# THE USE OF VIDEO AND MATHSCASTS TO ENGAGE AND SUPPORT THE LEARNER AND PROMOTE MATHEMATICAL THINKING

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**Abstract**: This paper discusses how mathscasts and videos have been used to support the learner and promote mathematical thinking in a module on Operational Research. The mathscasts were produced using Camtasia and a graphics tablet. Evidence presented suggests that these have helped students improve their understanding of the material leading to improved results for this module.

**Keywords**: Mathscasts, screencasts, video, operational research, mathematical thinking

## 1. Introduction

Videos teaching mathematics have been around for many decades. For example there are many recordings of televised Open University lectures, which are still of interest: some were reshown recently at a meeting of the British Society of the History of Mathematics (BSHM, 2014). Today there is a vast array of such videos online. MIT (2014) have made a range of videos of mathematics lectures available to all and there are also several free massive open online courses (MOOCs) covering numerous mathematical topics from providers such as Coursera (2014) and Udacity (2014). Such videos are generally 'receptive' in that they are viewed by a passive audience (Klay and Ketskin, 2012), whereas there are fewer examples of 'problem-based' videos. More recently the problem-based MOOC, Citizen Maths (Citizen Maths, 2014) encouraged learners to experiment writing programs in Scratch as well as completing other exercises in order to improve their basic numeracy and mathematical understanding.

One of the pioneers of the 'problem-based' mathscast, Tim Fahlberg, describes his motivation for producing these as being that students can see and hear the thinking, listen when they want and understand the process and not just the result (Fahlberg et al., 2007). Other research focuses on student feedback, showing the effectiveness of the medium by providing many examples of positive student comments. Students say they are: enjoyable to watch (Winterbottom 2007), inspiring (Hill & Nelson, 2011), help them to learn (Morris and Chikwa, 2014) and enable them to have control over their learning (Meehan, 2014) (Loch, et al., 2012). Some researchers have shown a link between these media and improvements in study habits (McCombs & Liu, 2007) as well as an increase in attainment and skills acquired (Alpay & Gulati, 2010).

The literature makes very little mention of any drawbacks of using short, 5-10 minute, mathscasts and screencasts to supplement the usual lectures. However it is worth mentioning that they do take time to create and it is important to identify appropriate software and hardware on which to create them. The technology is discussed in more detail in section 4 and problems to do with creating them are

discussed in section 5. Where the screencasts are much longer and are used in place of the lecture as in the flipped classroom approach (Douche, 2012) then there are criticisms that students feel isolated from other learners, they miss interaction with staff and they feel the files take a long time to watch in order to find the information they require (Winterbottom, 2007). Further discussion on the flipped approach is beyond the remit of this paper.

Many people use the terms mathscasts and screencasts interchangeably. Fahlberg (2007), one of the first to use the term "mathscast", defines it as "*a screen recording of writing plus voice and/or text explaining a mathematical concept, or solving a problem that has been produced to Flash movie and is distributed via CD or Internet*" and Loch et al. (2012) describe the term "mathscast" as "*narrated recordings of handwritten communication providing mathematical explanations".* Winterbottom (2007) says that screencasts are "*effectively, a digital recording of your computer screen, and can include an audio commentary".* This paper takes the view that most mathscasts are also screencasts. However, mathscasts can also be produced by setting up a video camera over a table to record pen and paper workings as in the production of the videos for the Citizen Maths MOOC (Citizen Maths, 2014). This is shown in figure 1.


Figure 1 Creating handwritten mathscasts for Citizen Maths (2014)

## 2. Background

Operational Research is a core module for all second year students on any undergraduate mathematics programme delivered by the Department of Mathematical Sciences at the University of Greenwich. As well as the technical theory, it includes the second year personal development material which is focussed on employment outcomes. Many mathematics graduates from Greenwich progress into careers that fall within the area of Operational Research and several undertake OR focussed placements during their studies. For example, in 2014/15 three final year students undertook placements at the Observatory and Cutty Sark Museums in Greenwich investigating real-life queueing problems to help the Royal Museums Greenwich improve their visitors' experience. One of these students was subsequently offered a job with SIMUL8, a leading provider of simulation software for operational research, whose software is used in the Greenwich module. Thus understanding SIMUL8 and the related OR techniques is not only important for module marks but also has a direct effect on a student's employment opportunities.

## 3. Motivation

In 2012 it was noticed that second year maths students at the University of Greenwich were struggling to appreciate how to apply some of the algorithms in the operational research module (Bradshaw, 2013). Students thought that they understood the work but, when they attempted tutorial questions which differed slightly from the lecture examples, they realised they lacked full understanding. Rather

than voicing this, students asked for and eventually received written tutorial solutions, which they then often regurgitated, out of context, in attempting to answer different exam and coursework questions.

In particular students struggled as they usually thought the first lecture on simulation straightforward and then postponed attempting tutorial questions because they assumed the work was easy. When they finally came to attempt the exercises after a couple of weeks of further lectures they found that the material had increased in complexity and they struggled to relate the lecture examples to the tutorial questions without additional explanation. Alongside this, simulation is also taught using both SIMUL8 and Microsoft Excel. Whist students seemed to be able to follow instructions for the Excel simulation workshop, they struggled with the one on SIMUL8.

After a slightly disappointing set of exam results, tutors looked for ways to address these issues. The conclusion was that students were looking for ready-made recipes for solving problems as a substitute for the thought required in this subject. A conference presentation on the flipped classroom by Andrew Douche (Douche, 2012), where the use of video and screencasts were discussed in the context of teaching Biology to secondary school aged pupils, provided inspiration for using mathscasts as a vehicle for encouraging students to think, rather than blindly attempt to apply an answer to a previous problem.

**4. Methodology**

Several software packages and media for recording mathscasts were investigated. Because Camtasia (TechSmith, 2015) was already available, it was decided to use this along with a graphics tablet. The software that came with the tablet did not seem to work well so SmoothDraw (SmoothDraw, 2015) was used instead which improved the quality of the drawing. Other technologies such as the use of smartpens are discussed in Rowlett (2012). Since the technology is fast-changing, other methods are now being investigated such as the use of Vittle on an iPad and a tablet PC such as Microsoft Surface Pro.

The flipped classroom approach was not used. Lectures and tutorials (example classes) continued as before but rather than providing students with a written solution to a tutorial question, as in previous years, students were provided with a mathscast in MP4 format showing the lecturer going through a question in detail explaining why they were doing it in a particular way. The mathscast shows the pen and paper calculation as well as recording the lecturer's voice. The recordings varied in detail, so the one coving the first tutorial question (simulating the direction three cars turn at a road junction) (figure 2) is longer as it contains more information about the thinking process and the different ways of addressing the problem than those for subsequent questions. The screenshot does not fully capture the information as most of the detail is provided by the spoken explanation.

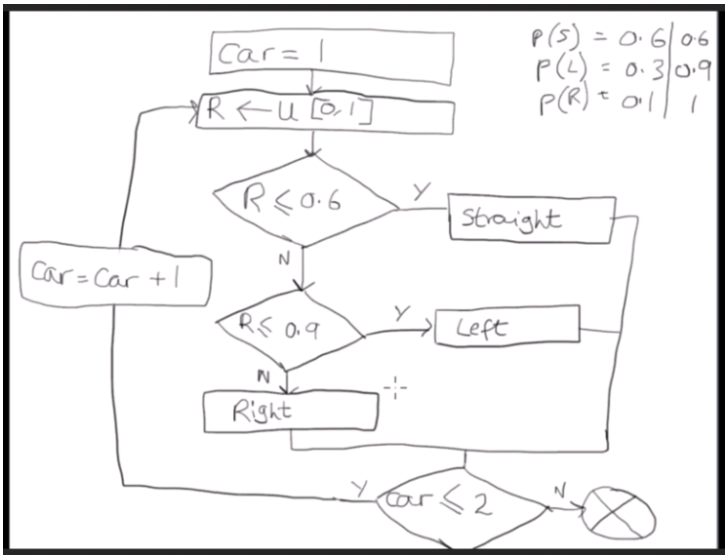


Figure 2 Screenshot showing the flowchart of a simulation described in the first mathscast

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As well as mathscasts depicting the actual hand calculation that took place, some screencasts were produced to show the students how to use SIMUL8 software. In this case students were shown how to create a simulation from scratch, partly in order to understand the principles but also to see details such as how to start a simulation, how to drag icons on to the screen etc. Figure 3 is taken from a screencast demonstrating how to set up a probability-based distribution, which was previously something that students found hard to comprehend just from instructions on paper or using the help facility on the software.

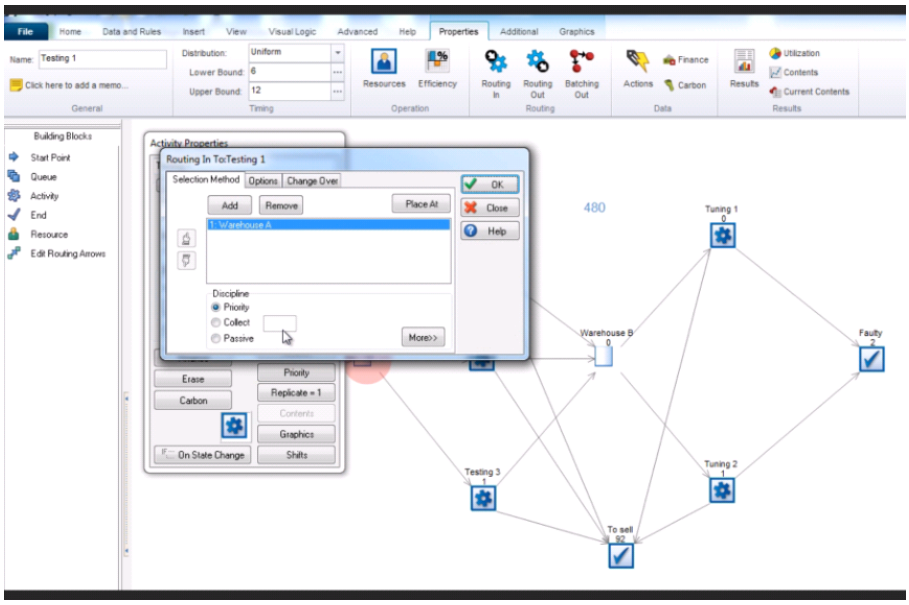


Figure 3 Demonstrating how to set up a probability distribution in SIMUL8

### *4.1.Videos*

As well as teaching students the mathematical concepts of operational research, the module includes an assessment requiring students to give a group presentation. Those working in operational research frequently say that as well as understanding and being able to use numerical techniques, OR graduates need other skills such as communication and presentation skills and other employee competencies (Bradshaw, 2014). Consequently maths students are required to deliver presentations several times during their studies and also, frequently, as part of the process of applying for graduate jobs. It is always hard to find an appropriate time in the lectures to talk about presentation skills, so it was decided to make a video which students could access through the virtual learning environment.

The initial idea was to film a lecturer giving a presentation about how to give better presentations in a TED-type (Technology, Entertainment and Design) format meaning that it would be scripted, rehearsed and professionally visualised, but for various reasons, including lack of access to specialist equipment, this was not possible. In the end the video was produced by a learning technologist using a variety of camera positions (Downes, 2014). Sometimes a talking head was presented alongside a PowerPoint slide (figure 4), while some sequences featured a close-up of the presenter with the slide not being visible (figure 5). In this particular shot (figure 5), students can fully appreciate the problem of the presenter turning their back to the audience: something that is best demonstrated to students by example. Other sequences used a long shot when it was important to capture the whole presenter. For example figure 6 shows how the use of role-play, in this case a light-hearted re-enactment of the death of Galois, can be used to enhance audience engagement.

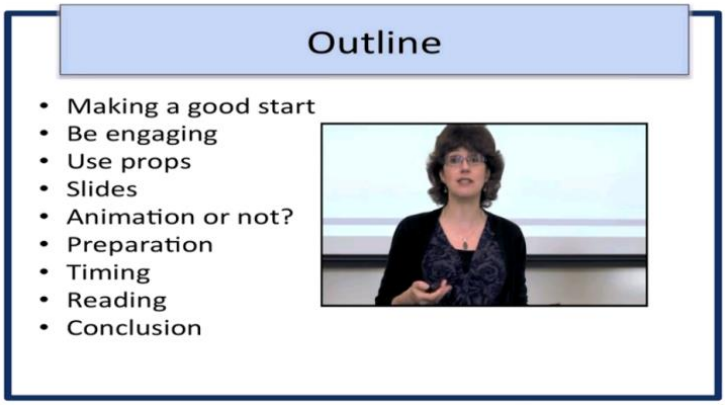


Figure 4 Close up of presentation also showing relevant PowerPoint slide

Figure 5 Close up demonstrating how not to do a presentation

Figure 6 Long distance shot demonstrating the use of role-play

Students commented favourably on this video, and appreciated the slightly humourous approach. There was some evidence that those who had watched it had taken the content on board for their group presentations in January, when there were fewer groups then in previous years who had used unreadable colour schemes or who had tried to cram too much detail into the slides.

Videos were also created to provide students with good and bad examples to competency based interview questions (Downes, 2014b, 2014c). As well as helping the students applying for palcements to prepare for interviews they also enabled staff to explain in a humerous way how to approach certain aspects of the curriculum such as group work. The poor answer in example 2 (Downes, 2014b) depicts the interviewee dismissing her group and saying that as a good team leader she did all the

work herslf whereas the better answer (Downes, 2014c) provides a method for encouraging weaker students to participate.

## 5. Problems

The first year that mathscasts were used in this module an unanticipated issue was that some students were seen writing down the solution from the final screen without having watched the whole video or listened to the explanation. They had seemed to miss the point that the explanation was the key part of the mathscast. In figure 7 the most important part of the recording is the explanation as to why this algorithm works, and skipping straight to the answer misses this entirely.

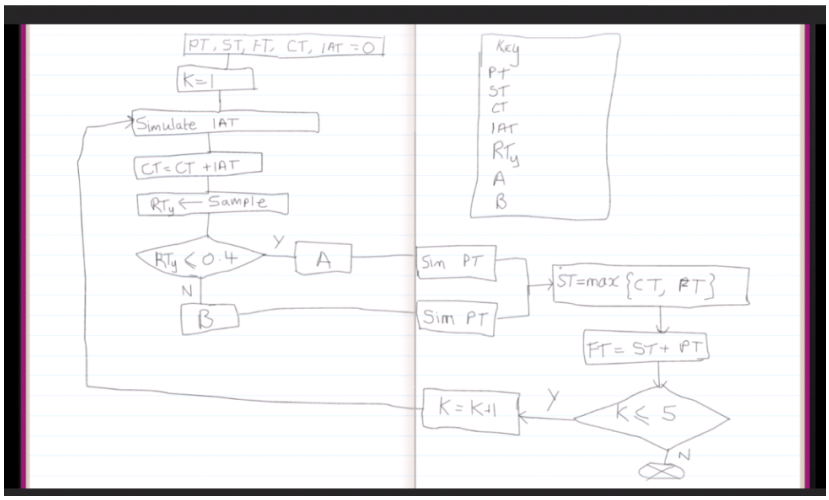


Figure 7 Screenshot showing final solution – the key was discussed but not reproduced in full

Another concern for tutors was whether it is necessary to record new examples every year, since the time taken to produce mathscasts and screencasts is significant. In the mathscast example above, the lecturer referred to a question that a student had asked in class the previous week, making the recording more relevant to that cohort but perhaps mitigating against its future use. While it is unlikely that students will be unduly concerned by an inconsistency like this, producing new videos each year would enable staff to answer new questions. One option might be to reuse the old mathscasts for the tutorial questions while adding an additional screencast covering this cohort's new questions. This would mean that each year only one new file would need to be recorded. However, arguably this additional recording might appear less attractive to students if it did not relate to a specific tutorial question.

## 6. Results

Data gathered in the first year of providing these mathscasts shows that they were all accessed a large number of times by students. Exact figures for individual viewers are unavailable. The most downloaded mp4 (one directly relating to coursework) was downloaded 231 times and was the most popular mp4 file in the University's School of Computing and Mathematical Sciences. This year the comparable file was accessed 457 times by 103 out of 129 students.

For technical reasons, in the most recent running of the module (2014/15), it was only possible to gather data on the MP4 files relating to the term 1 coursework rather than all files for all tutorial solutions. However, it was also possible to find out which students had accessed these files and look at this in conjunction with student attendance and coursework marks. It was found that 90% of those getting a mark above 70 on the simulation question had accessed the appropriate file, whereas only 66% of those with a mark above 70% on the SIMUL8 question had accessed the relevant MP4 file. The difference between these is interesting. The first question is mainly paper-based, so students are arguably more likely to complete this at home on their own, whereas the SIMUL8 question (and tutorial work) is generally completed in the computer labs on campus. It is possible that, when working on

tutorial questions, students who had seen the MP4 file were helping to teach other students who had not seen it, or indeed that students were watching the MP4 together.

Of those not getting a first class mark for their coursework only 36% had seen the relevant MP4 file. Obviously there are plenty of other factors that contribute to student success. Some of these are also measurable (such as attendance) whereas others are less easy to quantify (such as motivation and perseverance).

In the first year of using these mathscasts, marks for both coursework and exam improved whereas the standard of the work set (as moderated by internal and external examiners) and the general ability of the students (as measured by their achievement in other modules) is thought to have remained the same. Results suggested that the mathscasts had contributed to the students' improved performance by assisting their understanding.

### *6.1 Feedback*

Student feedback has been very positive. In the first year students said that they wished other staff would make similar mathscasts as they found them so useful. Students appreciated that they could pause the recording, rewind and play again to make sure that they had indeed understood the method. This has resulted in fewer emails from students about tutorial work and coursework, since the students listened to the appropriate mathscast before discussing problems with a member of staff. Students have reported that the mathscasts have enabled them to understand the work without the need for further help which has contributed to their independent learning development.

Student comments this year included:

"Helped develop my understanding."
"Having someone talk me through things when I am stuck is always really useful."
"Incredibly useful, more lecturers should do these."
"It is easier hearing you go through the tutorials again."

## 8. Further work

As a result of the success of these maths and screencasts further screencasts were created for other modules in 2013/14. These helped maths students understand what is expected in academic writing and how to reflect on their placement experiences by showing previous final year project reports and logbooks and talking through some of this work. Previously many students had shown weakness in these essential skills and had frequently asked staff for further explanation without being able to apply successfully what they had been told. Staff were unprepared for the enormous difference that these short screencasts appeared to have made to students' understanding of what was expected from them. There was a marked improvement in student outcomes in terms of both performance and marks. Although these screencasts were not directly promoting mathematical thinking, they certainly contributed to students' understanding of how to present and reflect upon their work, improving the quality of their final year placement reports, and enhancing their employment prospects.

Further work could be carried out to investigate what makes an effective mathscast in terms of content and duration as there is very little in the literature on either of these.

## 9. Conclusions

The evidence from this work and the work of others (Klay and Ketskin, 2012) suggests that short mathscasts in which tutors show how to address a mathematical problem is extremely beneficial for increasing students' understanding and attainment. Once they have become used to benefiting from this method of instruction, students have found other screencasts on academic writing and other general skills to be of benefit as well.

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