

Use of online video in a first year tertiary mathematics unit

Vaile Dawson and Ian van Loosen

Science and Mathematics Education Centre and Department of Mathematics and Statistics, Curtin University, Australia

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Abstract The exploratory case study reported here used an action learning approach to examine the impact of online video on students studying a first year mathematics unit aimed at non-mathematics majors. After this intervention, the students completed a written questionnaire to determine their views on the impact of online video material on their understanding. Although most students were frequent users of online video only a proportion viewed the online video material. Two thirds of students who viewed the online video found it useful for visualising and understanding the practical applications of exponential function. The findings of this pilot study are encouraging and provide impetus to repeat the intervention, and develop online video material in other difficult areas of mathematics.

Background

Throughout Australian universities, first year mathematics units are studied by students enrolled in a range of disciplines. The teaching of these units, (called ‘service units’), presents significant challenges to staff. Lecturers and tutors are faced with an increasing diversity of student backgrounds (e.g., language, cultural), career aspirations, mathematical ability, interest and preparedness (increasingly on the low side), large student enrolments and reduced face to face time coupled with increased content. The majority of students are in their first year of university and are adjusting to a changed teaching and learning environment compared with secondary school. The pace is fast and students are expected to master a wide range of mathematical concepts and skills, in some cases the equivalent of two years of senior secondary mathematics content, within a 12 week semester. Some students find the mathematics content difficult, boring and irrelevant. The use of information communication technology (ICT) has the potential to improve students’ academic achievement and engagement.

The increasing diversity of students presents challenges to tertiary teachers when teaching mathematical concepts. Not only do students have varied mathematical education and ability, but diverse cultural, social and language backgrounds. Students also bring with them perceptions of the subject of mathematics as well as their own mathematical ability,

known as 'Maths anxiety' (Taylor & Galligan, 2006). Kajander and Lovric (2005) found that students with negative experiences at high school suffered with confidence in tertiary mathematics and as a result achieved poor results. Much research has been undertaken to determine how much the affective domain affects the cognitive domain, especially in maths anxious students, and ways in which this anxiety can be overcome (Kajander & Lovric 2005; Perry, 2004; Taylor & Galligan, 2006). Some universities perform a diagnostic test on incoming students to determine their level of mathematical knowledge and then advise students on the appropriate mathematical course to take (Kajander & Lovric 2005; Taylor & Mander 2002). Some provide support for students in the way of bridging courses, mathematical review manuals and/or technological packages (Kajander & Lovric 2005; Selden 2005; Taylor & Galligan 2006). Whichever way it is provided it is irrefutable that support that caters for a diverse range of needs is necessary for many students studying mathematics.

The student diversity is magnified in large first year mathematical service units where students are studying for a wide range of undergraduate degrees. The challenge facing each mathematics teacher is maintaining the engagement and relevance of the material to a group of students with a variety of career choices and aspirations. Wood and Solomonides (2008) believe that students of mathematics do not always have a clear idea of their professional use of mathematics, which affects their perceived relevance of what they are learning. This affects their engagement and ultimately their understanding. Once again ways need to be found to adapt the mathematics course being taught to cater for students' varied professional uses and thus engagement.

Students live in a technological world with information constantly at their fingertips. They instantly relate to video screens and online technology. The use of familiar tools such as these may be used to highlight relevance, promote engagement and facilitate a deeper understanding of mathematical concepts (Cretchley, Harman, Ellerton & Fogarty, 1999; Taylor & Galligan, 2006). Students in most first year mathematical service units are given at most three hours of lecturing per week, usually on different topics and concepts, followed by a one or two hour tutorial. For some students, this is not enough time to gain a deep understanding of mathematical concepts. By using technology (such as online videos) and presenting mathematical concepts in a familiar and engaging context, deeper understanding could potentially be promoted (Niess & Walker, 2010). Students can also view/use these technological and visual aids at their leisure and as many times as is needed to become familiar with concepts. The use of online video has the potential to improve academic achievement through visualisation and the provision of practical applications of mathematical concepts (Luk, 2005).

Can the use of technology increase students' engagement with mathematics? Despite searching the literature we were not able to find any published peer reviewed studies in tertiary mathematics settings where the use of online video was evaluated. Tertiary mathematical concepts are more difficult and abstract than that which is found in

secondary school and are taught in a hierarchical manner. Students need to fully comprehend the basics before progressing further. In first year service units, it is difficult to teach concepts and maintain relevance among students from a number of different degrees. The use of ICT gives teachers the opportunity to increase relevance and hence engagement by providing examples of the same concept in different contexts. Students' individual attitudes towards mathematics are more difficult to alter, however, if enjoyment and relevance is increased, perhaps students' attitudes to and perceptions of mathematics can improve. The advancement of technology occurs at such a rapid rate that it seems impossible for teachers to keep up. However, its use gives them incredible opportunities in their teaching. The use of technology in mathematics education needs to be embraced.

The eScholar project reported in this chapter was undertaken collaboratively by the authors. The first author, a science education researcher provided input into the research design (method, data collection and analysis). The second author, an early career mathematics academic was the unit coordinator, lecturer and tutor of the mathematics unit. He provided important contextual information and allowed himself and his students to participate in this research.

The aim of this pilot research study was to implement and evaluate the teaching of a difficult abstract mathematical concept (exponential function) in contexts that would be relevant and engaging to diverse students studying a compulsory first year mathematics unit. Online video (e.g., YouTube) was used to demonstrate exponential function in a visual and engaging format. After viewing an online video, students read accompanying text and solved related mathematics problems. The solutions to the mathematics problems were subsequently discussed within tutorials. This research study addressed the following question.

1. What are students' perceptions of the use of online video material on their engagement and understanding?

Approach

The research method is an exploratory case study (Stake, 2005) of students studying a compulsory first year mathematics unit as part of a science degree in the Faculty of Science and Engineering at Curtin University. An action learning approach (Kemmis & McTaggart, 1998), was used to implement and evaluate the use of online video material on students' interest and understanding of a difficult mathematical concept (exponential function). The primary data source was a post-intervention written survey. The University ethics approval was obtained prior to commencement of the study.

Context

Students from over 24 different science courses within the Faculty of Science and Engineering complete the unit, Mathematics 101, within the undergraduate science

degree. The disciplines from which students are drawn include computer science, multidisciplinary science, secondary education, software engineering, mining, chemistry, physics, biology, astronomy, surveying, geophysics, environmental science, extractive metallurgy, geology, information technology, nanotechnology, computer systems and networks, resources and actuarial science. The unit is offered in the Department of Mathematics and Statistics in both Semester 1 and 2, with enrolments typically exceeding 250 per semester. The aim of Mathematics 101 is to develop students' understandings of how mathematical techniques and applications can be used to model real world problems in their science disciplines.

The syllabus covers the following topics:

- Functions and their graphs
- Limits and continuity
- Differentiation and integration
- Transcendental functions
- Vectors
- Matrices
- Systems of linear equations and solution methods
- Eigenvalues and eigenvectors
- Complex numbers.

The curriculum is delivered in a traditional face to face mode through three one hour lectures and a one hour tutorial per week for 12 weeks. A blended learning approach is supported at the university with students having access to the online learning management system, Blackboard. The Blackboard site provides students with access to unit outlines, recorded lectures (ilectures), lecture notes, tutorial exercises, assignments, online quizzes, past exam papers and solutions, announcements and discussions.

Participants

Three randomly selected tutorial groups from Mathematics 101 in semester 1, 2011 comprising 49 students (35 males and 14 females) participated in this pilot study. A total of 22/49 students (13 males and 9 females) completed and returned the questionnaire, producing a response rate of 45%. The students were aged 17 to 24 years with 86% of aged 17 (27%), 18 (32%) or 19 (27%) indicating that most respondents were teenage school leavers. The 22 students, who were all studying a Bachelor of Science, were from at least seven different disciplines including computer science (4 students) multidisciplinary science (3), actuarial science (3), chemistry (3), geophysics (3), physics (2) and environmental science (1). Three students did not state their discipline.

Research Design

Selection of mathematical concept

Based on having taught and coordinated the unit for three years, the lecturer noticed that students experienced difficulties with several mathematical concepts, including exponential function, complex numbers, integration, differentiation and eigenvalues and vectors.

Exponential function was selected as the mathematical concept to be addressed in this study for several reasons. First, many students enrolled in Mathematics 101 characteristically experience difficulty with this concept. This anecdotal observation by the lecturer is also borne out in Jennings' (2009) finding in pre-unit diagnostic testing of Queensland students who had studied senior secondary mathematics. Jennings found that exponential function was one of three least understood concepts along with integrals and product rule. Second, exponential function is applicable to many science courses (e.g., rate of change in physics, population growth in biology), thus establishing its relevance to a multidisciplinary cohort. Third, exponential function is a relatively highly weighted content component in the final examination, making it a content area likely to impact students' overall achievement in the unit. Fourth, exponential function is taught in Week 7, making it a period when most first year students are likely to have transitioned to the university learning environment and more specifically the teaching and learning processes adopted in the unit. Finally, a search for available online resources to enhance student learning produced mostly text based content materials and mathematics problems, which were not particularly engaging for learners. The search also yielded online videos that demonstrated practical applications of exponential function visually, making this a suitable enhancement to the unit.

Selection of online video material

An initial internet search was conducted for online video that would be suitable for students. Nine potential online videos from *YouTube* and *Google video* were identified. The number of videos was reduced to five based on length (less than 10 minutes), context (science or of interest to young people), and content (level of difficulty and accuracy). The contexts of the online video were distance, bacterial growth, compounding exponential growth, use of natural resources and folding paper from *Mythbusters*. Accompanying text and problems were developed by the lecturer / course coordinator. An independent expert (an international student (and mathematics academic at her university) studying a doctorate in mathematics at Curtin university) checked the online video, text and problems (termed online video material) in terms of conceptual difficulty and simplicity of language. This review process resulted in the length of the supporting text being reduced.

Development and implementation of post intervention questionnaire

A post intervention questionnaire was developed to determine students' perceptions of the use of online video material on their motivation and understanding. The

questionnaire included questions about students' gender, age, science discipline, highest level of mathematics studied, attitude to mathematics, and use and perceptions of the online video material. The questionnaire results were coded and analysed using SPSS (Allen & Bennett, 2008). The analysis of each section is described in the results section below. The questionnaire was anonymous and no students' names or student ID numbers were collected.

Intervention

In Week 6 (the week before the lecture on exponential function) the online video material was made available to all enrolled students through Blackboard. Students were informed about the material in the lecture and via announcement on Blackboard. The lecturer facilitated discussion about the online video material during tutorials with the randomly selected groups in Week 8. The solutions to the accompanying problems were also posted on Blackboard. The students were then invited to complete the post intervention questionnaire in their own time. Students who were absent from the tutorial did not participate.

Findings

Diversity in Mathematical Background

One aspect of diversity is reflected in students' mathematics background. The students' highest level of mathematics is summarised in Table 1. Completion of a range of nine different pre-university courses was reflected among respondents indicating their diversity in mathematics background. This finding supports the premise that students studying this first year mathematics unit are diverse in relation to their mathematics background.

Table 1: Highest level of mathematics studied

Mathematics course	Number of students (n=22)
Mathematics: Specialist 3C/3D (WA)	6
Mathematics 3C/3D (WA)	5
Calculus (WA)	3
International Baccalaureate	2
International mathematics equivalent	2
Applicable mathematics (WA)	1
Tertiary maths course	1
Form 5: Additional mathematics (Hong Kong)	1
Mathematics B (Queensland)	1

Students' Attitudes to Mathematics

In addressing students' perceptions of online video we considered that it was important to ascertain students' attitudes to mathematics. We surmised that if they did not like mathematics, they might also not like online video. To determine students' attitudes to mathematics, students responded to four Likert scale items for each of four categories: attitudes to lectures, tutorials, mathematics and academic efficacy. The scales were from the TOMRA (Test of Mathematics-Related Attitude Survey) (Hoang, 2008). Students circled a number from one to five where one was almost never, two was seldom, three was sometimes, four was often and five was almost always. The responses relating to the four statements for each category were aggregated and the mean calculated. Table 2 summarises the mean and standard deviation for each category.

Further to the descriptive statistics, scale reliability was generated for all the four scales of the questionnaire. To determine the degree to which items in the same scale measure the same aspects of attitudes to lectures, attitudes to tutorials, attitudes to mathematics and academic efficacy a measure of internal consistency, the Cronbach alpha reliability coefficient (Cronbach, 1951) was used, as shown in the presentation of data in Table 2. Scale reliability estimates for different scales range from 0.63 to 0.80 suggesting all the scales of the questionnaire were reliable for use (De Vellis, 1991).

Table 2: Students' attitudes to mathematics

Attitudes towards:	Mean	SD	Cronbach alpha
Lectures	3.88	0.53	0.68
Tutorials	3.80	0.71	0.80
Mathematics	3.94	0.65	0.63
Academic efficacy	3.11	0.76	0.71

Overall, students' attitudes towards mathematics lectures and tutorials were positive. Indeed students were positive towards mathematics in general. They were slightly less positive about their own mathematics ability. Although not reported here, these findings are supported by students' written comments on eVALUate (the university's online unit evaluation system). One hundred and twenty students responded to the semester one 2011 eVALUate survey and their comments were unequivocally positive about the quality of their lectures and tutorials in the mathematics unit.

Students' Use and Perception of the Online Video Material

Students were asked to indicate and explain their use of online video for entertainment and university study. Students were then asked specific questions about the online videos on exponential function. Almost half (45%) of the students who responded to the questionnaire stated they use online video every day while a further one third (32%) indicated they use online video at least once a week, for entertainment purposes.

However, most participants (77%) seldom or never used online video to assist their learning of university coursework. Their reasons included that they did not have time to search for or look at suitable online video. For example students commented:

Sometimes I found it is quite hard to find a good video to assist me in coursework because [there] is quite a lot of video[s] on YouTube and sometimes I have no idea which of the videos I should follow because different teachers have different explanations. It just confuses me.

I have found some good websites but lack time to do any extra work.

Nevertheless almost all (21 out of 22) students stated that they understand concepts better if they are presented visually. Students' comments included:

I am a visual learner. More likely to understand something if I see it rather than hear it.

Graphics can sometimes be easier to understand and remember than just plain words.

Students get a better idea of what they are studying rather than just memorising from the book.

Almost half (45%) of the participants stated they viewed all five videos while five (23%) viewed only some of the videos. The students who did not view the videos cited lack of time or already having understood exponential function as reasons. Several students stated that the online videos were too long. Of the 15 students who watched all or some of the videos, 10 (67%) perceived that the online videos helped them better understand exponential function because of visualisation and the use of practical applications. Their comments included:

I was able to understand the concept better as the videos showed real applications to the concept and I find that putting it into practice in an application, I can understand how the concept actually works.

Seeing exponential growth in real life help[ed] me to understand the concept better.

Videos were useful to understand application of exponential functions.

The practical real life examples give us real life data that we can practically count and double check.

Three students stated that the online video material did not help their learning and two students were unsure. These students commented that the videos were too long (the combined length of the online video was 32 minutes) or that they had already understood exponential function from their previous studies or the lectures.

Discussion

This research examined the use of online video material to support learning in a first year mathematics unit for students studying an undergraduate science degree. The unit is compulsory and is aimed at students who have not studied calculus previously. The

online video presented practical applications of exponential function in a visual way. Normally, students only have access to written text and diagrams from the lectures and their textbook. As found by Jennings (2009) and others students studying first year mathematics have a diversity of mathematics backgrounds. In this study the 22 students who responded to the questionnaire had studied nine different pre-university mathematics courses offered in Western Australia, nationally and internationally. The students also were enrolled in seven different science disciplines. Although the majority of students were teenage school leavers, the diversity of student backgrounds and science disciplines presented challenges in finding relevant online video.

The use of online video has the potential to be engaging and to improve students' attitudes towards mathematics (Niess & Walker, 2010). However, we found that those students who responded to the questionnaire seemed to already hold positive attitudes about their mathematics lectures and tutorials and mathematics in general. The means for each scale was close to 4 (with a maximum of 5 possible). Thus, in future interventions, the selection of online video will be primarily based on increasing students' understanding rather than improving students' attitudes.

Almost all students perceived that they found concepts easier to understand if presented visually. This finding is supported by Luk (2005) who argues that visualisation will improve students' understanding of mathematics, in particular, abstract concepts. Two thirds of the students who watched the online video perceived that they understood exponential function better because of visualisation of practical applications. Some of those students who did not watch the online video indicated that they did not have time to watch it. None of the students referred to technology problems (e.g. lack of access to the internet). Several students who did watch the online video stated that they were too long. The five online videos comprised 32 minutes of viewing time. The first video on distance, in particular, was considered too long and boring. This video of nine minutes will be removed in subsequent interventions so that the total length of online video will be 23 minutes.

Conclusion

In this pilot study, students from a range of undergraduate science disciplines and pre-university mathematics backgrounds agreed that the use of online video that visually demonstrates practical application of exponential function assisted them in understanding the concept. The intervention was limited to three tutorial groups taught by the mathematics academic. Thus the sample consisted of the 49 students who attended the tutorial class where the online video material was discussed. Of these 49 students, only 22 completed and returned the written questionnaire. This was partly because the students were given the questionnaire to complete in their own time. In a subsequent intervention, all students enrolled in the mathematics unit will be invited to participate and the online video material will be discussed in all tutorial classes. Students will also be informed about the online video from the first week of semester. Also the students may

be offered a small incentive to increase the response rate. The use of a single data source limits the reliability of the findings. In future interventions, focus group interviews will be conducted with randomly selected students to determine their perceptions of the use of online video material. In this study, only one tutor (the mathematics academic) participated. In subsequent interventions, all tutors (and their students) will be invited to participate).

This study was a pilot study with a modest intervention. The authors are aware that several weaknesses limit the robustness of the findings. These weaknesses are discussed above with suggestions for improvement in subsequent interventions. Nevertheless, these research findings provide impetus for the intervention to be modified and repeated in the mathematics unit in a subsequent semester.

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[eScholar 2011 – Ian Van Loosen – Case Study Video](http://youtu.be/K0sCrdQlwoQ)

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