Video in engineering courses to promote active online learning environments

Nicholas Jackson, Diana Quinn, Anne Lonie, Pramila Rathore, Patrick James
University of South Australia
Nicholas.jackson@unisa.edu.au

Structured abstract

BACKGROUND
Online learning provides flexible opportunities for people to pursue higher education opportunities and to study towards qualifications often while they are working. Online delivery streamlines the learning process and allows the student to take control of their learning. However, the challenges of creating effective online learning experiences for students are well documented. Although video in higher education has been described as a passive way to acquire information, it is increasingly being used as bandwidth and accessibility hurdles are overcome. Student engineers need to develop a strong knowledge and skill base, engineering ability and professional attributes to become competent engineers. Given that a large proportion of engineering students are spatial and visual learners, developing online learning environments with a diverse and rich use of video, is desirable as a strategy. To reach engineering students studying online, the integration of video in learning environment needs to be coupled with active learning design to support achievement of the desired learning outcomes.

PURPOSE
The aim of this paper is to provide engineering educators with guidance for the use of online video in their courses by examining the different ways that video can be used in a spectrum of engineering courses, ranging from introductory and technical, to practice-based and professional.

DESIGN/METHOD
A mostly-online Australian Associate degree in engineering program that has been operational since January 2012, was selected as a case study. The videos embedded in 21 courses were categorised by learning objective and experience across a range of course types.

RESULTS
A total of 1617 videos in 21 courses were reviewed. A large proportion of videos (40%) were used solely as a narrative, to support understanding and remembering. This type of video was present across all courses. Those courses that focussed on integrating theory and practice, commonly included videos supporting interaction (28%) and communication (11%) while 'adaptive' videos were used to support evaluation and experimentation (20%). In eight instances, students were required to create video as part of their assessment. The videos are categorised on the basis of the their various learning objectives in engineering.

CONCLUSIONS
Video is a highly versatile tool within the engineering educators' toolkit that can be reused and reintegrated in different ways to achieve different learning outcomes that promote student engagement and learning. The constraints of online video need to be appreciated and managed. The rationale for including online video within an engineering course needs to be clear as this informs the best ways in which it can be integrated.

KEYWORDS
Video, active learning, framework, engineering.

Background

Online learning facilitates the notion of learning from anywhere at anytime, provided you have access to a computer and to the internet for a significant portion of most courses. As such, online courses are intended to provide flexible opportunities for people to pursue higher education options (James *et al*., 2011). Learning while you are working is one such approach to higher education where the flexibility of online courses provide students with the chance to study at a time and place that suits their working and domestic arrangements. Established practices in online delivery such as the organisation of content into modules, providing teaching materials for the whole course at the outset and in various formats, contribute to a learning environment that aids self-directed learning (Candy 2004).

Challenges remain, however, in the creation of effective online learning experiences and these have been well documented (Bender, 2003; Palloff & Pratt, 2002). These include teaching and learning complexities such as motivation, communication and interaction between participants of an online course coupled with the demands of facilitating a student-centred approach to teaching and learning where an environment of social constructivism is propagated (Conrad & Donaldson, 2011). Additionally, there are constantly evolving practices of learning design, particularly e-learning design, legal issues around copyright and the more technical issues of trying to accommodate bandwidth and accessibility issues (Moore & Kearsley, 2011).

In 2002, Laurillard devised the Conversational Framework to assist those designing online learning courses. This framework depicted how interactions between student and teacher formed the learning process. The framework was used to analyse various educational technologies, including video (Laurillard, 2002). The basic categories that technologies were grouped were narrative, interactive, communicative, adaptive and productive. In this classification, video was grouped as a solely narrative media (Laurillard, 2002).

Since that time there has been a lot of change in relation to video. Developments in broadband provision and a new generation of powerful video creation and editing software, has made it possible for desktop creation of engaging video clips that include callouts, animations and interactions (Lucking *et al.* 2011).

To minimise bandwidth issues, short video clips are preferred (Mangan, 2005) and the practice of sharing long lectures has advanced to using edited shorter, scaffolded segments of learning and more recently, the production of screen captured short lecture summaries with annotations, and animation to enhance student experience (Rowlett 2012). Kale & Whitehouse (2012) argued that video presented in segments rather as a continuous unit, can benefit students in solving ill-defined problems and that they gain a better understanding of complex situation when presented with different "*lenses*" and "*layered*' resources.

Videos can present ideas in more accessible and engaging format for visual learners (Andrew, 2012). Gibbons, Kincheloe & Down (1977) outlined issues with the idea of students receiving instruction from a 'talking head' video delivery. Using videoed dialogues (two-way conversations) that were authentic and less scripted than talking heads, were favoured by far more students (Andrew, 2012). It was also seen as a significant factor in allowing learners to contextualise their understanding and '*provide a space for critical thinking and reflection*' (Andrew, 2012). The discussions that form the content of the videos can prompt further interrogation, activities, analysis and/or evaluation by the students after viewing them (Sturges & Reyna, 2010).

Australian engineering students need to develop a range of key competencies for practice including knowledge and skills, engineering and application ability and personal and professional attributes (Engineers Australia). The flexibility of learning some, or all of their courses online, attracts an increasing number of students. The design of online engineering courses is demanding because of the need to provide 'hands on' practical activities to develop engineering ability. A large proportion of engineering students are spatial and visual learners (Felder & Silverman, 1988; Kuri & Truzzi, 2002). Video can be a desirable approach

to actively engage engineering students in key concepts and learning experiences such as meeting engineers, visiting dangerous places and operating machines and software.

The aim of this paper is to provide engineering educators with guidance for the use of online video in their courses. We examine different ways that video can be used in a spectrum of engineering courses, ranging from theoretical and technical, to practice-based and professional. We argue that video, when integrated in online engineering activities, extends beyond the narrative.

Design/method

An Australian Associate degree in engineering program, operational since January 2012, was selected as a case study. The courses had been designed and co-developed by a team including lecturers, tutoring staff, instructional designers, technical administration support staff. Different forms of video content were developed and incorporated into the online engineering websites to achieve different learning objectives. Based on continuing student and teacher feedback, team consensus and 6 weekly-learning analytics reports (reflecting on student usage patterns and behaviour), iterative enhancements and improvements have been made to all courses.

To better understand the use of video in this program, the courses active in August 2013 were analysed by the instructional design team. As a group, initial classifications were identified based on their learning experience (Laurillard, 2002). Each designer closely examined the courses they had worked on, putting videos into these categories. With that information collated, further refinement of the categories was made by the instructional design team and the forms of video were described. These observations were then used to re-design a framework for the use of online video in engineering courses.

Results

Of the 23 courses of the Associate degree in engineering, 4 were broadly classified as introductory, 1 as technical, 12 as theory-practice and 6 and practice-based or professional. A total of 1617 videos in 21 of the courses were reviewed (Table 1). A large proportion of videos (40%) were used solely as a narrative, supporting understanding and remembering (Laurillard, 2002). This type of video was present across all course types. Those courses that focussed on integrating theory and practice, commonly included videos supporting interaction (28%) and communication (11%) while ‘adaptive’ videos were used to support experimentation primarily in the introductory courses (20%). In eight instances, students were required to create video as part of their assessment.

Table 1: Average number of video by purpose per course

		Average number of videos by purpose per course (Laurillard, 2002)				
Course type	Number	Narrative	Interactive	Communicative	Adaptive	Productive
Introductory	2*	8.0	47.0	9.5	150.0	0.0
Technical	1	5.0	40.0	7.0	0.0	0.0
Theory-Practice	12	45.7	20.6	12.3	1.3	0.25
Practice-Professional	6	13.7	13.7	0.83	0.0	0.83
Total	21	651 (40.3%)	463 (28.6%)	179 (11.1%)	316 (19.5%)	8 (0.5%)

*Only 2 of the 4 introductory courses could be analysed for video use

Examples of how video was used are presented in Table 2.

Table 2: Examples of video categories and spread in courses

Experience	Category	Duration (min)	Format	Number courses (21 max)
Narrative	Welcome video	<5	Head and shoulders of coordinator welcoming students to the course	21
	Tour of web site	<10	Narrated screen capture of web site	21
	Module/Assessment introduction videos	<10	Combination of talking head and screen capture explaining key concepts	7
	Recorded lectures – sometimes with visiting experts	<60	Narrated slides (Echo360); or video camera in theatre	10
	How to videos - training	<10	Screen capture of software with narration	5
Interactive	Lecture summaries with embedded video	<20	Narrated presentations with embedded video (using iSpring Pro)	9
	On-site video interviews of experts/professionals	<10	Head and shoulders on location	3
Communicative	Virtual classroom recording	<60	Recording of webinar sessions using Adobe Connect	21
Adaptive	Video experiment	<15	Head and shoulders in laboratory or workshop	5
	Solution walk through	<15	Video at whiteboard or screen capture at Wacom tablet	7
Productive	Student generated video for assessment	<20	Home movies	6

Discussion

Although video has been described as a narrative media for acquisition of information (Laurillard, 2002, 2013), video can be incorporated in learning environments in a myriad of different ways to achieve a wide variety of outcomes. However, it should not be approached as a simple or random process. Rather, the integration of video in online and blended learning needs to be thoughtfully done and coupled with active learning design so as to engage learners (Hartsell & Yuen, 2006; Downes, 2008).

Narrative video

We were able to identify 5 different categories of narrative video (videos that merely provide description and/or information) used in the engineering program. Site tours and welcome videos were ubiquitous orientation activities that utilised video as a narrative tool (Table 2). Welcome videos also provide the human touch (Andrews, 2012) to support early social integration (Salmon, 2002). Recorded lectures were used in just under half the units available (Table 2). In its raw form, full lecture recording while still relevant, is not the leading academic video use model. Essentially, recorded lectures are designed for linear viewing (Wieling & Hofman, 2010) and we are trying to replace these or at least provide opportunities for students to engage with more dynamic use of recorded lecture content.

In 5 courses there was specialised software, hardware tools and/or machinery that required some narration to describe. Video was used largely as a training tool to instruct students on how to use the equipment in question. This was created in-house due to the specialist and technical nature of the instruction required (González, Montero, de Heredia & Martínez, 2010).

Interactive video

Developing learning environments for active learning means that learners are encouraged to participate “beyond the passive mode of classroom lectures” (Kaufman, 2010). It involves maximising opportunities for students to learn by ‘doing’, by experimentation, collaborative working and physical activities (Kolmos & Holgaard, 2008). The essence of the learning environment being developed here, is to stimulate learners to interact. This interaction will see them involved with the learning materials, actively participating in the learning process and their own learning (Felder, 2004). This was achieved by students having tasks to complete where the videos were an integral part of the process, a source from which information had to be gathered analysed and reflected on in terms of their own learning. In this sense, the definition of videos has developed considerably from Laurillard’s Conversational Framework (Laurillard, 2002). Videos have become a conduit for more interactive learning experience than just provision of information.

Video interviews of experts/professionals have been used in 3 courses to provide a real sense of the working environment and vocations within the various disciplines of the engineering industry. They are very much the foundations of work integrated learning in the sense that experiential learning can be achieved through application of Kolb’s model (Kolb, 1984) to work integrated learning (Smith, Brooks, Lichtenberg, McIlveen, Torjul, & Tyler, 2009). The expert video interviews used for interactive tasks have been referenced and approved by the owners to use in the courses.

Communicative video

Virtual classrooms are a major feature of the online engineering degree as they give students the chance to interact with the tutor(s) on the course and in some cases each other, synchronously. This real-time communication is a key feature in the design of successful, active online delivery (Salmon, 2002) and go some way to providing a tutorial scenario that can otherwise be difficult to replicate online.

Recording of these virtual classrooms provides two main functions: As students enrolled on the engineering degree are often working full-time and spread out over different time zones, it is common that students are unable to attend a live virtual classroom. Access to a recording of a virtual classroom, although not as strong a learning experience as actually engaging synchronously, provide those who are unable to attend with an insight into what has been covered, the discussions, the tutor’s feedback on assessment tasks, the question and answers. In addition, whether a virtual classroom session has been attended or not by a student, watching a recording can provide access to that discussion which can be replayed and controlled at the whim of the viewer. Again, this does not enable active participation in the sense of being able to ask questions and contribute to live discussions as a synchronous event would. It does, however, give students a chance to see what has been said, possibly a reflection of what they would have said if they had been present.

Adaptive video

Solution walkthroughs videos are used to demonstrate problem solving processes to students often where there are advanced multi-step mathematical processes involved. This is an attempt to replicate the face-to-face activity of students observing the teacher setting the context for the problem, performing the calculations, asking questions and clarifying points, and then working through similar problems themselves, individually or in peer groups, with the teacher's assistance. The context of a problem was outlined for the students in an online presentation, and then the mathematical steps demonstrated via an animated presentation with text notes, and a short video clip of the teacher working through the calculations for a similar problem. The animated presentation simply presented the mathematical steps progressively. However, the video was able to enrich the demonstration in that the teacher provided hints to simplify the processes, gave explanations of common errors and pointed out process variations for specific engineering contexts.

Using video in this way, gives students individual control over the pace of their learning and the opportunity for repeated viewing (Dolan & Prodanov, 2012). The activity was supported by an embedded online forum for communication among teachers and students, and students used this forum for questions and discussion of content and processes.

Another example of adaptive video use is video experiments. Here videos were used to give students the chance to view engineering equipment in operation and replicate how experiments are carried out in a face-to-face practical or workshop. These videos were often recorded with no students present to assist in clarity by being able to use specialist lighting and the best camera angles.

Using video in this way provides students with experience of specialist equipment used in particular areas of engineering. Although, they really only get the visual and audio 'feel' for the equipment, specialist staff often provide explanations while machinery is in operation and the experiment is running. This is intended to give students greater insight into what is happening relevant to the practical. Close ups of readings on gauges for instance, provide data for students to carry out assessment tasks based on the experiment being run.

Productive video

Another area of growth is the use of student generated video. This is becoming increasingly popular in reflective assessment using ePortfolios (Smith & Lonie, 2012). Students use video as a tool to support reflection on their learning and development (Cheng, & Chau, 2009). The quality and style of these videos varies and is commonly driven by the students themselves. Having students generate videos in this way again promotes the notion of active learning. Students are responsible and involved in their learning (Kaufman, 2010).

Video framework

Classifying the uses of videos as learning tools from the case study of 21 units and analysing how the videos have been used since inception of the associate degree engineering program, enables creation of a descriptive framework (Table 3). This framework has the types of video mapped to the main learning opportunities they provide. The mapping of the classifications to the opportunities is by no means intended to be exclusive and is intended to further develop as experimentation with video increases.

Table 3: Generic framework for use of video in engineering courses

	Orientation	Teacher Led Explanation	Lecture	Tutorial	Training	Practical Activities	Feedback	WIL
Welcome video	**x**	**x**						

Site tour	x							
Module/Assessment introduction video	x	x						
Recorded lecture		x	x					
Lecture summaries with embedded videos		x	x				x	
Virtual classroom recording		x		x			x	
Video of experiment						x		
Video interviews of experts/professionals								x
How to video for software/hardware tools/machinery					x			
Student generated video						x		x
Solution walkthrough		x		x			x	

In this framework (Table 3), we are situating video as a tool in scaffolded tasks. This can move video beyond being considered one technology or method, and beyond classification as solely a narrative media form (Laurillard, 2002) to a less linear media form (Laurillard, 2013). In other words, we are looking at video not as a medium solely for delivering content. Rather, our study focusses on videos being an integral part of structured learning resources and used in diverse ways for active learning that can move beyond classification as solely a narrative media form (Laurillard, 2002) to a less linear media form (Laurillard, 2013).

However, video may not be for everyone. The production of video (filming, editing, etc) beyond the point-and-click variety, is often a longer and more involved process than say, using text or images. Editing requires specialist software, computers with higher specifications and considerations for storage issues due to large file sizes. Thus, producing videos may mean working with a team of people rather than as an individual and on an institution level, and technical support, particularly in respect of storage and upload. In addition, a more dynamic use of video where the expectation is for students to do more than passively watch the content, will require specific instructions. These instructions are in respect of what students should be actively engaged in during or after watching the videos, and/or why accessing the videos is significant for their learning.

Conclusions

Through this case study, we have shown that video is an integral and essential component of the learning activities provided in an online engineering program. The scope for online video use has improved with faster internet speeds and student familiarity and engagement with online video content (Andrew, 2012). Videos are dynamic learning tools that can be used to provide various scaffolded learning experiences (Rowlett, 2012; Masats 2011), can often be provided with video at the heart of the experience. It is intended that the case study, classification, generic framework provide engineering educators with perspectives on how they can use video in many different ways to promote an active learning experience in online and blended courses. It is hoped that by doing so, the diverse uses of video for learning will further expand.

References

Bender, T. (2003). Discussion-based online teaching to enhance student learning: Theory, practice and assessment. Stylus Publishing, LLC.)

Candy, P. (2004). Linking thinking: Self-directed learning in the digital age.

Cheng, G., & Chau, J. (2009). Digital video for fostering self-reflection in an ePortfolio environment. Learning, Media and Technology, 34(4), 337-350.

Conrad, R. M., & Donaldson, J. A. (2011). *Engaging the online learner: Activities and resources for creative instruction* (Vol. 38). Jossey-Bass.

Dolan, D., & Prodanov, V. I. (2012). Student Perception of Lecture Video Use as a Means to Increase Time for in Class Problem Solving Applications.

Downes, 2008

Engineers Australia https://www.engineersaustralia.org.au/about-us/program-accreditation#AP2

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education*, 78(7), 674-681.

Felder, R. M. (2004). Changing times and paradigms. Chemical Engineering Education, 38(1), 32-33.

Hartsell, T., & Steve Chi-yin, Y. (2006). Video Streaming in Online Learning. *AACE Journal*, 14(1), 31-43.

Gibbons, J. F., Kincheloe, W. R., & Down, K. S. (1977). Tutored videotape instruction: a new use of electronics media in education. Science, 195(3), 1139-1146.

González, M. J., Montero, E., de Heredia, A. B., & Martínez, D. (2010, April). Integrating digital video resources in teaching e-learning engineering courses. InEducation Engineering (EDUCON), 2010 IEEE (pp. 1789-1793). IEEE.

James, P., Quinn, D. & Dansie, B. (2011). Re-engineering for Australia's engineering skill shortage. *In* G. Williams, P. Statham, N. Brown, B. Cleland (Eds.), Changing Demands, Changing Directions. Proceedings ascilite, Hobart 2011. (pp.624-629).

Kale, U. and Whitehouse, P. (2012). Structuring Video Cases to Support Future Teachers' Problem Solving. JRTE | Vol. 44, No. 3, pp. 177–204 | ©2012 ISTE | iste.org/jrte

Kaufman, K. K. (2010). A new wave in engineering education: understanding the beat of active learning through innovative tutorial assessment.

Kolb, D. A. (1984). Experiential learning. Englewood Cliffs, NJ: Prentice Hall.

Kolmos, A., & Holgaard, J. E. (2008). Learning styles of science and engineering students in problem and project based education.

Kuri, N. P., & Truzzi, O. M. S. (2002, August). *Learning styles of freshmen engineering students.* In Proceedings, 2002 International Conference on Engineering Education.

Laurillard, D. (2013). 1.2 Rethinking the teaching of. Mediating Science Learning Through Information and Communications Technology, 27.

Limniou, M., & Smith, M. (2010). Teachers' and students' perspectives on teaching and learning through virtual learning environments. European Journal of Engineering Education, 35(6), 645-653.

Moore, M. G., & Kearsley, G. (2011). Distance education: A systems view of online learning. CengageBrain. com.

Palloff, R. M., & Pratt, K. (2002). Lessons from the cyberspace classroom: The realities of online teaching. Wiley. com.

Rowe, S., & Ellis, A. (2010, June). Moving Beyond Four Walls: a fully online delivery model. In World Conference on Educational Multimedia, Hypermedia and Telecommunications (Vol. 2010, No. 1, pp. 2887-2895).

Salmon, G. (2002). E-tivities: The key to active online learning. Psychology Press.

Smith, E., & Lonie, A. (2012). Towards a sustainable support strategy for online students (Doctoral dissertation, ASCILITE-Australasian Society for Computers in Le).

Smith, M., Brooks, S., Lichtenberg, A., McIlveen, P., Torjul, P., & Tyler, J. (2009). Career development learning: maximising the contribution of work-integrated learning to the student experience: Australian Learning & Teaching Council Final project report. University of Wollongong, Careers Central, Academic Services Division.

Swart, A. J. (2010). Evaluation of Final Examination Papers in engineering: A case study using Bloom's taxonomy. Education, IEEE Transactions on, 53(2), 257-264.

Wieling, M. B., & Hofman, W. H. A. (2010). The impact of online video lecture recordings and automated feedback on student performance. Computers & Education, 54(4), 992-998.

Copyright statement