Blended learning in Engineering Design: Using YouTube analytics to track student engagement with online content

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Introduction

Design-centric courses play an important role in developing students' understanding of Engineering (Dym, 1999). Design projects typically require the application of many technical competencies to produce a valid outcome (Dym, et al., 2005). Design-centric research highlights the importance of context in setting a design challenge, with authors prescribing courses that provide real-life experience, improve engagement with industry, and support the development of students' confidence and communication skills (Dutson, et al., 1997).

2502ENG Mechanical Engineering Design is a second-year course delivered to students studying Mechanical Engineering or Industrial Design at Griffith University. For the major assessment, students are engaged in Engineers Australia's Weir Warman design and build competition, as the basis for a Problem-Based Learning (PBL) approach. The brief changes yearly, but considers the design and prototyping of an autonomous vehicle/device capable of performing a designated task (Warman, 2019). To meet the challenge and achieve high performance scores, students must have a working understanding of first-year technical competencies and motivation to further their knowledge (Wijnen et al., 2018). The requirement for a high-functioning prototype increases the time required for the project. Satisfactory completion of the project requires a high level of student initiative, motivation, and organisation (Mills & Treagust, 2003).

In the six years Griffith University has run the challenge, few teams have produced prototypes capable of scoring maximum points. Anecdotally, this lack of success stems from a failure to form well-communicating, functional working groups in the time available. Students struggle with ideation and fixation, further exacerbating these issues. Student evaluations surveys reflect this, with comments focussed upon difficulties in group dynamics and the volume of work required in the twelve-week period.

Historically, the taught content for the course was delivered via didactic lectures. Due to Griffith University's high student numbers and rolling timetables, these lectures were scheduled for 8 am. Student engagement and attendance was acceptable but was supported by the implementation of credit-bearing, in-class clicker responses to questions embedded in the lectures (10% of the total marks for the course). This taught material was valued, but added to the time pressures, detracting from the PBL environment and reducing the time the students had to synthesise multiple ideas or implement techniques to address fixation (Crilly & Cardoso, 2017). Cohort and educators reported that the linear delivery of content didn't address the sequencing and access needs of PBL. Accordingly, the course team changed the delivery method for 2019 to a blended learning approach with fewer didactic lectures, supported by online video content.

Video-based delivery was introduced as this method has been shown to improve problem-solving performance (Hoogerheide et al. 2019), but also to address issues with the timing of lectures. However, the engagement of students with the new content was not as clear to the educators as it had been in lectures. Previous studies have shown sporadic interaction with online content, with a focus on content that directly links to assessment activities (Belski, 2011). The teaching team had concerns that less-motivated students would disengage and that the new content will be 'lost' online, so to drive engagement questions pertinent to the video lecture content were posed online with the videos.

The aim of this study was to evaluate the effectiveness of changing the taught content of the course to a blended learning approach. The study aims to do so by evaluating the engagement of the students with the online content delivered during the trimester. This data will support future decisions regarding similar changes for other courses and provide insight into the success (or otherwise) of the recorded lecture format.

Methods

Eight of the twelve lecture sessions were re-worked into videos of approximately 25 minutes using Griffith University's 'Create Your Own' (CYO) recording suites. The remaining content was delivered in person. The videos were shorter than the lectures they replaced, but it is noted that they are still considered 'long' in literature (Slemmons et al., 2018). Videos included worked examples, with hand-written examples, as shown to be successful in Engineering Education (Wandel, 2010). The video segments were hosted (unlisted) on YouTube and linked to the students via the 'Learning@Griffith' (Blackboard VLE version 9.1, Washington DC) interface. The content was then 'published' to the students during the trimester. Online quizzes were constructed using the Blackboard platform to drive students to engage. The response to these quizzes was to be submitted by the end of the trimester and the quizzes carried 15% of the total mark for the course.

Lectures that were delivered in person were also captured in video format, using Echo 360 capture facilities (Reston, VA, USA), combining screen capture with audio from the lecturer's microphone. This was also uploaded largely unedited, resulting in segments of over an hour in length. In week seven, a guest from the National Council of Engineering Design delivered a lecture regarding their career history with some key case studies. This lecture formed the basis of a 10%-weighted assessment task.

The integrated analytics of YouTube Studio allowed deeper analysis than previous studies that have considered interaction based upon number of unique visits for a video segment (Albó, et al., 2016; Lucke, 2014). Studio analytics were used to track the bulk engagement of the audience in terms of watch duration and cumulative watch duration, and the number of unique interactions, but also the timing of engagement/disengagement within the timeline of each video segment. The data was monitored on a segment by segment basis and the change in audience interaction was mapped across the weeks of the course.

Results

Figure 1 shows the cumulative engagement of the cohort with the online content over the trimester. There are 19 video segments plotted, of which three videos were selected for an in-depth analysis within this paper. Table 1.1 presents the engagement data on a segment-by-segment basis as well as the cumulative data above, normalised against number of days listed. As the face-to-face lectures are presented at two campuses, the data presented here is the combined watch time and mean interaction of the two lectures. Figures 2–4 show three videos segments that have been selected to show the typical engagement and retention of student viewers over the duration of the video segment. Peak interaction with the video segments has been highlighted. Figure 2, for example, shows the audience retention for week two's 'Effective Teamworking' segment. This video is approximately 21 minutes long and delivered in online format. The plot expresses video duration as a percentage of total length (absolute value, 20 mins 39) and audience retention as a percentage of the maximum viewer number (absolute, 125 views). The viewer retention is shown to decrease, following an overall linear trend, with distinct peaks in viewer engagement that rise above this trendline.

Figure 3 shows the audience retention for week three's 'Introduction to Project SOLVE' segment, delivered in online format. The plot shows duration as a percentage of total length (absolute, 22 mins 27) and audience retention as a percentage (absolute, 146 views). The viewer retention is shown to decrease, following an overall linear trend, but with more distinct peaks in engagement—note the three (highlighted) sections that rise above the trendline.

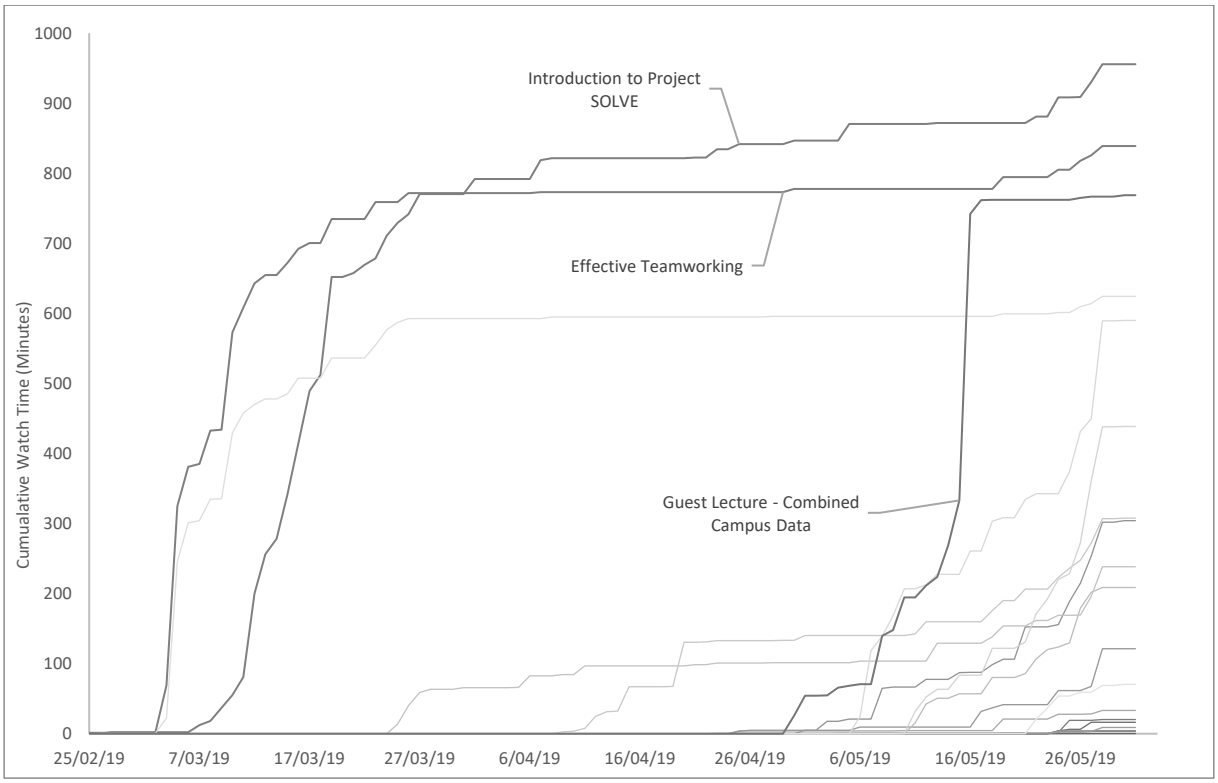

Figure 1: Cumulative watch time (in minutes) for all 19 videos over the trimester.

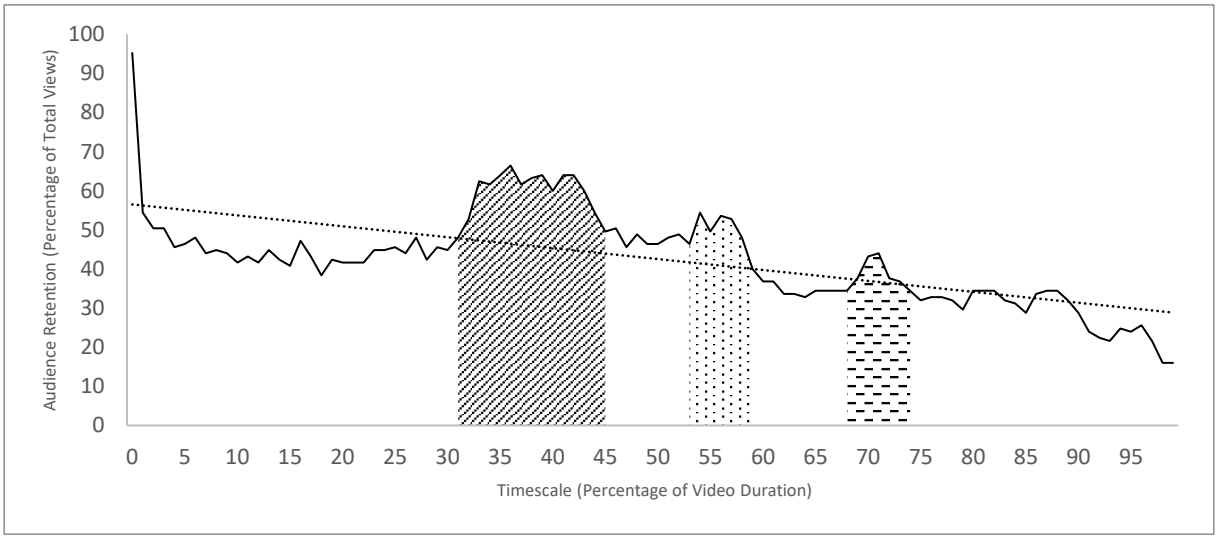

Figure 2: Audience retention for week two, 'Effective Teamworking', delivered in online format only. The plot shows video segment duration on the *x*-axis, with percentage of viewer retention on the *y*-axis. Peak interaction is highlighted. Linear regression is identified via dotted line.

Figure 4 shows the audience retention for the 'Industry Guest Lecture'. This content was delivered in person on both campuses. This plot shows the data for the Gold Coast Campus. The plot shows duration and retention on a percentage basis (absolute, 69 mins 20 and 61 views, respectively). Again, the viewer retention is shown to decrease, following an overall linear trend, with distinct peaks in viewer engagement. In this instance, five key sections that rise above the trendline have been identified.

Table 1: Segment topic, delivery method, video duration and watch data for the 19 segments listed. Online and in person deliveries are denoted by O-L and I-P, respectively.

Video Segment	Delivery method	Segment Length (Minutes)	Upload date	Total watch time (Minutes)	Number of views	Watch time per day listed (minutes)	Discrete views per day listed
Assessing risk	O-L	30:41	07/05/19	589.9	118	34.7	6.94
Guest lecture	I-P	69:20	01/05/19	768.7	70	33.4	3.04
Sustainability - concepts	O-L	24:38	10/05/19	438.6	77	31.3	5.50
Sustainability - applications	O-L	21:07	10/05/19	208.7	52	14.9	3.71
Success, failure and ethics in design	I-P	33:12	02/05/19	304.1	71	13.2	3.09
Introduction to Project SOLVE	O-L	22:27	27/02/19	955.6	146	11.1	1.70
Course wrap up	O-L	19:02	22/05/19	70.5	10	10.1	1.43
Effective teamworking	O-L	20:39	26/02/19	838.9	125	9.6	1.44
Project management	O-L	21:40	26/02/19	624.3	107	7.2	1.23
Product generation	I-P	93:17	10/04/19	307.7	70	7.0	1.59
Design calculations	O-L	53:05	24/04/19	121.3	17	4.0	0.57
Concepts and creativity	I-P	93:54	26/03/19	238.3	62	4.0	1.05
Engineering drawings	O-L	19:52	24/04/19	33.2	8	1.1	0.27
Early design phases	I-P	26:04	24/04/19	20.3	5	0.7	0.17
The mechanical design process	I-P	47:33	24/04/19	16.3	8	0.5	0.27
Tolerancing	O-L	19:06	24/04/19	8.9	9	0.3	0.30
Arduino	O-L	22:52	24/04/19	4.4	3	0.1	0.10
Mechatronic hardware	O-L	21:37	24/04/19	3.3	1	0.1	0.03
Intro to course	O-L	28:01	24/04/19	0.3	1	0.0	0.03

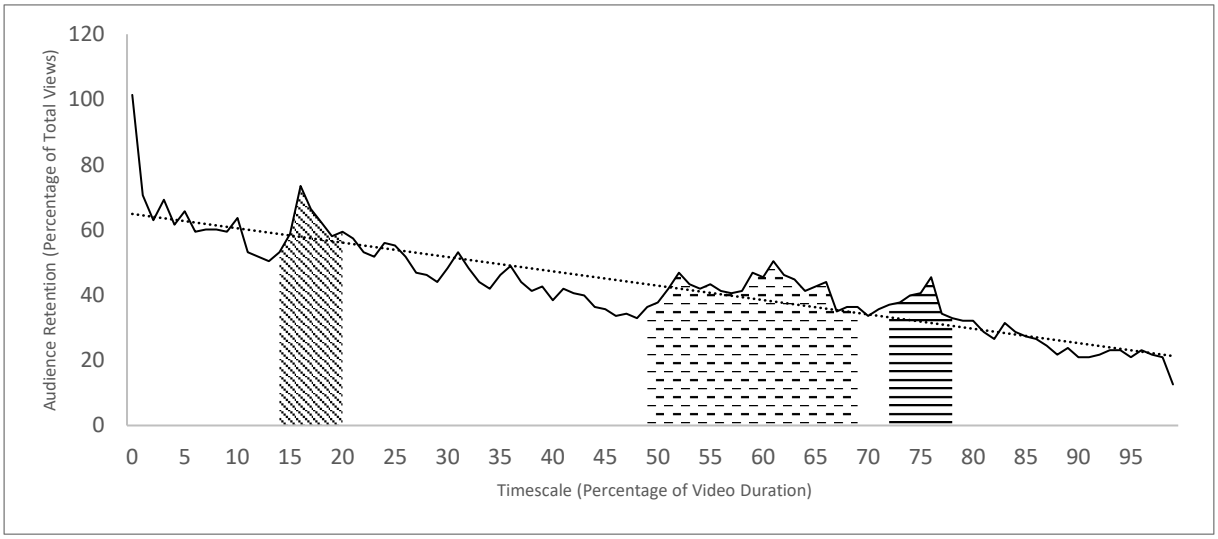

Figure 3: Audience retention for week three's 'Introduction to Project SOLVE' segment, delivered in online format only.

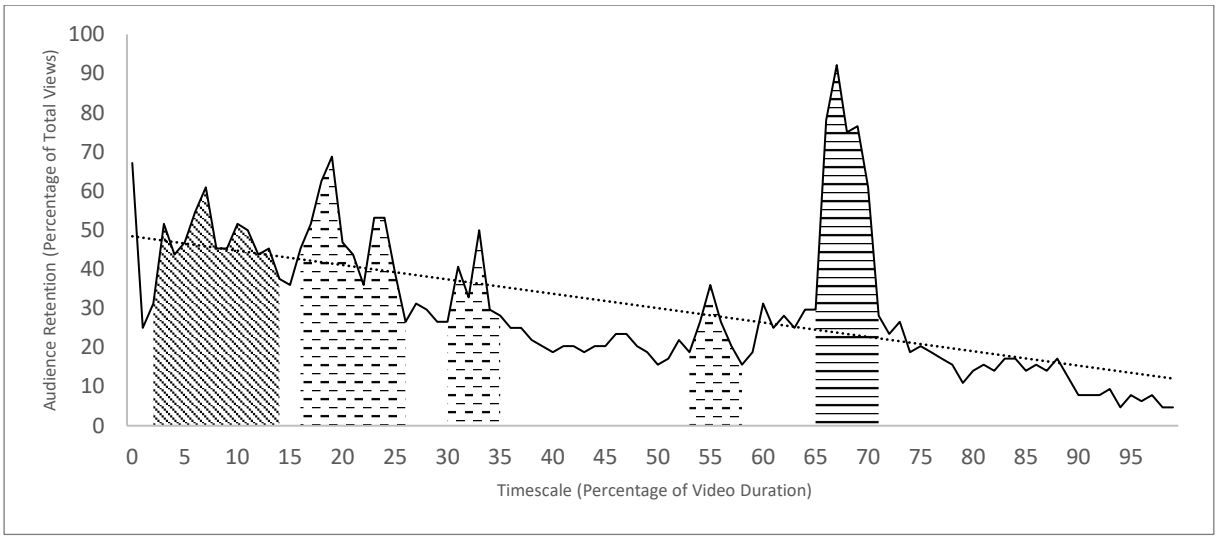

Figure 4: Audience retention for week nine's 'Industry Guest Lecture'. This content was delivered in person. The lecture capture video was uploaded following the lecture session.

Discussion

The headline outcome of this analysis is that the students show poor engagement with the online content during the trimester. For even the most watched video segments, the average view duration is under 7 minutes, approximately 33% of the segment's length. This trend is identified across all 19 of the segments listed. The mean viewing time for all segments is 4 minutes 17 seconds. The uploaded content shows a total of 984 views, or approximately 10.4 video views per student enrolled in the course. The number of discrete views for a given video segment could be considered to be a measure of 'virtual attendance' in the classroom.

Given the number of segments uploaded, these values are initially discouraging. However, it should be noted that the student attending face-to-face lectures (1/3 of the content) are receiving the information directly, and potentially have little need to sit through a 1.5 hour recording of the same content. Additionally, the slides for each of the sessions are appended within Blackboard, allowing students to view this content in static format. The engagement of students with this static content was not monitored.

The cumulative viewing data in Figure 1 and the retention analysis shown in Figures 2–4 was used to track the interaction of the students over time. In both cases, the data appears to indicate a focus on assessment outcomes, as has been reported in previous studies (Belski, 2011). The cumulative data shows that students typically view a segment at the time of release, then not at all until the final submission of quiz responses is due. This pattern is consistent for all videos that were listed in the first half of the trimester, with the exception of the Introduction to 'Project SOLVE'. This segment has an in-depth look at the scoring system for the project and may have been a valuable resource to refer back to.

The retention analysis shows a decrease with watch duration. For the three videos considered in detail, linear regression shows viewer drop off at a rate ranging from 0.028 to 0.044. Outside of this, distinct peaks that rise above the trendline are noted. Analysis of the quizzes shows that these peaks occur around the responses to the questions posed. In the 'Effective Teamworking' segment, there is a distinct uptake from a baseline interest of around 45% to a peak of 67% around 6 mins 30 (30%) through the video. This peak (upward-sloped hatching in Figure 2) pertains to a section of the video regarding personality traits. This information was the basis of three multiple choice questions within the question pool. The second peak (~55% duration) shows a rise from ~48% to ~54.4% and corresponds to a section of the video regarding team requirements—this is the subject of two questions within the pool. The final peak (~70%) is centred around a bullet-pointed list on the same topic. Three less distinct peaks

are noted after 80% duration. These points are not the responses to questions for the segment but occur in time with the revealing of slides containing bullet-pointed lists of information. In the other online-only video a similar trend is observed. The first peak in interest pertains to a response to 'what does SOLVE stand for?'. The second, much larger section of interest follows a complete, worked explanation of the scoring system for the project. This is the subject of a quiz question, and a second question regarding the scoring rules. The final peak is aligned with a bullet-pointed list entitled 'Additional points of note'. This is useful information for the project, and a *possible* answer to a quiz question (although not the correct response required).

For the Guest lecture in Figure 4, more distinct peaks are apparent. This segment is significantly longer (lecture capture). The session is the topic of a standalone assessment task. Students are asked to reflect upon the career of the speaker, define the Engineers Australia Stage 1 Competencies (Professional & Personal), and provide specific examples of how they and the speaker have been shaped by these competencies. 20% of the marks are attributed to their understanding of the Competencies. The distinct peak shown 65% of the way through the segment is the point at which the guest speaker discusses a bullet-point list of the competencies. The first peak in Figure 4 (from 2–14%) is a segment in which the speaker introduces themselves, their responsibilities and the type of work they do. The remaining three peaks (highlighted in the same dashed horizontal line) are three separate case studies of projects the speaker had worked on, highlighting their roles and responsibilities. After approximately 75% duration, there are no further questions or tasks relating to video. The engagement tails off continually, showing no further peaks above the trendline.

Despite valuable insight the study has limitations. Previous work has proposed that all video segments should be released on (or before) the start of teaching (Wandel, 2010). This may be implemented for future years to aid sequencing issues. The analytical data is presented as *bulk* interaction (e.g. percentage of maximum viewers). This overlooks the requirements of the individual, and further efforts will be made to gather qualitative feedback in future. It should be noted that the analytics considered here reflect the period for which video segments were playing, and do not assess the student's actual *engagement* with the content. This is somewhat harder to quantify but leaves room for further study as the course continues in future.

Conclusion

The advanced analytics tools used give valuable insight into the engagement of students with online content. The preliminary analysis conducted in this study has shown that students appear unmotivated to engage with the online video content. The students may prefer to engage with the uploaded written content, and engagement with this will be monitored in future years. The analysis of the video content shows a definite assessment-orientated interaction. The most watched sections of a video segment align well with the responses to questions posed to the students. Bullet-pointed lists appeared to also catch the attention of students during individual segments. It is not clear if this was in response to 'looking' for quiz responses, but the finding may be useful in the design of future materials for online content.

Cumulative data shows that students have limited reengagement with content delivered earlier in the trimester, although there are exceptions, where the content is particularly pertinent. General reengagement with the content increased towards the end of the trimester, in line with the final submission of the online quizzes. The findings highlight the importance in reviewing the interaction of students with online content. Such analysis can help in the shaping of course materials for online hosting, for example, in ensuring that quiz questions cover material that is evenly spread across a given video, such that duration of interaction can be maximised.

Future work will consider the analysis of the remaining video segments to develop the understanding of interaction behaviour over the whole course. The engagement of students with the online videos will also be correlated with performance in the quizzes and major design challenge to identify if any further conclusions can be made regarding the efficacy of the blended-learning approach.

References

Albó, L., Hernández-Leo, D., Barcelo, J., & Sanabria-Russo, L. (2016). Video-Based Learning in Higher Education: The Flipped or the Hands-on Classroom? *European Journal of Open, Distance and E-learning*, *19*(2).

Belski, L. (2011). Dynamic and static worked examples in student learning.

Crilly, N., & Cardoso, C. (2017). Where next for research on fixation, inspiration and creativity in design? *Design Studies*, *50*, 1–38. https://doi.org/10.1016/j.destud.2017.02.001

Dutson, A. J., Todd, R. H., Magleby, S. P., & Sorensen, C. D. (1997). A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses. *Journal of Engineering Education*, *86*(1), 17–28. https://doi.org/10.1002/j.2168-9830.1997.tb00260.x

Dym, C. L. (1999). Learning Engineering: Design, Languages, and Experiences *Journal of Engineering Education*, *88*(2), 145–148. https://doi.org/10.1002/j.2168-9830.1999.tb00425.x

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education*, *94*(1), 103–120. https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Hoogerheide, V., Renkl, A., Fiorella, L., Paas, F., & van Gog, T. (2019). Enhancing example-based learning: Teaching on video increases arousal and improves problem-solving performance. *Journal of Educational Psychology*, *111*(1), 45–56. https://doi.org/10.1037/edu0000272

Lucke, T. (2014). Using learning analytics to evaluate the effectiveness of the flipped classroom approach.

Mills, J. E., & Treagust, D. F. (2003). Engineering education—Is problem-based or project-based learning the answer. *Australasian journal of engineering education*, *3*(2), 2–16.

Slemmons, K., Anyanwu, K., Hames, J., Grabski, D., Mlsna, J., Simkins, E., & Cook, P. (2018). The Impact of Video Length on Learning in a Middle-Level Flipped Science Setting: Implications for Diversity Inclusion. *Journal of Science Education and Technology*, *27*(5), 469–479. https://doi.org/10.1007/s10956-018-9736-2

Wandel, A. P. (2010). Student usage of videos containing worked solutions.

Warman (2019). Design and Build Competition. Retrieved from https://warmandesignandbuild.org.au/

Wijnen, M., Loyens, S. M. M., Wijnia, L., Smeets, G., Kroeze, M. J., & Van der Molen, Henk T. (2018). Is problem-based learning associated with students' motivation? A quantitative and qualitative study. *Learning Environments Research*, *21*(2), 173–193. https://doi.org/10.1007/s10984-017-9246-9