How do Australasian students engage with instructional YouTube videos? An engineering mathematics case study

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CONTEXT
As the popularity of blended and online learning continues to grow in higher education, the role of the engineering educator will continue to change for developing the future engineer. Over the past 10 years there has been a worldwide shift by educators to use online educational video to enhance student learning of course material. However, few (if any) long-term studies are available regarding this new paradigm in engineering education.

PURPOSE
The purpose of this work is to examine and address the following research questions regarding the student experience of YouTube videos used in engineering mathematics courses:

- Do students use online video for their learning?
- What is the nature of the engagement?
- What are the students' perceptions of the usefulness of these resources?
- What recommendations can be made to the engineering educator, based on the above?

APPROACH
Beginning 2008, several hundred instructional videos on mathematics were created for engineering students as a learning resource and freely shared via YouTube. The videos were designed as optional out-of-class educational resources for students to enhance regular face-to-face lectures and tutorials, rather than replacing them. We then began to measure usage and student perception of these resources, starting our analysis in 2010. Our mixed-methods approach includes:

- Examining popularity and usage patterns of the resources via YouTube Analytics over 5 years across Australasia
- Analysing watch-time and other indicators of learning engagement across Australasia
- Examining satisfaction scores regarding the students' experience with the videos at UNSW
- Analysing user comments regarding their experience with the videos at UNSW.

RESULTS
The key results are as follows:

- Over 71% of students chose to use the online videos for their learning
- Student use of the resources was particularly concentrated around revision periods for tests and examinations across Australasia.
- A growing trend in student engagement involved accessing the videos on mobile devices.
- Over 96% of students broadly agreed that the videos were a useful learning resource.
- Comments from students were very positive regarding the value of the videos, including identifying value in them as tools for: revision; catching up on missed material; and preparing for class.

CONCLUSIONS
We conclude that a large percentage of students chose to use the online videos for their learning and that higher usage was seen around assessment time. We observed students moving towards mobile learning in their behaviour. Overall, students saw significant educational benefits in engaging with online educational video for their learning.

KEYWORDS
Blended learning; engineering mathematics; online educational video; YouTube; open educational resources.

Introduction

The engineering educator faces significant challenges in developing mathematical and quantitative skills within the future engineer. The diversity of students entering Australian universities has continued to increase (Baik et al, 2015; Brown, 2009) and thus many are not sufficiently equipped with the mathematical knowledge that they need for their university study. In addition, studies by Baik et al (2015) and James (2010) have revealed that students are spending less time on campus and so require more flexible learning, often looking to the web for instruction.

Many universities are taking action to address the aforementioned issues through blended and online learning. The benefits of blended and online learning have been identified by such scholars as: Baloian et al (2000); Kumar et al (2001); Piccoli et al (2001); and Soong et al (2006), and include:

- providing flexibility of time and location;
- promoting self-directed and self-paced learning;
- creating a collaborative learning environment by linking each learner with geographically dispersed experts or peers;
- enabling virtually unlimited access to digital learning material;
- allowing content to be maintained and enhanced in a timely and efficient manner.

Online video is a powerful and expressive way to capture and present information and has been gaining popularity as an educational resource across universities in the past 10 years. Studies by Zhang et al (2006) have illustrated that *the overall learning outcomes with instructional video is superior, or at least equal, to that of accustomed classroom learning*. They discovered that:

- students who used interactive video as a learning resource achieved superior test scores to those who did not use interactive video, including those from the traditional classroom environment and those who used video without embedded interactivity;
- given identical amounts of learning time, the test scores of students who used interactive video were higher than those students in the traditional face-to-face classroom environment;
- students using interactive video as a learning resource reported higher levels of learning satisfaction than those who did not use interactive video.

Recently, Tisdell and Loch (in press) examined the usefulness of closed captions in online video to enhance learning, finding that closed captions were perceived as uniformly useful in a wide variety of learning situations.

Purpose

The purpose of this work is to examine and address the following research questions regarding the student experience of online educational videos used in engineering mathematics courses:

- Do students use online video for their learning?
- What is the nature of the engagement?
- What are the students' perceptions of the usefulness of these resources?
- What recommendations can be made to the engineering educator, based on the above?

Our study differs from Zhang et al's (2006) as we are more interested in how students are using these videos, which can uncover engagement patterns in learning, and has important implications on learning design for those educators who are creating, sharing and measuring educational videos as part of their practice.

Approach

Beginning in 2008, several hundred instructional videos on mathematics were designed and created for engineering students as a learning resource and freely shared online. The videos were designed as optional out-of-class educational resources for students to enhance regular face-to-face lectures and tutorials, rather than replacing them. The videos were distinctly low budget, no frills productions made by the author. UNSW students were made aware of the existence of the videos through announcements on Moodle.

The videos were aligned with content from large mathematics courses. These courses were compulsory units of study for almost all engineering students in their first and second years of university. They included foundational engineering mathematics like: complex numbers; vectors; matrices; single- and multivariable-calculus; vector calculus; Fourier series; Laplace transforms; and partial differential equations.

The videos were placed on YouTube (2005) - the world's most popular online video community, specifically on the author's YouTube channel (Tisdell, 2008). YouTube provides a natural environment for educational videos as it offers high levels of interactivity and engagement for the learner. Specific examples of interactivity embedded within the YouTube framework are:

- the learner can Rewind/Pause/Replay/Fastforward each video, enabling selective and personalized self-paced study;
- the learner can raise a question or comment about videos by using the "Post Comment" feature of YouTube. The video creator has the opportunity to respond to the comment. Other learners or viewers can also contribute to the discussion;
- videos can be embedded within existing learning management systems like Moodle or Blackboard to ensure easy access;
- each video may feature carefully chosen keywords, known as "tags", that describe it, so that learners can search for terms, and the associated videos will appear in their search results.

YouTube Analytics offers video creators a way of measuring performance of their YouTube videos through metrics such as: popularity, demographics, engagement and watch-time.

It is through YouTube Analytics that we have measured usage patterns of the resources across Australasia over a 5 year period by analysing views, watch-time and other indicators of learning engagement. We have also employed YouTube Analytics to better understand the kinds of devices that students were accessing these video resources on. We commenced our analysis using YouTube Analytics in 2010, two years after we had started to create the videos.

We examined learner satisfaction with the videos by collecting student ratings and comments regarding their experience with the videos at UNSW. This includes a timeline of five years and nine courses.

Results

In this section we present our results based on YouTube Analytics and student survey data.

We asked the students to indicate whether they had used the videos for their learning. If the students indicated that they had used the videos for learning then we asked them to provide a rating for their overall level of agreement with the statement "Overall, the YouTube videos were a valuable learning resource". The level of agreement was measured on a 6-point Likert scale, with possible ratings: 1 = Strongly Disagree; 2 = Disagree; 3 = Mildly Disagree; 4 = Mildly Agree; 5 = Agree; 6 = Strongly Agree.

Below, Figure 1 summarizes overall student satisfaction with the videos over a five year period.

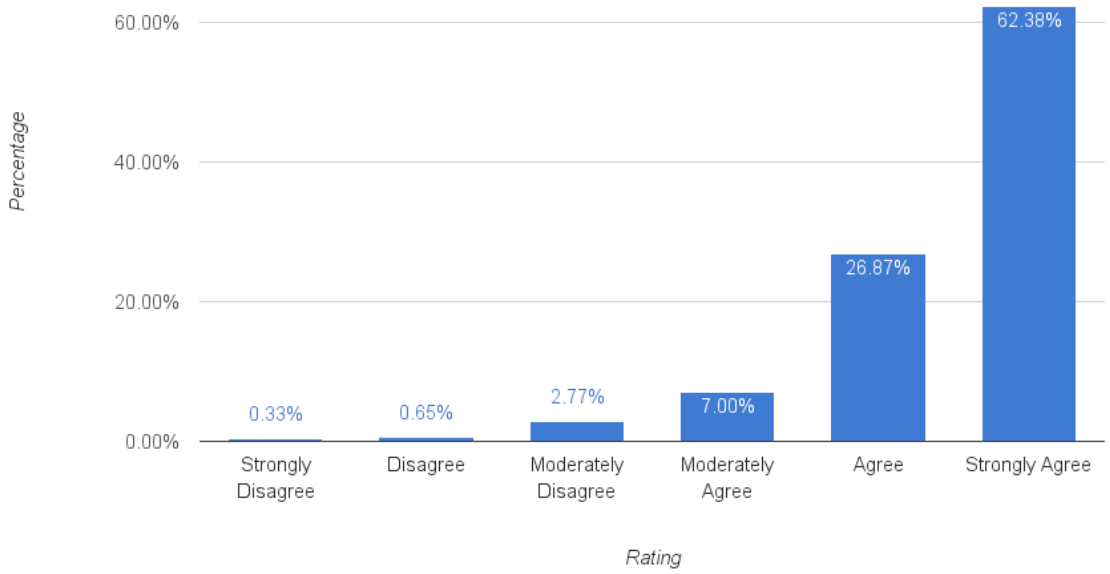

Figure 1: Summary of student responses to "Overall, the YouTube videos were a valuable learning resource" 2010-2014

Below, Table 1 summarizes the percentage use of the videos and student satisfaction data, both overall and within specific courses.

Table 1: Summary of survey data for student feedback regarding usage and the statement "Overall, the YouTube videos were a valuable learning resource"

Course	Semester and year	Number of survey respondents	Percentage who used the videos	Mean satisfaction rating out of 6 with 95% confidence interval	Video creator also taught the course?
MATH2111	S1, 2010	29	62%	5.61 ± 0.28	Yes
MATH2019	S1, 2010	182	58%	5.31 ± 0.17	No
MATH1231	S2, 2010	242	67%	5.25 ± 0.13	No
MATH2011	S1, 2011	52	100%	5.85 ± 0.1	Yes
MATH2019	S1, 2011	158	55%	5.27 ± 0.19	No
MATH2019	S2, 2011	72	96%	5.75 ± 0.13	Yes
MATH2019	S2, 2012	52	96%	5.88 ± 0.09	Yes
MATH3121	S2, 2013	23	96%	5.77 ± 0.26	Yes
MATH1131	S1, 2014	106	92%	5.67 ± 0.17	Yes
All	**2010-2014**	**864**	**71%**	**5.47 ± 0.07**	N/A

In addition to asking students to quantitatively rate their perception of the usefulness of the videos as a learning resource, there was also an opportunity for students to provide some feedback on the videos in response to open-ended questions. For each course, we collected responses to “The best features of this course / lecturer’s teaching were….”

There were hundreds of comments that referred to the usefulness of the YouTube videos. Some students simply listed YouTube as the best feature of the course / lecturer’s teaching, while others elaborated with additional comments as to why they believed it was useful. We identified the following themes within student feedback regarding the usefulness of the videos, including:

- a revision tool to prepare for assessment
- a way of catching up on missed classes due to illness or late enrolment
- a mechanism for clarifying points that were not fully understood within class
- a forum to provide feedback or raise questions by commenting on the YouTube video
- an avenue that enabled self-paced study.

Five comments that typify these themes are:

> *The YouTube component of the course including online videos were immensely useful. They made revision for class tests and catching up on missed lectures very easy. I have not come across a better method for learning since beginning university study.*
>
> *His You Tube videos are absolutely useful. Especially when some of us fall ill and cannot attend the lecture. Also it’s a great revision tool & if students don’t fully understand what was said in lectures, they can easily go back and listen to the explanations again.*
>
> *everything being on youtube (the youtube videos were great! keep them up! especially as I missed a few lectures in the beginning due to late enrolment)*
>
> *it was great to have complete access to important questions in an internet based service. The commenting function for this also enabled us to clarify points directly to Chris himself.*
>
> *youtube for selfstudy.*

We used YouTube Analytics to track the popularity of the learning resources across Australasia (defined in YouTube Analytics as Australia and New Zealand) for in excess of a 5 year period. Below, Figure 2 graphically illustrates the number of daily views of a typical video.

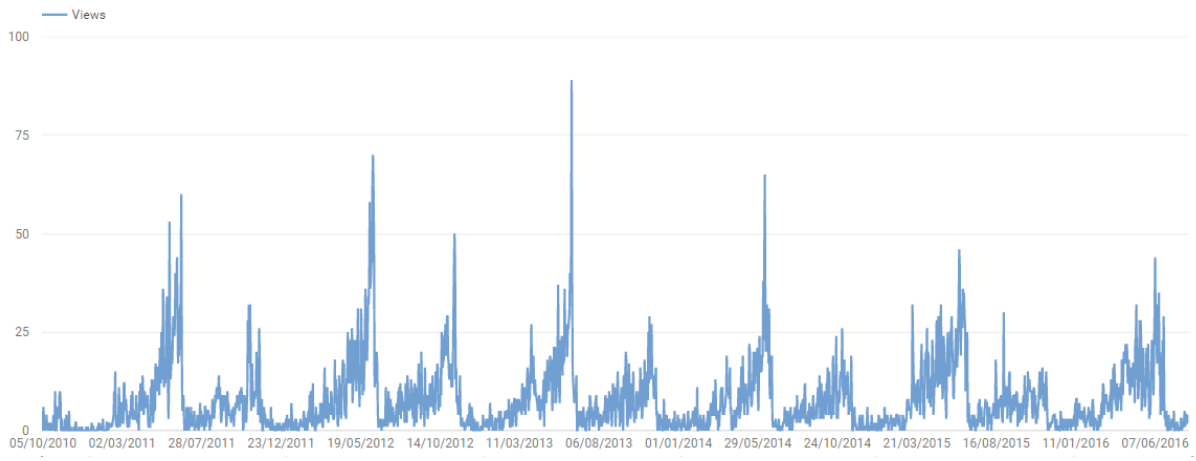

Figure 2: Daily number of views on a typical YouTube video across Australasia

We have used YouTube Analytics to track the engagement of the learning resources across Australasia for a multi-year period. Below, Figure 3 illustrates daily Watch Time - the number

of daily minutes watched for a typical video, with the asterisk (*) denoting that the Watch Time metric was not available before 1st September, 2012.

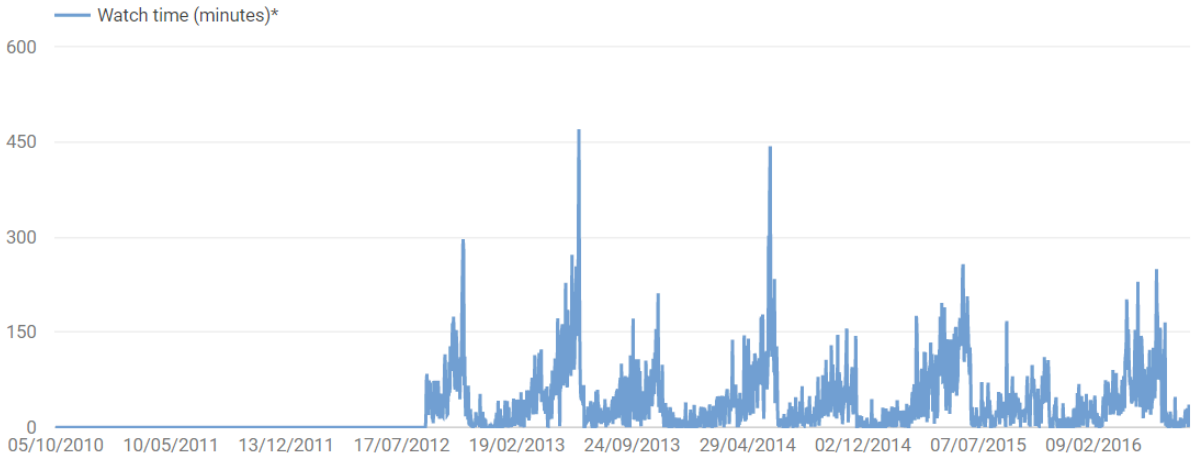

Figure 3: Number of minutes watched per day of a typical YouTube video across Australasia

We employed YouTube Analytics to see what kinds of mobile devices learners were accessing the videos on. Below, Table 2 summarizes the data regarding access with mobile devices over a three-year period. The values are percentages of total number of views for a typical YouTube video.

Table 2: Percentage of video views on mobile devices

	2013	2014	2015
Smart Phone	3.4%	4.6%	5.5%
Tablet	5.4%	6.3%	6.8%
Total	8.8%	10.9%	12.3%

Discussion

Do students use online educational video for their learning?

As can be seen from the final row in Table 1, 71% of the 864 UNSW students in the study self-identified as using the optional educational videos for their learning during the period 2010-2014.

It is interesting to note that three (of four) courses with participation rates between 55% and 67% in Table 1 were not taught by the creator of the videos. On the other hand, the courses with participation rates above 90% were courses where the video creator was also teaching the course. This seems to suggest that students were more likely to use learning resources if there is a strong connection between the resources and the teacher of the course, for example, if the videos featured, or were produced by, the same teacher associated with the course where they were used. We also acknowledge the possibility that the videos may not have been promoted by other teachers to their students.

What is the nature of the engagement?

We can see from Figure 2 that there was a cyclical pattern of repetition regarding number of daily views from 2011 onwards for a typical educational video across Australasia. We observe that the number of video views increase steadily with time, followed by a sharp spike, and then followed by a swift decrease in views, with the cycle starting again. The semester model (as opposed to a trimester) is common throughout many Australasian universities, with final examinations occurring in late June (for Semester 1) and in late

October / early November (for Semester 2). For the courses listed in Table 2, the final exam was worth around 60% of a student's total mark.

We can see from Figure 2 that activity spikes occur in late June for each of the years 2011 – 2016. Similarly, there are activity spikes in late October / early November in each year of the same time period. This strongly suggests that students were most engaged with the video resources in the lead up to final examinations to help with revision, preparation and just-in-time learning. This quantitative data agrees with the qualitative comments from the students regarding the YouTube videos – many identified as using the videos as a revision tool.

The "troughs" in Figure 2, with low number of video views, align with holiday periods in Australasian universities, such as the winter break (July) and summer vacation (December to February inclusive).

A similar pattern can be observed from Figure 3 regarding total watch time per day from 2013 onwards for a typical educational video across Australasia. The watch time metric was unavailable before 1st September, 2012. We hypothesize that paying attention to the watch time of a video is strongly connected to measuring "time on task", which is one indicator of learning engagement (with the other two indicators being attention to the area of focus and active participation in learning.)

From Table 2 we can see the types of mobile devices that students were accessing the videos with. We observe that, overall, the percentage of views on mobile devices, is relatively small, making up less than 13% of overall views in the period 2013-2015. However, we notice that both tablet use and smart phone use increased over that period. In particular, smart phone use increased by 62% and tablet use increased by 26%. We expect these trends to continue and the results suggest that educators who are considering creating online video need to accommodate mobile devices into the design of their videos, for example, ensuring text within a video can be easily read on a small, hand-held smart phone screen.

What are students' perceptions of the usefulness of these videos for their learning?

We observe from Figure 1 that overall, in excess of 96% of UNSW respondents either "Mildly Agreed", "Agreed" or "Strongly Agreed" with the statement that the videos were useful in their learning. We summarize this outcome as "over 96% of students broadly agreed that the videos were useful for their learning".

We can see from Table 1 that the overall mean satisfaction ratings of 5.47 ± 0.07 on the 6-point Likert scale when 95% confidence intervals were applied through a statistical analysis. Thus, we have a high degree of confidence that students agreed with the statement "Overall, the YouTube videos were a valuable learning resource".

From the section following Table 1, we can see that comments regarding the videos were very positive. We identified the following themes within UNSW student feedback regarding the usefulness of the videos, including:

- a revision tool to prepare for assessment
- a way of catching up on missed classes due to illness or late enrolment
- a mechanism for clarifying points that were not fully understood within class
- a way to provide feedback or raise questions by commenting on the YouTube video
- enabling self-paced study.

Limitations of the research

We note the following limitations of the research:

- while the learning analytics have been gathered from across the Australasian region via YouTube Analytics, the survey data was collected from only one Australasian university (UNSW)
- the limitations to the way that data can be accessed and analysed via YouTube Analytics is one reason we have not explored differences between student groups across Australasia.

Conclusion and Recommendations

We conclude that a large percentage of UNSW students chose to use online video for their learning and that higher usage was seen in the lead up to assessment time across Australasia. We observed that students moved towards mobile learning in their behaviour across Australasia. Overall, UNSW students saw significant educational benefits in engaging with online video for their learning.

Recommendations to the engineering educator based on these conclusions are:

- **"If you build it, they will come".** For educators who are considering creating these type of online learning materials, it is likely that students will use them, with the likelihood increasing if the video creator is also teaching the course that the videos are related to.
- **"Assessment drives activity and engagement".** The most critical time for these resources to be made available to learners is in the lead up to final examinations and educators can expect a periodic cycle of engagement.
- **"Get ready for the small screen".** Video creators are encouraged to consider design principles that enable learners to engage with the videos on mobile devices with small screens.

References

Baik, C., Naylor, R. & Arkoudis, S. (2015). *The First Year Experience in Australian Universities: Findings from two decades, 1994 – 2014*. Melbourne Centre for the Study of Higher Education (CSHE), Melbourne: University of Melbourne. Retrieved August 10, 2016, from http://fyhe.com.au/wp-content/uploads/2015/03/FYE-2014-FULL-report-FINAL-web.pdf

Baloian, N. A., Pino, J. A. & Hoppe, H. U. (2000). *A teaching/learning approach in CSCL*, in: Proceedings of the 33rd Hawaii International Conference on Systems Sciences, 447-456.

Brown, G. (2009). *Review of Education in Mathematics, Data Science and Quantitative Disciplines. Report to the Group of Eight Universities*. Retrieved August 10, 2016, from https://go8.edu.au/publication/go8-review-education-mathematics-data-science-and-quantitative-disciplines

James, R., Krause, K-L. & Jennings, C. (2010). *The first year experience at Australian universities: Findings from 1994 to 2009.* Centre for Higher Education, University of Melbourne. Retrieved August 10, 2016, from http://www.cshe.unimelb.edu.au/research/FYE_Report_1994_to_2009.pdf

Kumar, A., Kumar, P., Basu, S. C. (2001). *Student's perceptions of virtual education: an exploratory study,* in: Proceedings of the 2001 Information Resources Management Association International Conference, Toronto, Ontario, Canada, 400-403.

Piccoli, G., Ahmad, R. & Ives, B. (2001). Web-based virtual learning environments: a research framework and a preliminary assessment of effectiveness in basic IT skills training, *MIS Quarterly* 25(4), 401-426.

Soong, S. K. A., Chan, L.K., Cheers, C. & Hu, C. (2006). *Impact of video recorded lectures among students* in L. Markauskaite, P. Goodyear and P. Reimann (Eds.), Who's Learning? Whose Technology? Proceedings of the Australasian Society for Computers in Learning in Tertiary Education Conference (pp. 789 - 793) Sydney Australia, Dec 3-6.

Tisdell, C. C. (2008). Dr Chris Tisdell's YouTube Channel. Retrieved August 10, 2016, from http://www.youtube.com/user/DrChrisTisdell

Tisdell, C., Loch, B. (in press). How useful are closed captions for learning mathematics via online video? *International Journal of Mathematical Education in Science and Technology,* http://dx.doi.org/10.1080/0020739X.2016.1238518

YouTube (2005), Retrieved August 10, 2016, from http://www.youtube.com

Zhang, D., Zhou, L., Briggs, R. & Nunamaker Jr., J. (2006). Instructional video in elearning: Assessing the impact of interactive video on learning effectiveness. *Information & Management*, 43, 15-27.