PREPARING FUTURE GRADUATES TO BECOME LIFELONG, EXPERT LEARNERS: LESSONS AND CONSIDERATIONS FROM A BLENDED ENGINEERING MATHEMATICS UNIT

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KEYWORDS: blended learning, lifelong learning, expert learner, engineering, mathematics, video

ABSTRACT

We present an investigation of the uptake of opportunities for learning provided by a specific component (pre-lecture videos) of a blended learning model. The model, presented in previous work of the authors, was implemented to improve students' content and learning expertise in a foundation engineering mathematics subject. The ultimate goal of the model was to support future graduates becoming lifelong expert learners, facilitating their success in later studies in and after their degree. In particular, we investigated to what extent did the cohort take the opportunity to develop their expert learning skills as evidenced by pre-lecture video viewing, and what was the relationship between the identified behaviour and learners' progression and achievement. We present findings based on an analysis of data sourced from the unit website and propose further questions for future research.

Proceedings of the Australian Conference on Science and Mathematics Education, The University of Queensland, Sept 28th to 30th, 2016, page 182-187, ISBN Number 978-0-9871834-5-3.

INTRODUCTION

One of the biggest challenges faced by modern economies is how to equip graduates with the knowledge, skills and competencies to successfully fulfil requirements of employment in the digital age (Bates, 2015, Griffin & Care, 2014). However, knowledge, skills and competencies are constructs and as such require relevant theoretical frameworks to be explained, understood, taught and measured. Seen from the diachronic perspective, such concepts as graduate capabilities, employability or transferable skills have been transformed to adjust them to the requirements of knowledge-based economies. Knowledge itself is no longer the principal attribute of the graduate, with the concept of a modern graduate also encompassing creative thinking and innovation, conducive to creation of new knowledge within a dynamic environment. The new knowledge becomes obsolete as quickly as it is created and requires further research and innovation (Powell & Snellman, 2004) to remain fresh. Within this context, modern industry seeks creative and agile employees, ready to apply their skills and learn new ones while working within complex professional and social networks. The higher education (HE) sector, in conjunction with government and industry, is facing an important question: how to prepare contemporary graduates for the reality of the 21st Century?

LITERATURE REVIEW

For some time, employers have expressed concerns about the inadequate preparedness of graduates for the above-mentioned challenges of modern economies (McGaw, 2013). Independent thought, quantitative reasoning, collaborative problem solving skills, ability to ask critical questions, and the forming and testing of hypotheses (PMSEIC, 2013, p. 2) are key intellectual capabilities becoming increasingly important. These constructs need to be taught, learned, and the level of their achievement, measured. The learning of these constructs requires an independent, motivated and self-regulated learner capable of studying within a complex (on- and off-campus) environment over an extended period of time. Such a lifelong process can only be completed by an expert learner.

The current research uses the definition of expert learner associated with Universal Design for Learning (UDL). UDL argues in favour of an educational model that assists *any* learner in becoming an expert learner. Leading UDL researchers Meyer, Rose and Gordon (2014) describe an expert learner as "strategic, resourceful, and motivated" (2014, NP). We emphasise that an expert learner is not necessarily a content expert (and vice versa). Naturally, we aim to develop content expertise in students, but as it concerns a foundation subject, this current research also plays a role in the development of expertise in learning.

Contemporary HE institutions across the globe are rethinking their pedagogical approaches and implementing strategies aimed at assisting their graduates to become expert learners. One such strategy is the development and application of blended learning (BL) models (Moskal et al., 2013; Kirkwood, 2014, NMC Horizon Report, 2015; Porter et al., 2016). Influenced by the constructivist perspective on the nature of learning (Bandura, 1997; Greeno, 1989), BL offers a suitable, learner-centred environment to foster expert learners. For clarity, we note that here, the definition of blended learning of Alammary et al. (2014) best describes the model developed in this research. Specifically, a blended learning experience is one that: “1) thoughtfully integrates different instructional methods [...]; and 2) contains both face-to-face and computer-mediated portions” (2014, p. 443). However, the appropriate environment does not guarantee the development of expert learning skills by students. Hence, the following question stems: how do we assist a learner in becoming an *expert* learner?

This research reports on the results of a University-funded learning and teaching project that redesigned for blended learning a first year engineering mathematics unit offered at a large metropolitan university in semester 2, 2014. The intention of the research team was to create a learning environment model to promote students’ development of self-learning skills through diverse pedagogical approaches offered in both, on and off-campus modes. Off-campus elements included pre-lecture videos, mathematically rich online self-assessment tests and supplementary learning resources, while on-campus sections blended in-class activities and out-of-class, on-campus support. Mindful of the challenges the unit was facing such as diverse preparedness levels and the large volume of mathematical content to be covered, the research team intended to monitor learners’ cognitive loads. To this end, the learning environment was designed in a way that would expose novice learners to information presented through multiple representations (e.g. written text, video, face-to-face collaborative activities), in small topical chunks and spread over the semester.

The researchers hypothesised that analysis of usage of selected components of the environment (pre-lecture videos) would allow preliminary conclusions to be drawn regarding the development of students’ learning skills and strategies, hence providing some indication on the achieved level of expertise in learning. Pre-lecture videos were selected because of their unique nature - they were the only component of the model requiring fully independent and systematic learning to prepare for the coming week, with no on-campus support.

As retrieval is an effective strategy for enhancing learning and promoting deep, meaningful knowledge engagement (Karpicke, 2012), the researchers hypothesised that the learning design of the unit would influence students’ strategic approach towards the ways the pre-lecture videos were used as a learning tool. This, in turn, would influence learners’ resourcefulness while progressing towards completion of the unit. The research team also hypothesised that providing an effective strategy for enhancing learning (by setting up “points of retrieval”) would have a positive effect on students’ willingness to use it, thereby increasing their motivation, the third characteristic of an expert learner.

As a result, the research team formulated the following two questions: 1) with respect to the ways pre-lecture videos were used by learners, to what extent did the cohort take the opportunity to develop their expert learning skills, and 2) what was the relationship between the identified behaviour and learners’ progression and achievement?

RESEARCH CONTEXT AND METHODS

THE BLENDED INSTRUCTIONAL MODEL

A blended instructional model, involving the use of multiple, weekly learning-teaching activities comprehensively mapped and linked across and over the weeks, was designed and implemented for a large group (n=127) introductory engineering mathematics subject. The activities included short pre-lecture videos, face-to-face (f2f) lectures, small group workshops, online diagnostic tests, and optional learning support sessions. This BL model is located midway on the spectrum ranging from fully in-class with no technology support, to fully online distance education (Bates, 2015). The research team aimed at creating an environment that would harmoniously blend f2f with online activities to blur in time and through activities the experiences presented and engaged in by students. Elements of the model design are categorised in Table 1.

Table 1: Categorisation of elements of the blended learning model.

Off-campus environment	On-campus environment	
	In class	**Out of class**
Challenge questions: Problem-based, initiated in lectures, available online, solved during tutorials	Lectures (lectorial style)	Learning support
WeBWorK self assessment	Workshops (incl. challenge questions)	Lecturer consultation
Pre-lecture videos		Peer learning

PRE-LECTURE VIDEOS AND FACE-TO-FACE LECTURES

Short (4-15 minutes) pre-lecture videos, each focused on a specific technique or idea, were recorded by the teaching team and made available to students on the class Blackboard site prior to f2f lectures. The videos had two broad objectives, related to cohort preparation diversity. First, the videos aimed at assisting better prepared students as a retrieval cue to reconstruct their prior knowledge within the new context (Karpicke, 2012 p. 158). Second, for students who were unfamiliar with the content, the videos introduced new concepts and techniques. To encourage active retrieval (triggered by appropriate cues), at the end of the videos students were prompted and guided to work in their own time by reading reference texts and attempting problems in provided worksheets. Each week, watching videos prior to attending classes or attempting worksheets was expected and students' familiarity with their content was assumed by the lecturer during f2f lectures.

Face-to-face lectures occurred twice a week: a 2-hour followed by a 1-hour class. The first assumed that students had either watched the pre-lecture videos and attempted worksheet questions, or considered themselves otherwise equally prepared. Students were presented with problems set in engineering contexts that were also more involved than those seen in pre-lecture videos. Following presentation of problems, the lecturer worked with students and acted as a scribe while they constructed solutions as a group, offering suggestions when necessary. Fully blending pre-lecture videos with the f2f lectures in this way aimed at providing students with opportunities for retrieving knowledge from videos, reconstructing it within a new environment, and constructing new knowledge through practical engineering applications in collaboration with the lecturer – an expert (learner). Recordings of f2f lectures were also provided to students.

RESEARCH METHODOLOGY

At the end of the semester, video usage data was downloaded from the unit Blackboard site and subsequently, the data were quantitatively analysed to provide answers to the two research questions. Descriptive statistical methods were applied to data visually presented below, illustrating students' uptake of opportunities for learning provided by online video resources, and the relationships between students' behaviour, progression and achievement.

FINDINGS AND DISCUSSION

The primary pedagogical objective of making pre-lecture videos available to students was to prepare them for the weekly content. The usage data indicated that the vast majority of students (86/127) completed viewing an average of 20% or less of pre-lecture videos. There was however a group (41/127) of dedicated video viewers who averaged between 20% and 80% completion of videos while the highest completion rate reached was 90%. This raises a question about learners' uptake of the opportunities for learning. Was there a relationship between the nature of the videos (e.g. pre-lecture material) and the overall completion rates, or was it rather an indication of learners' pattern of behaviour characterised by relatively low engagement with videos available for self-learning? To look closer at learners' behaviour, we compared average completion rates for individual students for videos of the f2f lectures and pre-lecture videos. Figure 1 shows the completion rate for individual videos for individual students for lecture capture (left) and pre-lecture videos (right).

There was a total of 2921 potential video-watch instances for captured lecture videos. Of these, 2627 (or 89.6%) were watched to less than 10% completion and only 106 (3.6%) were watched to 70% or greater completion. On the other hand, the 50 individual pre-lecture videos gave a total of 6350 potential video-watch instances. Of these, 4439 (or 69.9%) were watched to less than 10% completion. Interestingly, of the remaining 1911 potential video-watch instances, 1540 (24.3%) were watched to 70% or greater completion. Clearly, the opportunity for learning was taken up far more often for pre-lecture videos than f2f recordings. This might suggest that those students who watched the pre-lecture videos (to completion) were making a strategic choice to watch the material which they considered beneficial for their learning. The pre-lecture video material, containing key information to be used across all weekly components of the unit, was seen as an important element to engage with.

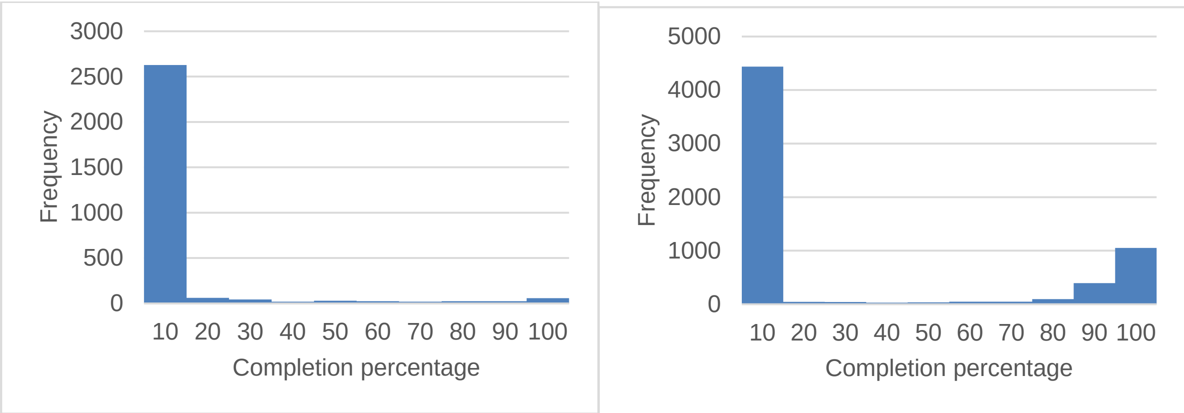

Figure 1: Average completion frequencies for f2f lectures (left) and pre-lecture (right) videos.

Considering the pre-lecture videos, we can further classify the cohort as shown in Table 2. We see that students who failed were far more likely to be non-video watchers – such students show no evidence of development as either content experts or as expert learners. Two-thirds of the video watchers passed the unit, indicating an interplay between content and learning expertise. But what is possibly more interesting is the potential to identify content novices early in order to strengthen efforts to provide greater support and encourage engagement with learning opportunities.

Table 2: Grouping students according to pass/fail and average video completion level.

	Pass	**Fail**	**Total**
20% or less	40	46	86
More than 20%	28	13	41
Total	68	59	127

Figure 2 (left) illustrates the relationship between pre-lecture video completion and students' final grades. It is clear that the level of video completion is likely to be higher for a student achieving a passing grade. In particular, of the students who averaged completion of 60% or more of pre-lecture videos, *none* failed the course. On the other hand, except for one student, all failing students watched an average of 40% or less of videos. This illustrates the value of active retrieval, as it has "powerful effects on long-term learning" (Karpicke, 2012, p. 162). We hypothesise that those students who realised the value of pre-lecture videos, not only perceived learning patterns, but also took up the learning opportunity by engaging with the resources, thereby beginning to develop expert learning skills.

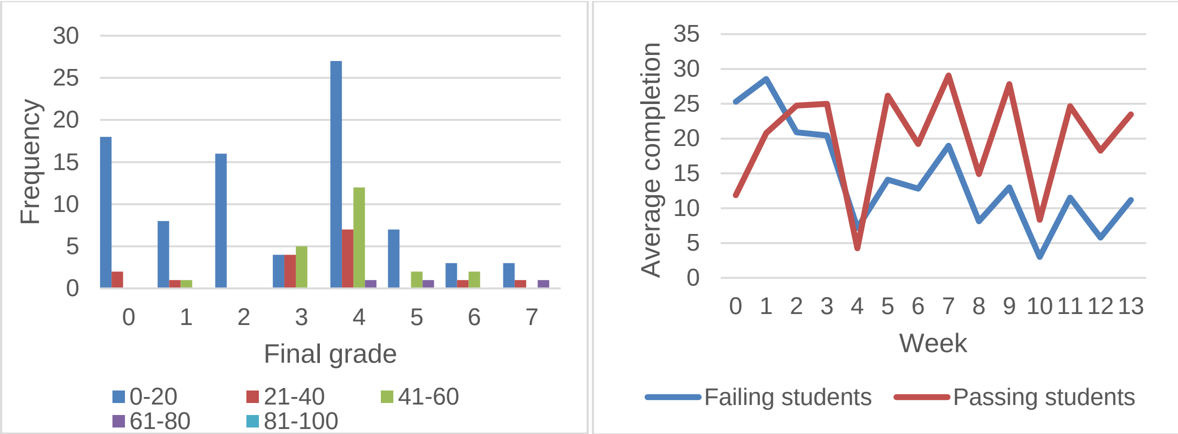

Figure 2: Viewing completion frequencies (# students) within each grade cluster (left). Average video completion for failing vs passing students, over the course of the semester (right).

In Figure 2 (right), average video completions for passing and failing students are shown over the course of the semester. Interestingly, students who failed the unit commence it with a far higher engagement with unit videos. However, by week 3 this relationship began to reverse, and from week 5, passing students consistently had higher viewing completion levels. How to explain 1) the fact that failing students had a high completion rate at the beginning of the semester and 2) the reversed tendency happening after week 5?

The data suggest that there was a cohort of students who perceived the opportunity for learning offered by the pre-lecture videos, took them up and attempted to successfully integrate new knowledge in long-term memory – an indication of a learner's strategic approach. As mentioned-above, the pre-lecture videos were only a preparation for contextualised problem-solving tasks embedded in face-to-face lectures. This might have negatively influenced the progress of those learners who did not integrate the schema in their long term memory. Sweller notes that "since schema acquisition is possibly the most important component of problem solving expertise, the development of expertise may be retarded by a heavy emphasis on problem solving (Sweller, 1988, p. 284).

CONCLUSION

Becoming an expert learner is a process and does not guarantee high scores, at least initially. In this research, we have attempted to begin equipping our first year students with tools and knowledge of how to learn sophisticated concepts, acquire and develop complex skills over a long period of time (lifetime). Here, we have focused on a selected component, pre-lecture videos, of our blended learning model (Czaplinski et al. 2015a, 2015b). We recognise that learning is a process requiring continuous, meaningful and repeated effort to take place in and "outside of the parameters of formal education institutions" (Dawson et al., 2015, p. 118).

In the current project we looked at possible correlations between the created learning environment, learning, acquisition of skills and students' progression and achievement. However, many factors influenced students' behaviour, such as variations in learning preferences, mathematics preparedness levels, students' socio-economic status, extra-curricular activities and interests. Based on the data collected and the analysis, we formulated preliminary conclusions indicating the pre-lecture videos have the potential of enhancing learners' meaningful engagement with knowledge positively impacting on their learning and achievement. However, there are certain conditions of learning design that need to be observed to ensure that the proposed pedagogical approach will be suitable for a particular cohort of learners. Learners should not only be able to perceive offered opportunities for learning and consciously take them up (or not), but, once the opportunities are taken up, the learners also should have an appropriate cognitive level to be able to use them effectively, that is to integrate new knowledge in long term memory.

In our research we identified a group (41/127) who regularly took up opportunities to develop their expert learning skills, as evidenced through regular and measurable completion of pre-lecture videos.

While this may seem a small percentage of the class, we note that pre-lecture videos comprised only one element of the entire BL environment and in a UDL-context, we hypothesise that for these students, videos provided the appropriate preparation for later learning of complex ideas in class. More precisely, through our BL model, we provided students opportunities for an action, as well as a trigger to take up the opportunity for learning by designing practical activities during lectures that required students to show their knowledge of the content included in the pre-lecture video. We conclude that BL (with special attention paid here to pre-lecture videos) can be an excellent way to encourage students' engagement, teaching them how to learn. However, the environment must be carefully designed, and learning experiences crafted to appropriately cater for diverse learners.

The current research allowed us to identify further research needs. We hypothesised that preparedness level was the factor preventing a group of students from passing the unit. This raises further research questions not only to confirm or refute our hypothesis, but also to look at its consequences. If, indeed, preparedness level was the factor preventing students' progression, should learners be tested for their preparedness level prior to commencing a unit? If yes, at what point of time of their studies? What consequences should the testing have on curriculum design and choice of pedagogical approaches?

REFERENCES

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches. *Australasian Journal of Educational Technology, 30*(4), 440-454.

Bandura, A. (1997). Self-efficacy and health behaviour. In A. Baum, S. Newman, J. Wienman, R. West, & C. McManus (Eds.), *Cambridge handbook of psychology, health and medicine* (pp. 160-162). Cambridge: Cambridge University Press.

Bates, A.W. (2015). Teaching in a digital age. Guidelines for designing teaching and learning for a digital age. Licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.

Bransford, John D. (Ed); Brown, Ann L. (Ed); Cocking, Rodney R. (Ed) National Research Council Commission on Behavioral & Social Sciences & Education, Committee on Developments in the Science of Learning Washington DC US, Expanded Edition (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC, US: National Academy Press.

Czaplinski, I., Mallet, D., Burrage, P. & Psaltis, S. (2015) Preparing engineering graduates for the knowledge economy through blended delivery of mathematics. In T. Thomas, E. Levin, P. Dawson, K. Fraser & R.

Hadgraft (Eds.), Research and Development in Higher Education: Learning for Life and Work in a Complex World, 38 (pp 107-116). Melbourne, Australia. 6 - 9 July 2015.

Czaplinski, I (2015). Investigating the effectiveness of an ecological approach to learning design in a first year mathematics for engineering unit. Conference Proceedings (pp. 65-76). ASCILITE 2015, 30 November – 3 December, Curtin University, Perth, Australia.

Dawson, S., Joksimović, S., Kovanović, V., Gašević, D. & Siemens, G. (2015*). Recognising learner autonomy: lessons and reflections from a joint x/c MOOC*. In T. Thomas, E. Levin, P. Dawson, K. Fraser & R. Hadgraft (Eds.), Research and Development in Higher Education: Learning for Life and Work in a Complex World, 38 (pp 117-129). Melbourne, Australia. 6 - 9 July 2015.

Greeno, J. G. (1998). The situativity of knowing, learning, and research. *American Psychologist* 53 (1): 5–26.

Griffin, P., & Care, E.(Eds) (2014). Assessment and teaching of 21st Century skills: methods and approach. Springer Netherlands, Dordrecht.

Karpicke, J.D. (2012). Retrieval-based learning: active retrieval promotes meaningful learning. *Current Directions in Psychological Science 21(3), pp. 157-163.*

Johnson, L., Adams Becker, S., Estrada, V., and Freeman, A. (2015). *NMC Horizon Report: 2015 Higher Education Edition*. Austin, Texas: The New Media Consortium.

Kirkwood, A. (2014). Teaching and learning with technology in higher education: blended and distance education needs 'joined-up thinking' rather than technological determinism. *Open Learning: The Journal of Open, Distance and e-Learning,* 29(3), 206-221.

Meyer, A., Rose, D.H., & Gordon, D. (2014) *Universal design for learning: Theory and practice*, Wakefield MA: CAST

McGaw, B. (2013). Developing 21st century competencies through disciplines of knowledge. International Symposium on Education and 21st Century Competencies. Muscat, Sultanate of Oman, 22-14 September 2013, Oman.

Moskal, P., Dziuban, C., & Hartman, J. (2013). Blended learning: A dangerous idea? *Internet and Higher Education,* 18, 15–23.

Porter, W., W., Graham, C., R., Bodily, R., G. & Sandberg, D., S. (2016). A qualitative analysis of institutional drivers and barriers to blended learning adoption in higher education. *Internet and Higher Education,* 28, 17–27.

Powell, W.W., Snellman, K. (2004). The knowledge economy. *Annual Review of Sociology.* 30, 199-220.

Report by the Australian Council of Learned Academies to Prime Minister's Science Engineering and Innovation Council (PMSEIC) (2013). STEM Country Comparisons: Recommendations. Australian Government, Canberra.

Sweller, J., (1988). Cognitive load during problem solving: effects on learning. Cognitive Science, 12, 257-285.