaching, interactivity and engagement should be the key principles at the forefront of the subject design and delivery process. Plain videos should be avoided as it lacks the ability to provide an engaging and active watching experience.

The investment in H5P interactive videos would be higher than plain videos. There is about 50% increase of the preparation time. Extra workload of lecturers in preparing interactive contents need to be recognized properly. However, H5P interactions can be reused so it also provides sustainability for the future. It must also be realized that prerecorded videos, being interactive or not, must be accompanied by live online lectures, consultation, or a certain percentage of face-to-face teaching when COVID-19 pandemic restrictions are relaxed.

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Acknowledgement

This study was reviewed and approved by the University of Wollongong Human Ethics Committee.

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