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## Do short screencasts improve student learning of mathematics?

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*"I really like this form of support. I would be delighted to [...] see any and all topics covered by such screencasts."*

The above comment was made by an MSc student after watching two screencasts on undergraduate calculus. They were produced as part of an MSOR Network funded mini-project to develop and evaluate screencasts on advanced calculus topics. The sentiment expressed was reflected in many other students' comments. This paper reports the outcomes of this project.

### Screencasts

Screencasts are video recordings of activity on a computer screen which can include narrator audio. They can be watched on a computer or on a mobile device with video playback capabilities. The video component is what distinguishes screencasts from audio podcasts. For mathematics learning, when created using tablet technology, screencasts enable the real-time recording of handwritten step-by-step solutions of problems including specialist mathematical notation. One of the strengths of screencasts is that, like live lectures, they *"allow communication through multiple channels: writing, visual aids and speech"* [1]. For this reason, screencasting has been especially popular for recording mathematics lectures [2, 3]. Screencasts may be accessed whenever a student likes, from wherever they are, and can be downloaded for later use offline.

An analysis of student perceptions of the effective use of such recordings has been undertaken by Yoon & Sneddon [4]. Some universities have produced screencasts exclusively for their students. In addition others, including some mathematics support centres, have also produced videos and screencasts which are available to all, for example, Mathcentre [5] and MathsCasts [6]. The Khan Academy [7] provides an extensive range of screencasts supporting mainly school mathematics.

### The project

Many tertiary mathematics students struggle with the algebra and calculus skills required for advanced study. Students often have difficulty with the techniques that are assumed prerequisite knowledge of a particular module of study rather than the content of the module *per se*. This is particularly the case for part-time and distance students, for whom the prerequisite topics may have been studied some years previously.

The aim of the project was to investigate and evaluate the value and effectiveness of short screencasts as educational support resources for such students.

More than twenty screencasts were produced by mathematicians using tablet PCs and the screen recording software Camtasia Studio [8]. All screencasts, but also details of the techniques used to produce the screencasts are available on the project website [9]. A variety of presentation approaches were used by different individuals, but in all cases an attempt was made to minimise production time required. Anecdotal reports from the presenters indicate that production always took longer than anticipated and many recorded several versions before a satisfactory outcome was achieved. Although making the occasional mistake in a lecture is not too serious and indeed can, if picked up, be beneficial to students, the odd slip of tongue or pen in a screencast is something presenters wanted to avoid, not least because once recorded a screencast is available indefinitely. At least for a novice presenter, a short 5-10 minute screencast could take half a day to produce. We believe this time should reduce significantly with experience.

### Evaluating the screencasts

The effectiveness of screencasts was evaluated in four different ways:

1. Evaluation of the performance of MSc students on a selection of mathematical questions, both before and after watching screencasts.
2. Evaluation of how the above study affected the examination results of one group of students.
3. Evaluation of feedback received from these students.
4. Evaluation of feedback received on screencasts made available publically.

These evaluations are described below. Further details can be found in [10].

### Evaluating MSc student performance

Two specific screencasts (covering applications of L'Hopital's rule and the solution of second order ordinary differential equations) were made available to two separate cohorts of Open University Mathematics MSc students who were studying a module on the Calculus of Variations. These screencasts were sandwiched between two quizzes. Students answered the first quiz then, having received no feedback, watched the screencasts, and then answered the second quiz. Feedback and worked solutions to the questions were provided after completion of the second quiz. Each quiz contained a minority of questions that covered techniques related to the two screencasts, the remaining acting as a control. Achievement of the students on the two quizzes was compared. It should be noted that, for ethical reasons, students self-selected to participate in this study and that the quizzes, screencasts and provision of feedback were voluntary activities. A screenshot of one of these screencasts is shown in Fig 1.

### L'Hospital's rule

If  $\lim_{x \rightarrow a} f(x) = \lim_{x \rightarrow a} g(x) = 0$  or  $\lim_{x \rightarrow a} f(x) = \lim_{x \rightarrow a} g(x) = \pm\infty$  then

$$\lim_{x \rightarrow a} \frac{f(x)}{g(x)} = \lim_{x \rightarrow a} \frac{f'(x)}{g'(x)}.$$

1. Evaluate  $\lim_{x \rightarrow \infty} x^2 e^{-x}$

$$\lim_{x \rightarrow \infty} x^2 e^{-x} = \lim_{x \rightarrow \infty} \frac{x^2}{e^x}$$

Fig 1 – A frame from one of the two screencasts that were sandwiched between quizzes

The first cohort of MSc students was offered the quizzes at a time they were revising for their examinations. Although the quizzes were intended to be comparable, the results showed that this was not the case. As a result we modified the quiz questions and procedure for the second cohort of students. Half the group attempted one quiz first and the second half attempted the other quiz first. Using a logistic regression model to fit the results of this second investigation showed there was overwhelming evidence ( $p=0.001$ ) that the screencasts had improved performance, although perhaps this is not surprising given the short time between watching the screencasts and taking the test. The model also confirmed the questions on each of the two quizzes were of similar difficulty.

### Effect on examination scores

About a month after the first cohort of students had access to the screencasts and quizzes, they sat an examination in which one part of a question was directly relevant to the screencasts. Examination of the data showed that the situation was complicated by the fact that 3 students who watched the screencasts chose not to do the related question in the exam. Omitting these students, the results show that screencasts improved the students' score on the relevant question part with a marginally significant p-value of 0.051.

### Evaluating MSc student feedback

Quantitative and qualitative feedback was collected from the students taking part in the above study. At the end of the second quiz, students were given optional multiple-choice questions about their confidence before watching the screencasts, and whether they thought the screencasts helped them better understand how to answer the quiz questions. Responses were similar for both groups. Out of the 140 students who responded 38% said they were confident in answering the questions on the screencast topics before watching the screencasts, and 47% said they were not. Close to three quarters claimed the screencasts helped them better understand how to answer the quiz questions. If we cross-tabulate responses to these two

Cross-tabulated results of evaluation questions.		Were you confident in answering the questions on the screencast topics before watching the screencasts?				
		Yes	No	I did not watch the screencasts	Not answered	Total
Did the screencasts help you to better understand how to answer the quiz questions?	Yes	43	59	0	0	102
	No	9	5	0	0	14
	I did not watch the screencasts	0	0	5	0	5
	Not answered	1	2	0	16	19
	Total	53	66	5	16	140

Table 1 – Cross-tabulated results, comparing confidence in topics covered by the screencasts and their role to improve understanding quiz questions

questions, a clear picture emerges: the screencasts helped both the confident and the not confident students. This means students saw a direct value for their learning in watching the screencasts. Students who felt confident before watching the screencasts were less likely to find the screencasts helpful to increase understanding (Table 1).

Students were also given the opportunity to provide open comments on the screencasts. Clear themes emerged from all MSc students who left general comments. Screencast explanations are easier to understand than text books *"They were an improvement on just picking up a technique from the notes"*, more engaging, and *"short and to the point"*. A student commented that *"sometimes it can be very dry reading maths from a book and sometimes just hearing someone actually talk through it with you helps you get it clear in your head"*.

However, there was some reflection on the one-way delivery nature of screencasts, with some students pointing out that although the explanations were clear and easy to follow, they would prefer to be able to ask questions when needed.

Students appreciated the expert walking them through problem solving of *"a few specially selected examples"*. The screencasts *"demonstrated the concepts, but most usefully showed how to apply the technique, and present the calculations in an efficient and readable way"*. The soft information which is often lost in printed material, i.e. the thinking about how to approach a problem, was included in the screencasts and a student said that they liked it when the presenter used *"phrases 'like the first thing I notice about this expression is ....'"*, as it helped them to know what to look for. Being able to watch an alternative approach to solving a problem was also mentioned as one of the strengths of the screencasts, as was the reinforcement of methods.

A student commented on the opportunity to *"pick and choose' according to your strengths"*. There was overwhelmingly positive feedback on the screencasts, and a clear call for more screencasts to be recorded, *"for each of the important techniques on the course"*. The screencasts in combination with the quizzes also provided important feedback for the students on their understanding of prerequisite material, and of the material covered in the

course. Students commented that the revision undermined their confidence initially, as they thought they knew more. This prompted them to study areas they may not have looked at to catch up on missing skills and understanding.

### Evaluating feedback through the project website

About twenty screencasts were produced as part of this project. All of these (including the two used in the MSc quizzes) were made available on an open website [9] for anyone to access. Over 2300 views of screencasts were made from January to July 2011. The web site also contained a survey of visitors' opinions. The feedback received was predominantly extremely positive and encouraging.

It was interesting to note that although the majority of those responding to the survey only watched one screencast, a significant number reported they watched several as shown in Fig 2.

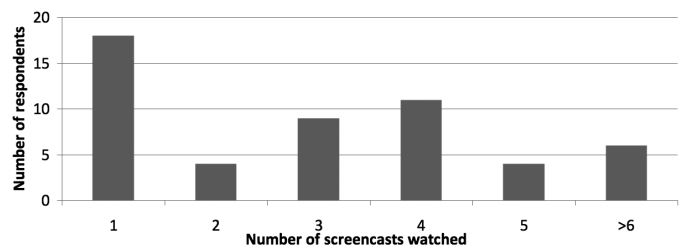


Fig 2 – The reported number of screencasts watched by visitors to the website.

In total, 54 volunteers responded to the questions. Out of these, 69% identified as tertiary students (30% undergraduate, 39% postgraduate), while 17% were teaching mathematics at university. A vast majority found the screencasts useful (94%) and thought the length was about right (85%), with no-one selecting file size as an issue. Most respondents thought that a student's understanding of mathematical concepts can be improved by watching screencasts (94%).

One of the questions this project sought to answer was whether there is a difference between handwritten and completely typeset explanations in a screencast, where typed information is presented one line or one expression at a time. Both types have been produced during the project to allow for comparison. Of the 47 respondents who answered these questions, 24 showed a preference for handwritten

explanations, and 18 were undecided. Only 5 respondents preferred the typeset explanations, mainly because the visual component would be clearer than reading the sometimes “appalling” handwriting of a mathematician. Comments were of the nature of “handwriting imparts methodology of solving” better, and “the handwritten ones give you a sense of ‘doing maths’”, but also that a “mixture of typed and handwritten” was “more ‘natural’”.

Table 2 provides an overview of the comments made on the differences between typeset and handwritten screencasts. Many comments in favour of handwritten screencasts relate to feeling, more engagement and spontaneity.

Reasons for typeset screencasts	Reasons for handwritten screencasts
• readability	• faster to produce
• faster to read	• immediacy, more spontaneous
• pages are organised better	• more engaging
• easier to follow	• more user-friendly feel • helps develop an “intuitive” explanation • perception of human interaction
	• more personal, warmer

Table 2 – An overview of visitors’ thoughts on handwritten v typeset screencasts

Many students appreciated the additional information imparted in the screencasts, over and above the main text of the solution. For example, “picking up little tips” from a mathematician, where the “narrator gives their initial impression, which helps “getting started on a problem by seeing what is relevant is a key skill that experience brings”. One respondent wrote that the screencasts “brought life to the problem being dealt with”, and that they help to “understand the thinking of the presenter”.

And finally, the audio quality was highlighted as an issue by some, although this may relate to the viewer’s hardware or software settings.

## Conclusion

This project has shown that students like short, focused mathematical screencasts recorded by an expert and moreover screencasts can be a powerful tool to support student learning.

Students feel that the screencasts help their understanding of mathematical techniques, and they would like more. Visitors watching the collection of screencasts on the project website were also extremely supportive of this approach to teaching. If they showed a preference, it was for handwritten rather than typeset explanations.

In summary, this project has been a very enjoyable and rewarding experience, partly through the fun in actually producing the screencasts, through the collaboration across

two universities and four locations, and partly because of the very positive evaluations and encouragement received from the students and from visitors to the website.

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