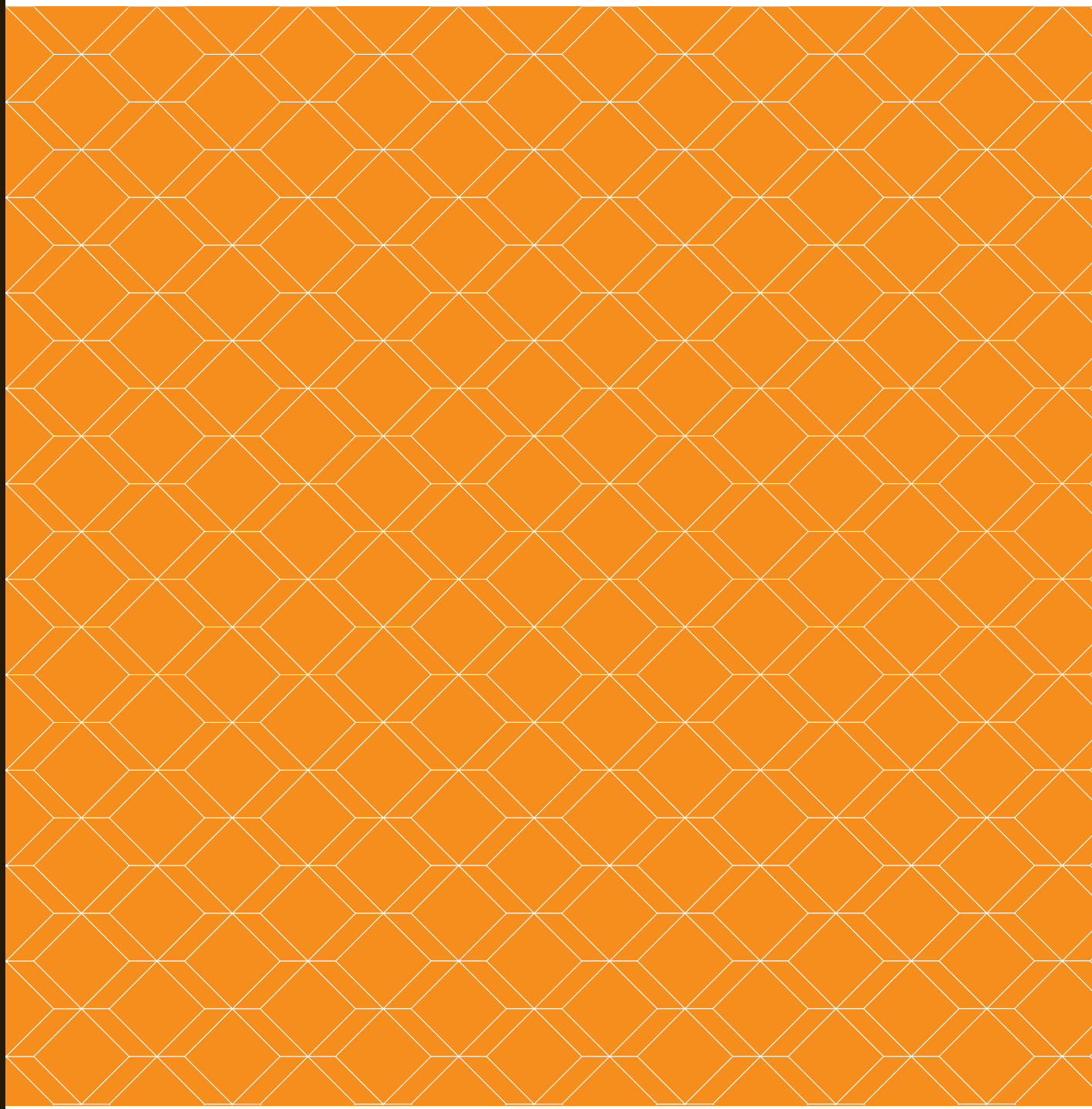
Mathematical Sciences HE Curriculum Innovation Project

Media Enhanced Teaching and Learning: case studies and evidence of effective use



Edited by Peter Rowlett

The Higher Education Academy Maths, Stats & OR Network

National HE STEM Programme

Media Enhanced Teaching and Learning: case studies and evidence of effective use

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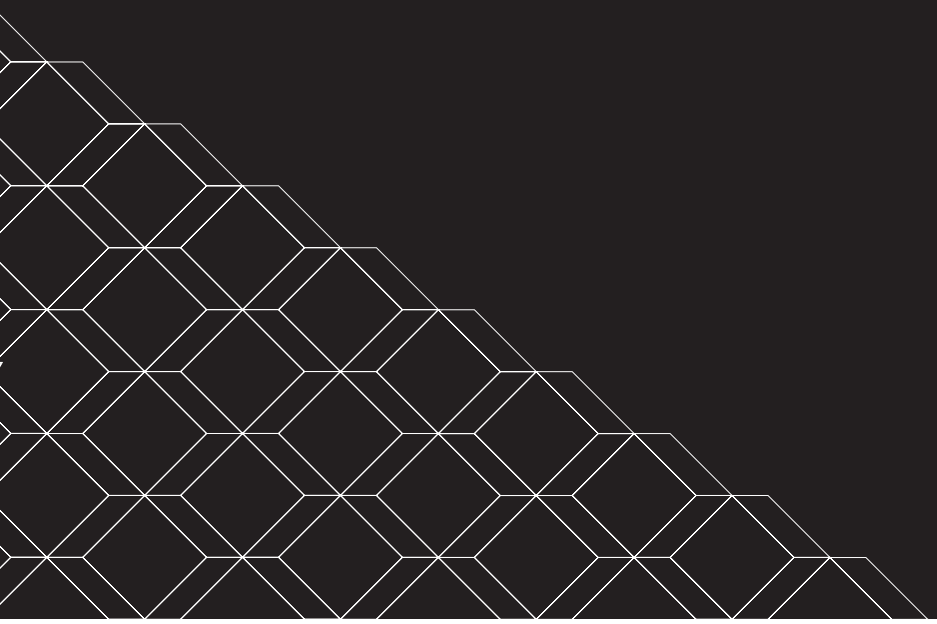
MSOR Network
July 2012



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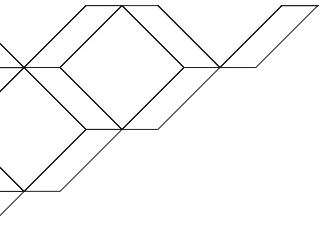


Contents

Introduction 5

Overview of METAL Project 9

Recording lectures 13

Recording mathematics lectures at Nottingham 13

Lecture capture in statistics at Newcastle 15

Producing supplementary teaching and learning material 19

'Pencasting' supplementary material in mathematics at Ulster 19

Smartpens in engineering mathematics at Loughborough 20

MathsCasts – enhancing the resource base for mathematics support centres 22

Recordings of students for assessment and feedback 25

Recording teacher trainees' lessons for enhanced feedback at Nottingham Trent 25

Engaging learners through video making at Nottingham 27

Student created video in geography at Nottingham 29

Making use of recordings 31

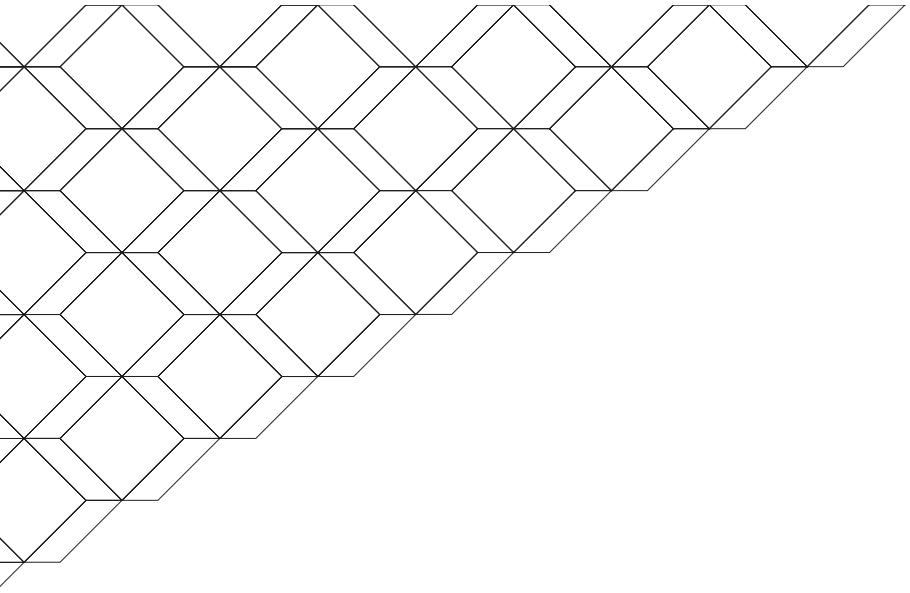
Use of smartpens by disabled students 31

Lecture capture technology – technically possible, but can it be used effectively? 32

Learning from video and making lectures interactive 36

The Internet Librarian and Curator of Mathematics Videos 40

A Framework for the Evaluation of Videos Tutorials in Mathematics 41



Introduction

> *The final question, again an insight into how the practice [of] mathematics relates to that of the visual artist, was about the 'extraordinary mark-making' mathematicians do on blackboards, and whether this can survive in the digital age. Atiyah's answer agreed on the importance of the hand in doing maths, and that communication of mathematics involves body movement, props, blackboards - the garnish that makes something palatable. Villani, noting that blackboards are now not always available in lecture rooms, felt that the blackboard is unrivalled: much more than with a computer, one can improvise, erase, keep some material and lose other bits; it forces you not to overflow, and when you're frustrated, you can bang your head on it!*
>
> Tony Mann, reporting on a discussion session with Fields Medallists Cédric Villani and Sir Michael Atiyah at Tate Modern in June 2012 [1].

Not that this booklet can definitively answer such a nebulous question, but it is certainly a pertinent area of discussion. The practice of doing mathematics and explaining this to others is necessarily very much embedded on pen and paper, or board; nevertheless, some have started to explore the potential of technology for augmenting this process. In a world of computers, tablet PC screens may provide the opportunity for mathematicians to leapfrog the innovation of PowerPoint slides completely. Writing mathematics using technology presents the opportunity to make recordings, and really it is that prospect that this booklet seeks to explore. Taking examples from mathematics and other disciplines, the practice of recording in and out of the lecture theatre is explored. Questions are asked about the use of recordings and whether these are effective for learning. Overall, I hope that this booklet gives an interesting account of this emerging area of practice.

This booklet has its origins in a workshop, 'Using IT when teaching mathematics classes', chaired by Joel Feinstein at the University of Nottingham, which took place on 19th November 2010 and was supported by the Maths, Stats and OR (MSOR) Network as part of the National HE STEM Programme. This was based on Joel's experience over several years of teaching from a tablet PC and recording lectures. In 2011, the University of Nottingham funded a cross-disciplinary project, entitled 'Media Enhanced Teaching and Learning' (METAL), to investigate such technologies. Support was provided to this project by the MSOR Network as part of the National HE STEM Programme for a series of four workshops with the same title to take place during the 2011/12 academic year.

This booklet is, then, a consequence of the METAL project. It contains contributions from Nottingham and elsewhere on the theme, about half of which were presented at METAL workshops. First, an overview is given of the METAL project, in the form of a transcript of a session given by Joel Feinstein at the fourth and final METAL workshop. The remainder of the content is arranged in sections.

Recording lectures: Two different experiences of recording lectures. At Nottingham Joel Feinstein takes a tablet PC with recording equipment into his mathematics lectures and records using this portable kit. At Newcastle, Phil Ansell uses a built-in system in lecture rooms to record his statistics lectures. Both describe their approach and students' responses.

Producing supplementary teaching and learning material: Three experiences in creating supplementary content. Mark McCartney at University of Ulster uses a smartpen to record solutions and commentary on mathematics assignment problems and to provide summaries of material covered in lectures. He discusses the strengths and weaknesses of the smartpen. Paul Hernandez-Martinez at Loughborough University uses one smartpen to record mathematics exercise solutions and another as a substitute for the whiteboard to present examples in

class. He explains his rationale and his experience – somewhat mixed – with the technology. Finally, the MathsCasts project is a collaboration between maths support centres at Swinburne University of Technology (Australia), Loughborough University and University of Limerick (Ireland) to create recordings of mathematical explanations of the topics and concepts with which students typically struggle. A report presents findings on student use of the MathsCasts.

Recordings of students for assessment and feedback: Rob Kearsley Bullen (Nottingham Trent University) uses a smartpen to record his notes during lessons given by mathematics trainee teachers and so is able to offer enhanced feedback. Michèle Clarke and Claire Chambers (University of Nottingham) describe how geography students produce videos for assessment and the skills they gain by doing so. Claire Chambers also describes the use of media in capturing the experience of geography field work.

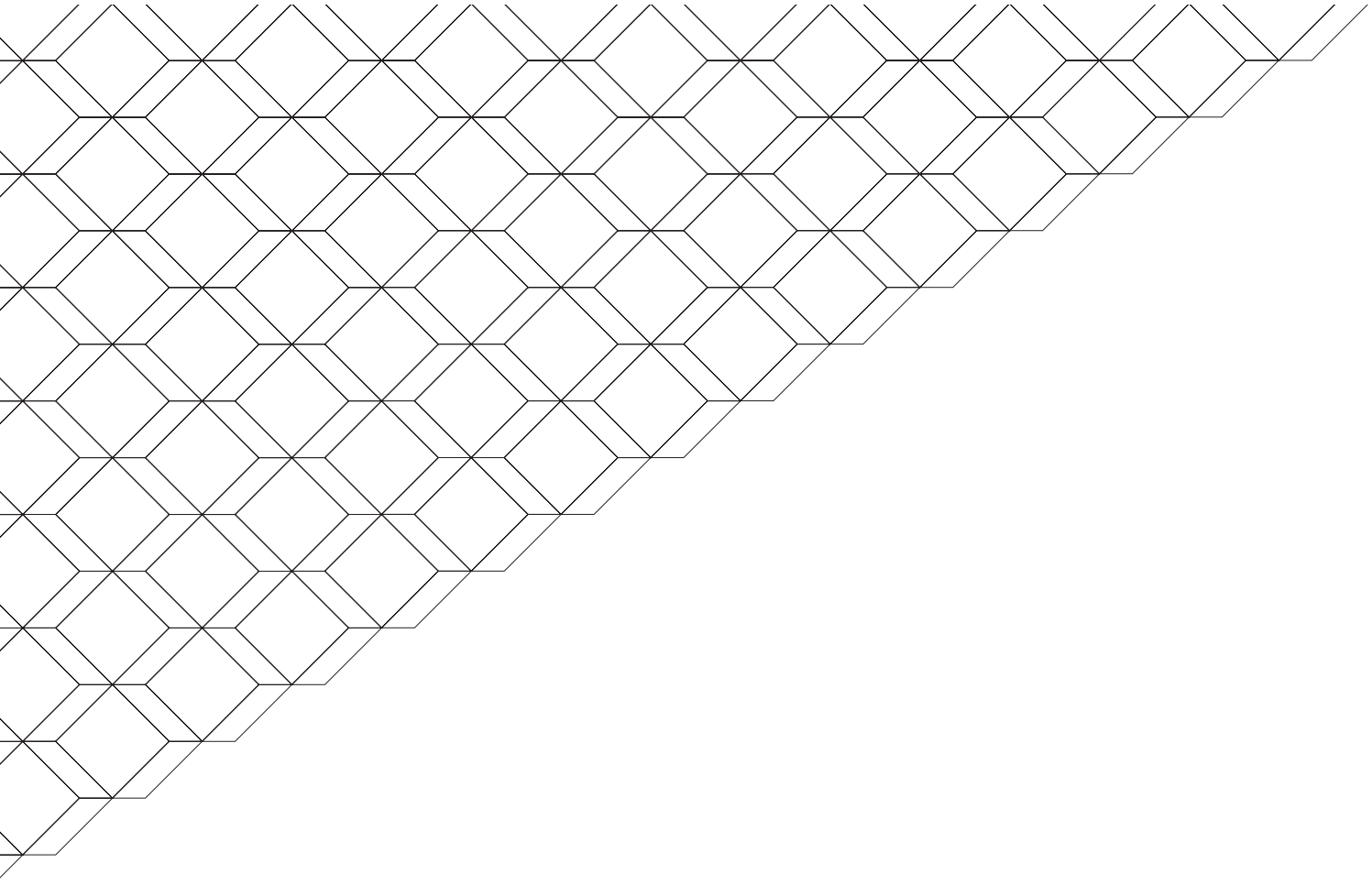
Making use of recordings: A final section considers the use of recordings; how students use recordings and the effect these have on student learning. This includes two reports from another project supported by MSOR Network as part of the National HE STEM Programme, 'The Internet Librarian and Curator of Mathematics Videos' by Trevor Hawkes, Coventry University. This project attempted to develop a system for curating the vast quantity of unsorted videos of mixed quality available on the Internet. One report gives the implementation of the project and the other gives a framework for evaluation of video tutorials in mathematics, considering mathematical, pedagogical and technical quality.

In keeping with the topic, recordings were made at the METAL workshops. These can be viewed via the METAL workshops page at explainingmaths.wordpress.com.

Peter Rowlett, July 2012.

References

1. Mann, T., 2012. Atiyah and Villani at Tate Modern - the value of blackboards. *Tony's Maths Blog*. Available via: http://tonysmaths.blogspot.co.uk/2012/06/atiyah-and-villani-at-tate-modern-value.html [last accessed June 2012].



Overview of METAL project

Joel Feinstein, School of Mathematical Sciences, University of Nottingham

Modified transcript of a talk given at the Media Enhanced Teaching and Learning Dissemination Meeting, University of Nottingham, 24 April 2012.

One of the things we've had from these four workshops is just so many different examples of what people are doing. And whether we have any final decisions about what best practice is, or what we should be doing and what we really shouldn't be doing, I'm not sure, but what we certainly have done is we've seen an awful lot of different types of things that people have been doing and perhaps that people could do.

So what have we seen? We've seen use of media in the class and we've seen use of media to produce supporting materials for the students. In the class we've seen the general use of Information Technology (IT). Obviously whenever you're going to present a class and you're not going to use chalk and talk you're probably using a computer or an IT system in some way, and there's so many different modes available. So now we've seen PowerPoint slides, we've seen tablet PCs where you can take pre-prepared PDF slides, annotate them by writing actually on your tablet and that can be one way to present. We've seen various kinds of digital paper.

We've seen all sorts of different ways to present using IT as alternatives to whiteboards and blackboards with the gains and losses that you get. We've had mention and examples of all the different ways you can actually use IT to demonstrate things in the class so that you can bring your big bang universe into the class, or whatever you want to do, in a way that you perhaps couldn't quite so readily do using a blackboard or a whiteboard.

We've heard about distance learning live. What do I mean by that? Well, distance learning has been going on for a long time and the Open University of course have been producing these television programmes for years and you can learn that way but what about interactive tutorials and teaching environments? Well we've seen examples. We've seen the Elluminate [now Blackboard Collaborate] virtual teaching room with a shared whiteboard and audio connection that has been used in Mathematical Sciences. We've heard, from Geography, about the group meetings online to help support the digital MRes in Contaminated Land Management. So this is a way to make distance learning a two-way use of IT media and a chance for those students to properly participate.

We've seen general use of IT to encourage interaction. We've seen the clickers, the voting systems, all the different things you can do using IT to make a standard class interactive. Of course, there are plenty of ways to make classes interactive with no IT at all but there are ways you can incorporate IT to help make the classes interactive.

What about the supporting materials? Whether or not these are a good idea, we've got lecture notes and annotated slides. That's something I do an awful lot of and the question of whether you should make the annotated slides available to the students immediately after the class, after a time delay or never is something for discussion. It's certainly something the students regard as helpful supporting materials and they certainly are very pleased to get them, or at least say they are.

Then you can record audio or you can record video and make these recordings available to the students online. We've seen plenty of examples of that. And, of course, you can also record all of these additional things like one of my colleagues who has just started recording commentaries on student performances. You might run through solutions as a little video and make those available. We've had all sorts of other things like tutorial materials and time lapse

photography. We've heard so many different variations on the kinds of material that you can make available to the students this way and how they can be used.

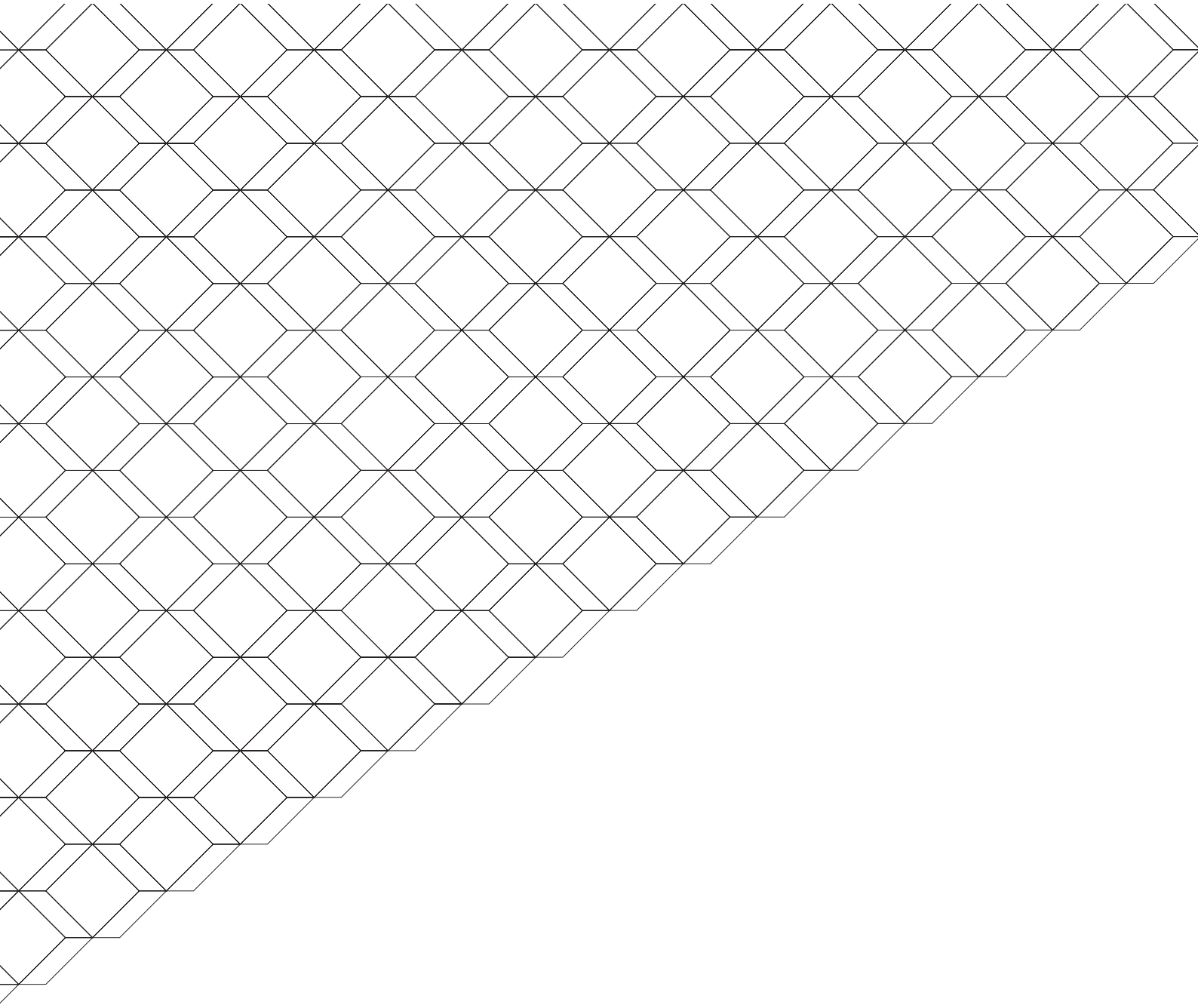
Then, rather than direct videos, there are various interactive learning resources. We've heard about very popular and highly used interactive resources online that students can access to really get their hands on things, well without being able to get their hands on them physically.

We've heard about full sets of resources for distance learning. We've got the interactive version, but you can also make your complete course available and that can be packaged up and made available for distance learning by whatever means you like.

There are materials produced by the students. We've heard about students on field trips recording videos and architecture students producing videos which are used in their courses. And, of course, much more.

There are issues to consider as well. Anything new, students are enthusiastic about. Well, maybe that's an exaggeration but certainly students seem to be very enthusiastic when you provide more materials. They always say 'give us more', 'make more available', 'we're really grateful for everything you give us', and 'here are all the ways these resources help us.' But there are some issues that we have had mixed experiences with, and there are always things you have to think about. We've considered what happens when you've moved away from using the blackboard and the whiteboard to all these ways of using IT, what you might have lost and what effect this has on student learning.

We've seen some very interesting approaches and considered various issues relating the technology to student learning and the student experience. I hope the METAL project represents a body of work taking first steps in this emerging area that will build momentum and carry on in the future. I've certainly learned a lot to inform my own practice and I'm sure attendees at the workshops have too.



Recording lectures

Recording mathematics lectures at Nottingham

Joel Feinstein, School of Mathematical Sciences, University of Nottingham
Peter Rowlett, Maths, Stats and OR Network

This article first appeared in MSOR Connections 11(3), pp. 37-38.

Experience has shown that one of the most successful ways to deliver mathematics lectures is by working through handwritten notes and examples. I (in this article, 'I' refers to Joel Feinstein) am interested in ways that technology can enhance this process. Tablet PCs offer a modern approach to chalk and talk that can replicate most of the best features of writing on a board while allowing improved delivery, such as being able to annotate existing notes and insert graphics such as circles and lines into diagrams. Using a tablet PC opens up new opportunities, such as integrating software into lectures and recording onscreen content as video with synchronised sound for later viewing and distribution.

Since 2006-7, I have used a tablet PC and a data projector to display slides which I annotate during classes. In 2007-8, I also made audio recordings (podcasts) of all of my classes. For more details concerning my early use of a tablet PC and audio recordings (podcasts), see [1].

Since 2009-10 I have been recording screencasts of my classes (movies of everything that is displayed on the screen during my classes, with synchronized sound). Along with other resources, I make the annotated slides and recordings from classes available to the students from the module web pages as soon as possible after each class. Classes which have been recorded in previous years are not recorded again, but the earlier recordings are made available to the students. For more details concerning my implementation of using a tablet PC to produce screencasts, see [2].

Many of the resulting screencasts are suitable for publication as open educational resources. I am making resources available directly through my blog and/or through several of the University of Nottingham's channels [3].

Feedback from students is extremely positive. Many of the positive features identified in student feedback are as in [1]. However, the screencasts appear to be even more popular than the audio recordings were. Selected specific feedback:

- Students find it very helpful to have access to the annotated slides and the recordings shortly after each class. In particular, if they suspect that there may be a mistake in their written notes, they can immediately check the annotated slides online in order to avoid wasting time.
- Students who miss classes, for example through illness, strongly appreciate the opportunity to have access to the annotated slides and the recordings at times convenient to themselves. They find this far superior to having only a copy of the notes.
- Students appreciate having the opportunity to revisit portions of the classes where they feel that they may have missed some useful spoken explanation. This is especially helpful for students who are not native English speakers.
- Students find large and clear writing helpful. This makes using the tablet particularly effective in rooms with large data projection screens. This has benefits for students with dyslexia.

The following issues are worth considering, however.

- A data projector can only display one screen at a time. If necessary you can scroll back through the preceding material, or display the slides at a smaller scale. Even so, the amount of material visible at one time is far less than there would be on a good set of blackboards/whiteboards.

- The microphone generally only picks up the voice of the teacher, and not the students' responses and questions. It is best to repeat what the students say both for the sake of the recording, and also for other students.
- While many students appreciate and take advantage of the materials available in order to improve their understanding, other students may stop attending classes, and may fall behind. As a result, some students may end up doing worse than they would have done if less material had been made available. One way to address this problem may be to have appropriate class tests or assessed coursework to discourage students from falling too far behind.

If you are prepared to invest the effort required these methods of teaching are highly rewarding. Your students will strongly appreciate the provision, and you will be able to produce high-quality learning materials which can be made available to a wider audience.

At the University of Nottingham, the popularity and success of my use of technology in teaching mathematics inspired several other members of staff in the School of Mathematical Sciences to use tablet PC's in their own teaching and to record screencasts. Now a group of colleagues in a number of disciplines have begun using Camtasia to record video materials to support their teaching. The University of Nottingham Media Enhanced Teaching and Learning (METAL) project, which Claire Chambers and I lead, aims to build and support the growing community of staff involved in creating audio visual teaching material by distributing 100 Camtasia licenses and running staff development workshops on this technology to disseminate ideas concerning good practice and to discuss methodologies. Recordings of sessions from the METAL workshops are available via my blog [4].

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[1] Feinstein, J.F., 2009. Using a tablet PC and audio podcasts in the teaching of undergraduate mathematics modules. *In*: K. Exley (ed.) and R. Dennick (ed.), 2009. *Giving a Lecture: From Presenting to Teaching*, 2nd edition, pp. 172-175. Oxon: Routledge.

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[3] Nottingham Educational Resources. *Explaining mathematics blog*. Available via: http://explainingmaths.wordpress.com/university-of-nottingham-videos/

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Lecture capture in statistics at Newcastle

Phil Ansell, School of Mathematics and Statistics, Newcastle University

Background

The event capture system at Newcastle University – known locally as ReCap [1] – is now installed in 60 venues across the campus. Since the system was introduced in January 2008, over 9,500 recordings have been made receiving over 480,000 viewings. The system captures audio and anything that is displayed on the data projector; there is no talking head. The session is booked using an online form and the lecturer receives via email a link that can be posted on a VLE or website.

Method used

When I was invited to be a part of the newly created University ReCap Education Steering Group in late 2007 I was sceptical of the benefits of lecture capture and concerned (as many still are) about how it would affect student learning, my lecturing style and attendance levels. However, as I was teaching the second half of a 20 credit Stage 1 lecture course during the next semester in a venue enabled with ReCap, I decided to put my prejudices to one side and experiment with the technology.

Although the majority of my lecture materials are delivered through LaTeX/Beamer (PDF) slides I also use whiteboards to produce some diagrams and asides. As this would not be captured I initially experimented using the visualiser as an alternative. In my opinion, this would not have been an acceptable replacement for large amounts of whiteboard work, but was perfectly acceptable for my purposes. I also experimented with Papershow [2] which enabled the data projector to be used like a whiteboard.

Although ReCap would allow the recordings to be streamed and/or downloaded, I decided that I would only allow recordings to be streamed and I made the recordings available as soon as I received the link.

Although a detailed attendance record wasn't kept attendance levels were monitored and students gave feedback on the module through an online questionnaire at the end of the module.

Evidence of success

As I had taught this course previously, it was clear the recording of lectures had relatively little effect on the attendance levels. Attendance levels seemed to be more related to the number of other timetabled lectures on a given day and the time of the lecture.

The questionnaire responses received were extremely positive. Students found the recordings an extremely useful additional resource. The comments suggested that students were using the recordings:

- for revision purposes;
- to revisit difficult concepts;
- to assist with assignments;
- to catch up on missed lectures.

Overall, I viewed the experiment a success and decided to continue, where possible, to record my lectures and make them available to students taking my modules.

Discussion

Since my first experiment with ReCap in 2008, all of my timetabled lectures have been recorded. This includes Stage 1 and Stage 2 probability and statistics modules and a Stage 2 service course for the School of Psychology. As well as additional comments in line with those given above, further student feedback has included comments relating to dyslexia, language issues and the ability to keep up to date when heavy snow prevented travel to the university in December 2010! Attendance levels continue to be unaffected.

In addition to recording of lectures, the ability to produce short recordings through 'personal capture' has opened up the opportunity for additional resources to be created to enhance the

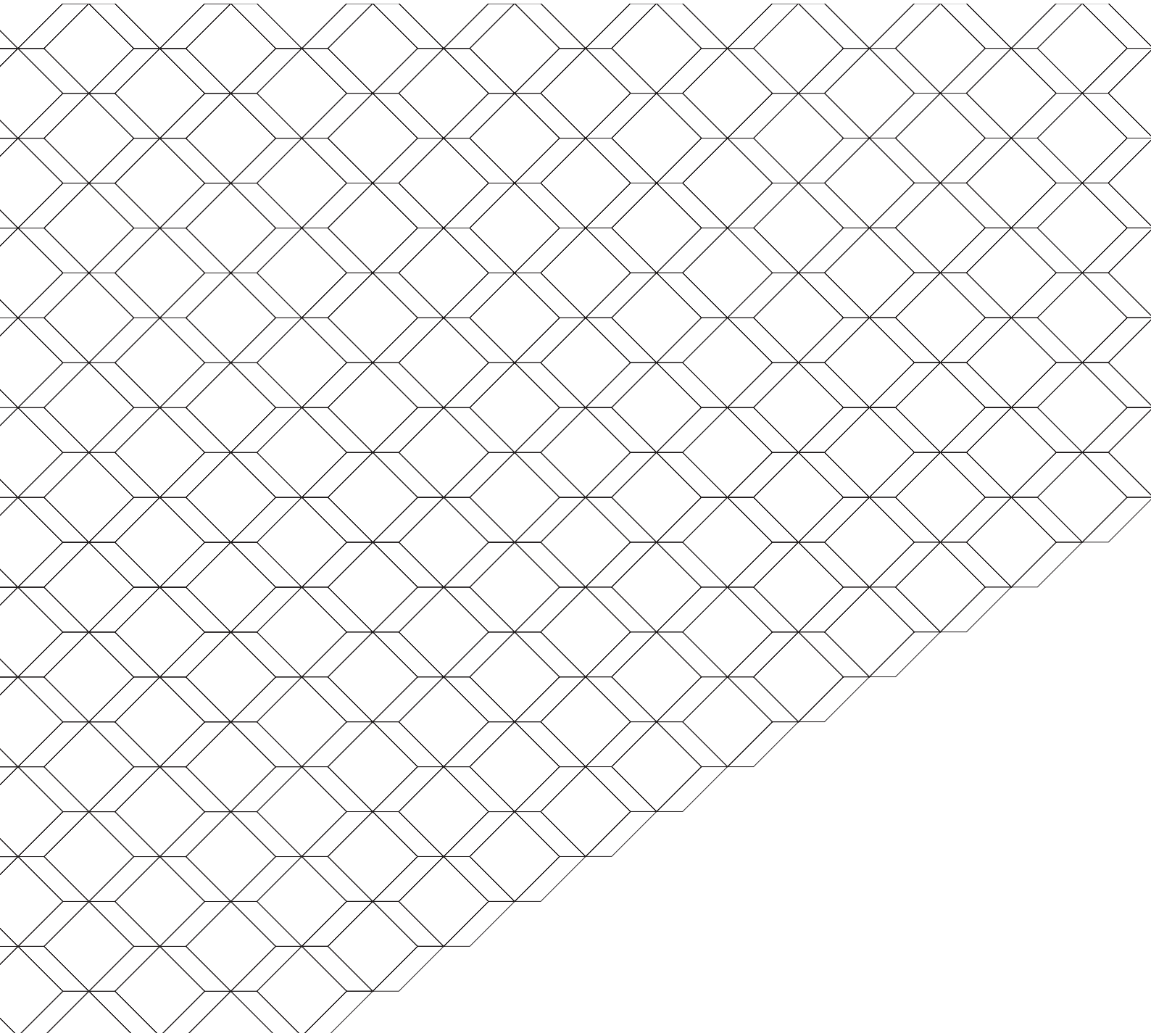
student experience. Examples include using short clips in statistics practical classes instead of paper-based methods. Other colleagues have produced 'pre-lectures' and provide feedback through short recordings.

Next steps

I continue to believe that the recording of lectures provides students with an extremely useful resource to enhance their learning experience. I will continue to record lectures and in my role as Chair of the University ReCap Education Steering Group try to address some of the other issues, e.g. copyright, that might prevent academic colleagues from engaging with this useful technology.

References

1. *ReCap – Lecture Capture System*. Available via teaching.ncl.ac.uk/recap [last accessed July 2012].
2. *Papershow*. Available via: www.papershow.com [last accessed July 2012].



Producing supplementary learning and teaching material

‘Pencasting’ supplementary material in mathematics at Ulster

Mark McCartney, School of Computing and Mathematics, University of Ulster

Background

Smartpens are a relatively new technology produced by the company Livescribe, with pens ranging in cost from approximately £70-£180 (with cost depending on the pen’s size of memory). In essence what the pen does is very simple: it records what you *write* and what you *say* and then allows you to replay the material on your computer or (the audio) from the pen itself. You can upload the material to the Livescribe website and make it available to others, with the viewer of the file being able to watch the material being written and hear the audio commentary by the writer. It is this last feature which is particularly useful for teaching mathematics.

In my own teaching I have used the smartpen in two ways: to provide solutions and commentary to assignment problems and to provide summaries of material covered in lectures. Initial feedback from students has been positive, with 50% of 26 respondents to a class questionnaire stating they made use of the pencasts, and all who made use of them finding them either ‘useful’ or ‘very useful’.

Broadly, the technology has a number of strengths and weaknesses.

Strengths

The technology is very simple to use – taking perhaps 30 minutes maximum to learn the ropes.

It is well suited to communicating mathematics electronically. The teacher can draw diagrams, sketch curves and talk the viewer through a solution as if they were sitting beside him or her in a tutorial.

In a pencast which, say, gives the solution to multiple tutorial problems the student can simply ‘click’ at the point on the page where the question they are interested in is located and the recording will start from that point.

It is highly portable, in that all is needed is the pen and paper. In particular this means that the technology could be used in a maths support environment – with a student then being given a link to an audio visual copy of the help they have been given.

Weaknesses

The pen requires special paper – which can either be bought in notebook format, or can be downloaded and printed off.

Unlike, say software recording on a tablet PC, where a user can write over the top of an existing document or figure, a smartpen will only record what it writes – thus you cannot use a smartpen to annotate another document.

The smartpen does not produce files in a common format (e.g. mp4) which would allow easy transfer. Instead, files are uploaded to the Livescribe site and users are given the link to view a stream of this.

Although recordings can be paused, they cannot be edited; thus if a significant mistake is made the whole recording needs to be redone.

Overall

My overall view of this technology is very positive. It is easy to use and gives a straightforward means of capturing both audio and autograph, allowing the teacher to quickly generate online learning resources.

Smartpens in engineering mathematics at Loughborough

Paul Hernandez-Martinez, Mathematics Education Centre, Loughborough University

Last semester, I began using smartpens in my teaching of mathematics to undergraduate engineers. I used two types of smartpens: the Livescribe pen [1] and the Papershow pen [2]. I used the Livescribe pen to record solutions to selected tutorial exercises (usually the 'hard' ones) that were later uploaded into the module's Virtual Learning (VL) space. I used the Papershow pen in my lectures as a substitute of the whiteboard to solve example exercises.

My motivation for using the Livescribe pen was that having the voice of someone explaining an exercise can make a real difference to understanding it. As a tutor in my university's mathematics support centre I have encountered many cases of students who cannot understand why certain steps were taken to go from one line to the next in the written solution to an exercise. The combination of written and oral explanations can certainly add to the quality of feedback that students get when trying to solve some exercises. For some students this could mean the difference between progressing and giving up.

My rationale for using the Papershow pen was twofold. Firstly, I could face my students while solving exercises, meaning I could see their expressions of understanding or confusion and either move on or slow down and explain in more basic steps accordingly. Secondly, I could alternate more easily between the computer (PowerPoint to present concepts) and solving example exercises. This meant that I didn't have to pull up and down the screen to use the whiteboard, which in one of my classrooms is a very slow and time consuming process.

I have to say that I enjoyed the use of these smartpens, but I had some troubles with the Papershow pen, which I describe next.

By week 3 or 4, the pen began to develop some glitches. Some letters were not correctly displayed, even when rewritten; something that in mathematics is critical (you don't want to mistake an x for a y, for example). By week 6 or 7, I received feedback from the department that a couple of students did not like the pen. Further to this, I sought direct feedback from my students in form of a questionnaire, including a question on the Papershow pen. From 17 answers that I got back (from a group of 35 registered students), 5 students were negative about the use of the Papershow pen, 4 students considered it positive and 8 were unsure about its use. Some of their comments were:

"I think is a waste of time. The whiteboard is simple and easier to read."

"I hate the electronic pen, it just makes things overly complicated. Just use OHP or whiteboard."

"More often an inconvenience than a help."

"Good idea, however it does not always work properly making text difficult to read. So there are some issues that need to be sorted."

"I think it is an excellent resource when it works, but sometimes it is not always clear."

"It's a good idea but temperamental and slows the class a little."

Further to this, in week 8 the pen suddenly stopped working during a lecture and I had to reset the laptop, wasting valuable time. I don't know if these glitches and malfunctions are due to the pen itself, its Bluetooth connection, the software or my laptop (a netbook), but by week 9 I stopped using it and went back to the whiteboard.

In relation to the use of the Livescribe pen for worked solutions, only 3 students gave feedback, which could mean that they did not have an issue with it (neither positive or negative). The few that commented on it had a positive attitude. Some of their comments were:

"The 'pencasts' that get uploaded onto LEARN [the VL environment] are useful to follow problems through after class."

"Good use of electronic aid. Allows for clearer explanations of concepts and for me works well."

"Very useful, allows an easy to view progression of the solution to a problem."

After this experience, I believe that smartpens can be a good addition to my teaching. I will certainly be using the Livescribe pen in more ways, maybe even to record summaries of my lectures to put on the VL space. Students seem to appreciate this, although some research should be done to establish how much this is really facilitating students' mathematical learning. With regard to the Papershow pen, I would be willing to try it again next year (if an attempt can be made to rectify the glitches), because I consider the benefits greater than the shortcomings. I hope that readers are able to imagine other uses of these basic technologies and how these can bring some benefits to their students.

References

1. *Livescribe*. Available via: www.livescribe.com [last accessed July 2012].
2. *Papershow*. Available via: www.papershow.com [last accessed July 2012].

MathsCasts – enhancing the resource base for mathematics support centres

Birgit Loch, Mathematics, Swinburne University of Technology, Australia
Tony Croft, Mathematics Education Centre, Loughborough University
Olivia Gill, Mathematics Learning Centre, University of Limerick, Ireland

Mathematics support centres can be found in many universities in the UK, in Ireland and in Australia as well as in other parts of the world. In these countries they are now part of the landscape of higher education – providing, as they do, individualised help to the many students who embark upon higher education courses and find that they are mathematically underprepared for the demands of those courses. Provision of mathematics support is widely recognised as a positive response to a deep underlying problem.

Widening of participation and budget cuts are strong drivers to motivate the investigation of educational technologies to benefit students seeking help in mathematics support centres. European universities face financial challenges as a result of the global financial crisis and budget cuts. In England and Ireland in particular there is increased uncertainty as a result of sweeping funding changes introduced for 2012/13. In Australia, the uncapping of university places from 2012 is expected to lead to an influx of students with lower mathematical backgrounds. The need to offer high-quality, flexible help to more students in this financially-constrained environment has led to the establishment of a collaborative research project based in three support centres.

The three centres at Swinburne University of Technology in Melbourne, Australia, the University of Limerick in Ireland, and Loughborough University in the UK have formed this research collaboration to produce and promote 'MathsCasts'. MathsCasts are short (typically 5 minutes) narrated recordings of handwritten communication on a computer screen, recorded by a tutor using tablet technology. They contain mathematical explanations of the topics and concepts that students visiting the three support centres struggle with. Many cover just one example in a lot of detail. Before publication, each MathsCast is peer-reviewed to ensure correctness and quality. MathsCasts provide students with the flexibility to receive mathematical explanations whenever and wherever they like.

For the benefit of students outside the three contributing universities, MathsCasts are released as open educational resources with a creative commons licence via the website www.mathscasts.org and also via iTunes U. This means that they may be used for teaching purposes, shown in class, added to study material, or linked to free of charge. In the first six months of 2012 the number of downloads of MathsCasts on iTunes U have doubled as MathsCasts were mentioned as an emerging technology in the Higher Education Horizon Report 2012 ([1], p. 16). At the time of writing, 270 MathsCasts have been produced; 130 are published online. Production is ongoing.

The research aspect of the project seeks to answer the questions: *Will students make use of MathsCasts to support their learning?; What are the perceived benefits of accessing MathsCasts?; and, How do MathsCasts impact on students' mathematics education?*

This investigation is at an early stage, however feedback received at the three universities so far is very positive. Students comments included:

- *"very useful", "clearly thought out", "It is like having a teacher on demand"* (Loughborough University)*;*
- *"good way to prepare for the lecture", "[they] break down [the] reasoning behind maths", "explain […] the reason for using a particular formula or rule"* (University of Limerick)*; and,*
- *"I can see step-by-step solutions", "vital to my style of learning", "Mathscasts are the most powerful tools"* (Swinburne University)*.*

Some of the recurring themes are that students appreciate that MathsCasts give clear explanations of concepts, allow them to learn at their own pace, reinforce what was covered in class, and provide different stimulation. Many students were asking for more MathsCasts; for example to cover higher level material for future semesters. We have evidence that some

groups of learners – e.g. mature students returning to learning, students with learning difficulties and students who have problems with accessing the more traditional support mechanisms – can benefit particularly from this mode of support.

Will students make use of MathsCasts to support their learning? The answer is "yes"! However, we have learnt from the feedback that it is not sufficient to make MathsCasts available; it is vitial to actively promotion and provide guidance via a pre-selection of relevance to particular groups of students. It would seem that students' primary routes to the MathsCasts should be through the links from the specific module pages on the VLE (Virtual Learning Environment). Given this, work needs to be done to explore the best ways in which those who work in support centres can liaise with academic staff in departments to raise awareness of relevant MathsCasts.

What are the perceived benefits of accessing MathsCasts? Preparation, consolidation, revision, explanations, improved understanding and reasoning are all given as reasons why students choose to use them.

What impact do MathsCasts have on students' mathematics education? Do MathsCasts enhance student understanding of key concepts? What affective benefits do they promote? These are questions the team is continuing to explore.

The authors invite readers of this case study to visit www.mathscasts.org to view some of the MathsCasts and complete the on-line survey.

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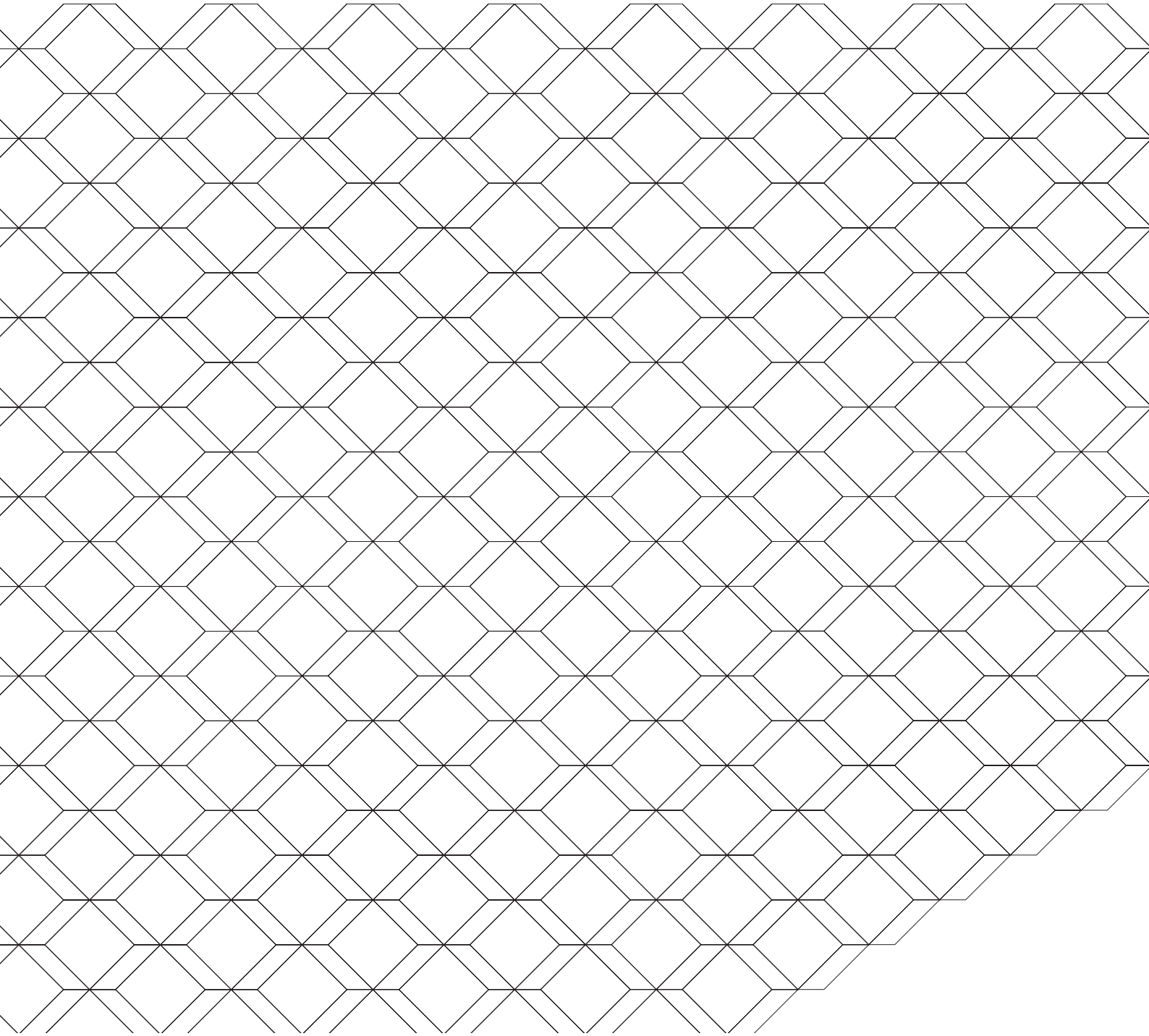


Recordings of students for assessment and feedback

Recording teacher trainees' lessons for enhanced feedback at Nottingham Trent
Rob Kearsley Bullen, School of Education, Nottingham Trent University

The technology

I was introduced to the Livescribe Echo smartpen in late 2010. Numerous products are available that either take digital notes (i.e. record in digital form what has been written on a tablet or a piece of paper) or audio record while you write. The Livescribe system does both of these things, with the significant difference that the two types of capture are linked via timestamping.

Hence, once a page has been written, tapping on any part of it will immediately cause the pen to replay the audio from that point. Once a page has been transferred to computer via the proprietary desktop application, it can be exported as a 'PDF pencast', which is basically a PDF with additional macro functionality in the form of a built-in player tool. Again, clicking on any part of the page plays back the relevant audio.

Seeing the pen demonstrated at a meeting of the School's Blended and Electronic Learning and Teaching group induced one of those rare revelatory moments when a vista of new possibilities is instantly glimpsed. I detail how I implemented some of these below.

Applications in the School of Education

As a teacher educator, I had toyed with the idea of audio-recording lessons given by trainees on school placement as a means of providing them with a record of events that they could review and reflect upon. However, it was also obvious to me that the interactive process of debriefing the trainee immediately after the lesson could be enhanced by having the capability of replaying parts of the lesson there and then.

The practice has met with the general approval of trainees who have been recorded. I quote here some of their feedback:

> *"Listening to the recordings afforded a different perspective on the lessons and allowed for some self-evaluation difficult to secure when so busy performing a multitude of tasks within the lesson."*
>
> *"It was good to be able hear what I sound like when I teach and the mannerisms I use with the pupils."*
>
> *"Listening back I could hear when I was enjoying the lesson and when I was getting cross, I could hear how I was dealing with low level disruption and learn from it."*

The pen is completely unobtrusive in use and thus goes unnoticed by pupils. Of course, this does raise some ethical issues, and these are addressed by obtaining the signature of a senior member of school staff on a recording consent form. This is sufficient to permit the process, as the vast majority of schools require parents to sign a release form covering photography, videography and audio recording when their children join the school.

The real skill of recording these sessions is deciding precisely what to write in order to make the audio easily navigable. I tend to use a mixture of clock times and key words on the left of the page to highlight significant events, together with additional notes on the right.

Other uses of the system include recording lectures, and although I have done this for personal use, I have found it particularly beneficial to record seminars that groups of trainees have been leading as part of their Education Professional Studies module. The trainees run two seminars during the course of the module, and are expected to use peer feedback to help them show development. It is easy to make the recordings available for the whole group of 18 trainees by uploading the pencasts to their wiki. The presenters can then use them to decide

on the improvements to be made for the next seminar, and the others can access significant discussion points again if they need to recall them for use in assignments.

Finally, as part of my role in delivering mathematics subject knowledge enhancement courses to pre-Initial Teacher Education (ITE) students, I have been recording the proofs and worked examples that I write on a whiteboard during a session and making these available to students via the university VLE. Students find the voice-over useful as I draw attention to significant points and comment on what I am writing, just as I would in class. It's not interactive, but it's better than just a piece of paper!

The Future

The technology itself is likely to benefit from further miniaturisation; the pen is still slightly bulkier than a standard fountain pen, for example. I see my role, basically, not as that of an expert (as I'm not up to speed with all the additional apps that can be run on the pen yet), but as that of an evangelist – to try to encourage the use of the technology wherever I can. Colleagues I demonstrate it to are rarely unimpressed by what it can do, and I find my 'paper memory' increasingly indispensable!

Engaging learners through video making at Nottingham

Michèle Clarke and **Claire Chambers**, School of Geography, University of Nottingham

Background

I don't think the way we organise assessments is as engaging as it could be (in this article, 'I' refers to Michèle Clarke). If students are enjoying themselves, there are going to be all sorts of added benefits: they put more effort in than they would normally, and the output is great. We had some equipment on campus which allowed students to film their own videos, but they couldn't edit them. Students would use them, they'd have great fun using them, but the output would often be poor in comparison to the effort they had put into it.

There was one student-access edit suite at the University. I found out about it through some students. News of the facility travelled, and in the end the demand was such that Information Services contacted me and said 'we clearly have a need here, what can we do to help?' They were really supportive, but clearly with only one facility for a growing number of students it soon became clear that we reached capacity very easily. A grant from the University of Nottingham Visual Learning Lab allowed investment in equipment aimed at enhancing the potential of video-technology for helping students learn.

Video for assessment

Video is a particularly good form of assessment. Other than being fun, students have to think more carefully about how to present information. When you are presenting something visually, you are using different tools to get to your audience. The structure and design of how to share information and the visual processes around that are something that they haven't necessarily engaged with before, but are implicit in using this kind of assessment; it develops their visual and technical literacy.

They like it because they feel they are being rewarded for the effort they have put in. I find that even when they get into the third year, they come back to me and say 'Can I have a copy of my video, cos I want to show it my mates'. They are so proud of it! When they graduate, it is one of the things they remember doing from the entire course. It is different. If I could think of new and other ways to engage with that kind of creativity and enthusiasm, it would be great!

The good thing about video as a form of assessment is that you can see how much effort goes in. This means that if you are lazy, it really shows! And the process of getting into groups and collaborating together develops a sense of peer competition. Once all the videos have been submitted, I book out a room and we all sit down together and watch them as a group. The students are very critical. 'That wasn't really very good because…'. And the ones they think are great they go 'Wow! Wasn't that great! I wish we had done that!' So they share their experiences in a way you would never get with an essay; it's real added value in all sorts of different ways. This is why I've been doing it for a number of years and, even with the timetabling problems and difficulties with accessing the facilities, I still pursue it.

Transferable skills

Students really appreciate the opportunity to develop their transferable skills. After you have left University, how often do you write an essay? Critical thinking and writing skills are important, but the ability to be able to use video and think about presentation skills in a wider context is something that is transferrable across all sorts of avenues and employment sectors. Receiving training on something that is professionally accredited gives them an extra point on their CV that they would not otherwise have. And I know they value it. The feedback shows that.

It is all about teamwork too and this helps them learn other employability and life skills: delegating responsibilities, diplomacy skills, negotiating. They have to sort all these issues out as a group in order to succeed.

Impact and success

The new facilities are again at capacity. As well, the quality of assessments I get improves every year, as students put more and more effort into it. I am getting submissions that are astoundingly professional in the way they have been produced. And this means that they do

very well in the module. The implicit assumption is that I am being too generous with the marks, whereas actually what is happening is that the students are putting much more effort into it, and doing better as a result. I consider that to be a great indicator of success.

I'm lucky as I'm in an environment where teaching innovation is very well supported. Word goes round. I have my colleagues come down and say to me 'I've just had students raving about your course so I thought I would pass that on'. There is a huge benefit from doing this kind of thing on a personal level as it makes the teaching process so much fun, and so rewarding. And what is a University if it is not about teaching?

Learning and future plans

What is really interesting about this is that it is really student-based, I'd like to see more staff involved. There are things we could do as academics with video-editing that could be really great. We were awarded funding to take video a bit further with lecture capture. Staff-training would also allow us to understand the processes that our students are employing in a more comprehensive way.

We have also been talking about developing some e-learning training packages for students. They could learn online and then use the equipment. I think there are some really exciting future developments that could grow out of this investment. So I would see where the project has got to so far as a first step on a path of increased use of different media in learning and assessment. Watch this space!

Student created video in geography at Nottingham

Claire Chambers, School of Geography, University of Nottingham

Here within the School of Geography at the University of Nottingham we have been encouraging students to use video in a variety of ways in teaching and learning for some years now.

In addition to giving students access to video to assist in their learning, such as lecture capture, software practicals and short lecture summaries on video, we also encourage student creation of video too. There are several modules, some of them field courses, which have a student diary as an assessed element, which the students can opt to create videos for. Other acceptable forms of submission include traditional written reports, PowerPoint presentations and posters; however students often opt for video and seem to hugely enjoy the process. There are other modules where the students create video diaries of their laboratory projects as part of their assessment, such as Michèle Clarke's module (see page 27).

Students often use video in innovative and exciting ways, using animation, time-lapse, sound and visual effects and other quite advanced techniques that we don't require them to use. They actively seek to produce an engaging and truly entertaining piece of work. They will also embed videos into other media, such as PowerPoint presentations or Second Life to create 'virtual' tours of places they have visited in the field.

We have some equipment available for students to borrow but are seeing increasingly that students will already have appropriate technology such as smart phones at their disposal.

We have a hydrology facility that mimics rainfall, storms, flood events, scour and erosion and sediment transport and their effects. The students can use this facility and it is equipped with several cameras that the students can use to record events as they unfold, and then play back the footage to analyse it in depth. These cameras also have the ability to record time lapse so events that happen over long periods can analysed, as well as giving the ability to slow down rapidly occurring events such as simulating flash floods.

The use of video is an extremely effective tool in helping students both to communicate and visualise concepts. Overall we are seeing the increased use and accessibility of video creation both by staff and students and expect this to continue.

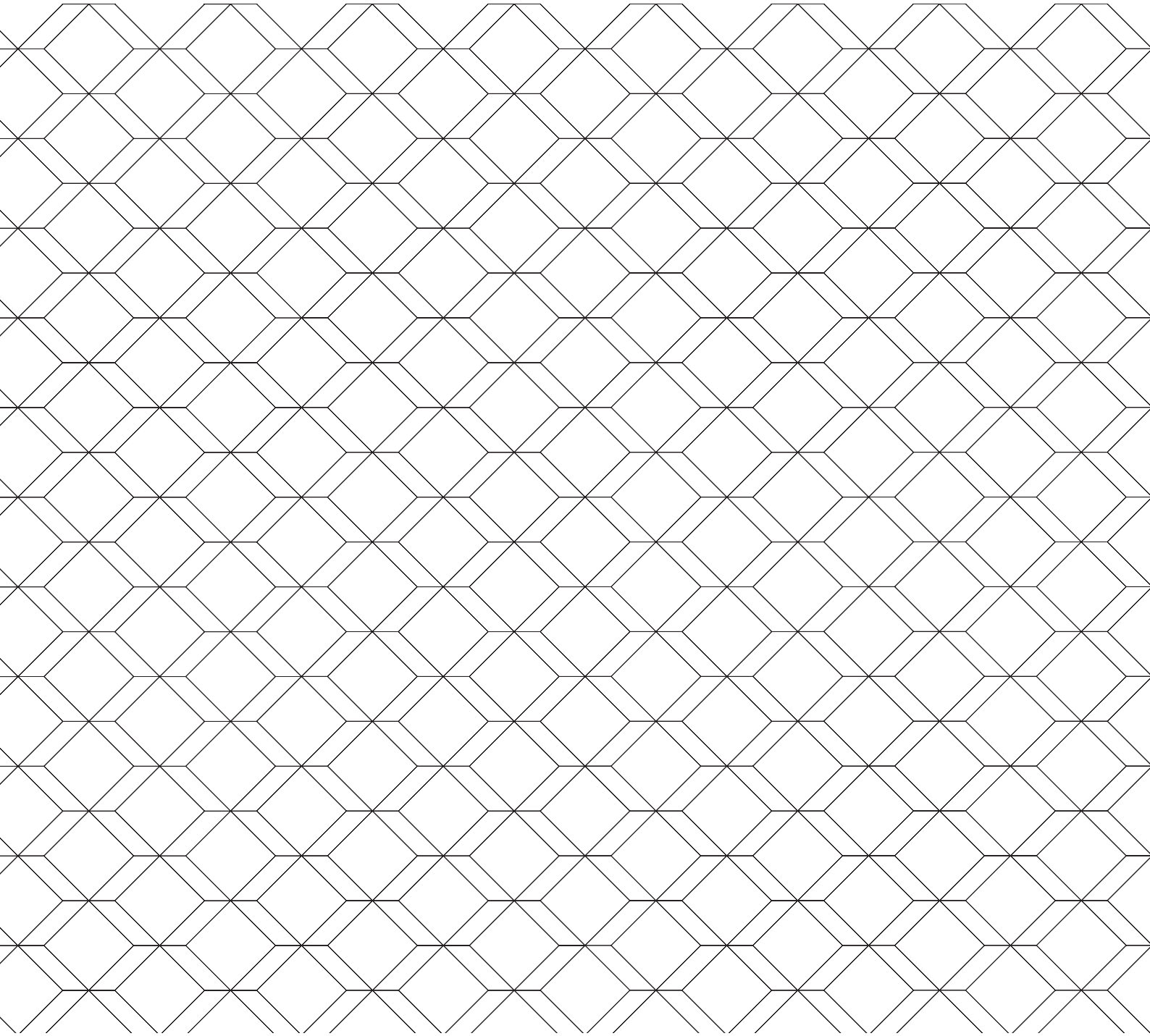
Example videos

Lake District Field Trip 2010 – Highlights: www.vimeo.com/10849871

Student created videos:

Desert Geomorphology Coursework at the University of Nottingham:
www.youtube.com/watch?v=PpHOPiRg5ws

Insolation Weathering in Deserts: www.youtube.com/watch?v=FxlLCP6FPyE



Making use of recordings

Use of smartpens by disabled students

Lesley Morrice, Student Services Centre, University of Nottingham

Having seen draft versions of the smartpen chapters of this publication, Lesley Morrice was kind enough to provide a few words about the potential use of this technology by some disabled students.

I am interested in 'smartpen' devices given that they could be used (and are already being used) by disabled students in the following ways:

- to record one to one study skills tutorials/mentoring sessions or tutorials where students may have memory or information processing issues and difficulties in recalling what has been said;
- to record lectures and formal sessions given that listening back to the lecture in conjunction with the notes/diagrams taken is a multisensory way of accessing information, which would be of benefit;
- to take notes in small group work sessions where again memory or information processing issues may impact;
- to take notes during lab work/when writing up lab reports when the student themselves can record their thoughts/findings;
- for ease of quickly jumping to the information you want to find rather than having to listen to hours of audio materials if student was using standard digital recorder.

We have already been recommending it for students and have had some very positive feedback from two students, although haven't heard back from any others. We've recently upgraded to the newer Livescribe pen and also have a couple of others. The original Livescribe pen that we have is very scratchy and annoying to listen back to, but I gather the new one is better!

Lecture capture technology – technically possible, but can it be used effectively?

Peter Rowlett, Maths, Stats and OR Network

This article first appeared in MSOR Connections 11(3), pp. 39-42.

It is now fairly straightforward to capture live lecture content for later distribution. This may be audio [1], perhaps linked to PowerPoint slides [2], or video recordings [3]-[10]. Preston et al. [8] notice in the literature a pattern of universities introducing these technologies to "adapt to the changing needs of their students". That students are positive about this technology (for a typical example, see [6]) is worth noting but, as Preston et al. observe academic staff struggling with the technology, it is important to ask what one aims to achieve and whether this technology can be effective against those aims.

For example, Cramer et al. [4] found that 73% of their students agreed that their use of a lecture capture system "would enhance their learning", 54% agreed it "would improve their grades" and 93% agreed it "should be offered in other courses" (pp. 111-112). However, they found "no significant relation between expected grade and both the number of accesses and duration" (p. 112). Perhaps, then, student positivity is not sufficient to recommend wider use of the technology.

It is also important to consider a possible negative effect on student learning. If the technology improves learning it may be judged a success (probably this is an aim), or if it makes no difference it may be a waste of time (although it may improve student enjoyment, and therefore feedback, retention, etc.). If instead the technology causes some unseen disadvantage to some students then that makes it potentially damaging.

What do lecturers intend?

Loch [11] remarks that "new technology is often used the same way old technology was used, and not to its full potential, because of lack of knowledge and comfort of familiarity on the user's part" (p. 236), suggesting a default mimicking of the replaced method without considering whether this approach is most effective. It is important to define why a new technology is being considered and how such technology is used, so a judgement can be made about whether that technology can be effective against the aims of its introduction.

Such aims may be general, perhaps to help students "achieve better results" or to make it "easier for students to learn" [9], or may be specific to a single aspect of student behaviour, such as solving tutorial problems [3], "improving student note taking and note use" [5] or to establish a "baseline of knowledge" ahead of lectures [2].

How do students use these resources?

Technology is often not used in a way that was predicted by its initiator. For example, Grabe and Christopherson [5] were surprised at the low rate of use of recordings to review lecture content in their research. They speculate that reviewing written notes is far quicker, so more efficient, than listening to the lecture (p. 7). Brindley et al. [3] made content available for mobile devices but found that 83% of students "accessed the videos via their home PC, with only a small number using a mobile device" (p. 5). When planning to use a new technology it is useful to consult such studies of what students typically do with resources.

White [1] and Yoon and Sneddon [10] found students using recordings to supplement lectures they had attended. White found that students "do not expect to understand the lecture completely when they first hear it" so review "difficult material several times" (p. 25). Yoon and Sneddon report this as the "most common reason for viewing recorded lectures", with "a secondary emphasis" on revision for tests and exams (p. 439). These findings are in line with those reasons found by Gosper et al. [6] in a survey of students across four universities in Australia.

Are these methods effective?

Let us say, for the sake of argument, that assessment performance is a good measure of 'success' in learning. Yoon and Sneddon [10] found that "the specific intentional use of recorded lectures as a back up resource to go over something that the student did not understand during the live lecture" was "weakly significantly associated with higher grades" (pp. 441-2).

von Konsky, Irvins and Gribble [9] say that students "may feel that listening to complex material multiple times will allow it to 'sink in'". Yoon and Sneddon found that "watching recorded lectures more than once", a practice observed also by White [1] and Gosper, et al [6], was not associated with grade (p. 442).

McFarlin [2] found that introducing an online component to a lecture course "was associated with a significant improvement in student grade performance" (p. 90). However, not all studies find similar results, for example von Konsky, Irvins and Gribble [9] found their system, while "a useful learning strategy for some", was "not required to achieve a successful academic outcome", "did not guarantee that learning would always take place" and "could not be used to predict the level of scholastic achievement." Stanca [12] highlights the problem that the students using the recordings may be those more inclined to do well in any case, meaning any difference in assessment performance may be inherent in providing some new learning opportunity. In that case, we must ask whether the students who are using the new opportunity would learn equally well from an alternative, and whether the students who are not engaging with the new opportunity are being disadvantaged more than they would by an alternative offering.

Many studies report usage; perhaps the nature of the technology makes this an easy to access metric. Of course, this approach can have measurement problems (some are discussed in [1]). In addition, Yoon and Sneddon [10] report "merely watching recorded lectures was not significantly associated with grades" (p. 441). von Konsky, Irvins and Gribble [9] note that, just as "physical presence during a lecture does not mean that a student is paying attention, synthesising new information in the context of prior understanding, or developing insights that will foster learning", so "playing a lecture recording does not necessarily mean that learning will take place". They warn that "sitting in a room while a recording is playing, perhaps while simultaneously engaged in other activities, may lead some students to the incorrect view that learning must be taking place".

Is there an effect on attendance?

Preston et al. [8], quoted an academic interviewee:

> *"I think it can help [students] to justify not coming to lectures. They think, 'it's OK not to go, I'll listen to the iLecture later.' I fear later never comes or comes too late and they cram for assessment."*

Stanca [12] suggests links between attendance and measurable performance may be found to be correlated (see, for example, [13]) simply because the students more likely to do well are also more likely to engage more fully (p. 252). Still, does the availability of recordings have an effect on attendance?

Several papers ([1], [4], [5], [7], [9]) find no link between availability of recordings and absenteeism. Yoon and Sneddon [10] found most respondents "attended the majority of those live lectures for which recorded lectures were available... and caught up with some of the lectures they had missed by watching the recorded lecture" (p. 438).

Preston et al. say lecture capture systems may have acted to focus attention of the existing trend of decreasing student attendance. They found that 55% of 155 academics "felt the [lecture capture technologies] had resulted in decreased lecture attendance". They listed lecturers' concerns about the impact on students, "including their ability to keep up with crowded curricula, engagement with the content and the continuity of lectures and tutorials". They note that "this concern was not shared by the students in the study", finding 68.3% of 331 students "agreed or strongly agreed with the statement 'I could learn just as well using [lecture recordings] as face to face'." Just 5 out of 155 academics agreed with this statement. Regardless of who is correct, this is clearly a discord between staff and student expectations about lectures and learning.

On assessment-driven working, White [1] and Brindley et al. [3] both reported large increases in downloads corresponding to exams, leading to concern about cramming.

Some respondents on one of the courses studied by Yoon and Sneddon "still missed 10% of lectures completely, by neither attending the live lecture nor viewing its recording"

(p. 438). Considering the reason for this, they note that 40% of respondents from that course "intentionally missed some live lectures due to the availability of recorded lectures" and 52% "said they had intended to watch more recorded lectures but did not get around to it" (p. 438). They suggest "the availability of recorded lectures may in fact contribute to students watching fewer lectures" (p. 438).

How might lectures be changed by this technology?

One problem with recordings was identified as far back as 1968 by McConnell [14]. Students "clearly preferred" being in a live lecture, whether this was small or large group, or taught by an experienced or inexperienced teacher, to watching a recording of an experienced teacher giving the session (p. 479). The reason given was that the recording lacked "direct question-and-answer and classroom discussion" (p. 479).

The studies reported above may differ in level of interaction. For example, while White [1] found "no significant association between attendance and download frequency", he used a personal response system in classes and assigned "points" for answering questions with this system in lectures (p. 27). This may have provided a greater level of interaction and strong incentive to attend. Yoon and Sneddon [10] note that the lectures in their study, for which decreased student attendance was observed, were "largely non-interactive". They suggest that the recording "mimicked the lack of interaction in the lectures" which meant a faithful recording of the lecture was an appropriate replacement. Further, they hypothesize that a high level of interaction and participation would mean the recording could only supplement, and not replace, the live lecture (p. 443). The question of attendance then becomes: what are students getting out of lectures? Some answers are given in [6], [7] and [15].

Preston et al. [8], report "a range of lecturers' responses to changing attendance patterns... including restructuring units to replace lectures with more interactive tutorials or workshops, replacing some face to face lectures with additional tutorials and providing the lecture materials as pre-recordings. In contrast, one interviewee had introduced roll taking to encourage students to attend lectures." They note that the introduction of this technology could act as "the catalyst for change" of "the whole teaching and learning context", but report that of the academics in their study: "43.2% of staff respondents had not changed their lecturing style; 36.7% had not changed what they do in their lectures; 74.9% had not changed the structure of their unit."

Discussion

Lecture capture technology clearly has some potential for having a positive effect on student learning. As seems usual for technology intervention, however, it seems that the positive benefit is observed when the technology introduction is associated with some change in the course delivery or design. The studies reported here are usually small scale, and this sort of curriculum intervention is naturally going to be hugely affected by contextual effects such as institution, discipline, method of instruction and instructor.

Availability of recordings may lead to cramming for assessments, but it seems reasonable to suggest that wholesale re-watching of lectures is not the most effective form of exam revision. Worse, it is possible some students are skipping lectures and watching them for the first time just before the exam, or not at all. Yoon and Sneddon identified a positive behaviour as: attending live lectures and using the recording shortly after the lecture to re-examine any parts they had not understood. After all, White reported that students do not expect to understand everything the first time they hear it.

If we would like to allow students to re-watch lectures as a reinforcement tool shortly after attending the live lecture or to catch up on lectures missed, but not for re-watching over and over or for revision, there may be some merit in making recordings available for only a short period[1]. Brindley et al. released recordings of particular parts of the material and this approach may be a more appropriate alternative.

[1]This was suggested to me by David Hodge when I gave a talk on this topic at the Media Enhanced Teaching and Learning workshop on 27th May 2011 at the University of Nottingham.

Instead, it might be fruitful to provide students with a summary of the findings given in the literature to allow them to make an informed decision about the best way to make use of this new technology. Yoon and Sneddon give an example of such advice (p. 444).

This technology seems to cast a light on the existing problem of non-attendance. A punitive approach to non-attendance – taking a register, or withholding recordings from students without a good reason for non-attendance – seems ill-advised. Instead, we might examine what lectures can deliver and how course delivery might be adapted to improve learning in light of the opportunity offered by using this new technology.

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Learning from video and making lectures interactive

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Peter Rowlett, Maths, Stats and OR Network

Introduction

The previous chapter (page 32) discussed the effectiveness of lecture capture technology. While students are positive about the availability of recordings, there is evidence that some practices are detrimental to learning. Specifically, intentionally missing lectures in light of the availability of a recording may lead to reduced learning as videos are passively watched or not watched at all. A behaviour found to be weakly associated with improved assessment grades by Yoon and Sneddon (2011) was attending lectures and using recordings to review the parts of the lecture that the student did not understand (pp. 441-2). Whether the availability of recordings reduces attendance may be related to the interactivity of the lecture; students might (perhaps rightly) feel that non-interactive lectures could be effectively replaced by recordings, potentially leading to reduced learning. This raises questions about what lectures can deliver and where learning takes place, which will be discussed here.

Where does learning take place?

Perkins (2006) says that students may meet "conceptually difficult knowledge" and form intuitive ideas about this before arriving at university (p. 38). In physics, Perkins gives the example of objects in motion (p. 38):

> *A mix of misimpressions from everyday experience (objects slow down automatically), reasonable but mistaken expectations (heavier objects fall faster), and the strangeness and complexity of scientists' views of the matter (Newton's laws; such concepts as velocity as a vector, momentum, and so on) stand in the way.*

Following instruction, Perkins says that the students learn to give "ritual responses" to concept definitions and quantitative problems but their intuitive beliefs remain and resurface on qualitative problems and outside the classroom (p. 38). Mazur (2009) recalls giving students a conceptual physics test and being asked by a student "How should I answer these questions? According to what you taught me or according to the way I usually think about these things?" (p. 50). In that sense, learning has not taken place, even among students who might perform well on assessments.

Perkins does not limit this problem to physics, saying "it can occur in any subject area" (p. 38). Alcock and Simpson (2009) write about preconceived or intuitive ideas of mathematical concepts, called "concept images", giving examples such as functions, limits and groups and discussing how these are relied upon by students above formal definitions, even when the two fail to coincide significantly (p. 13). Alcock and Simpson do not limit this issue to ideas first encountered prior to university teaching, saying that "even in situations in which a definition is introduced before any experience with the concept, students might still more or less ignore it and base their learning primarily on examples" (p. 13).

Learners can be reluctant or find it impossible to dismiss intuitive or long-established ideas in favour of difficult or counter-intuitive ones (Strike and Posner, 1985). Muller et al. (2008) conducted tests before and after exposure to exposition videos, which presented physics material clearly and concisely in a traditional lecture style, and found that rather than dispelling misconceptions the students actually gained more confidence in their incorrect intuitive ideas. Muller et al. attribute the higher confidence level to lower cognitive load; as the students believe that they already understand the concept, they watch the video with ease and strengthen their belief.

Challenging misconceptions

If simply watching a teacher talk through correct material does not help challenge students' misconceptions, what can be done?

Muller et al. (2008) advocate presenting students with videos that give information in the form of a dialogue between two actors, student and teacher, who present the concept and discuss

alternative conceptions (misconceptions). Participants reported finding the dialogue video harder to watch compared to the exposition video students; however, their post-exposure test scores were markedly higher.

Perkins (2006) also recommends that discussion of the contradictions in students' misconceptions may provoke students to rediscover concepts correctly (p. 39). History of the original development of ideas may be useful here. Consider, for example, the intuitive idea that heavier objects fall faster than lighter ones (an idea students share with Aristotle). Challenging this idea, Galileo posed a thought experiment (O'Connor and Robertson, 2003):

> *In* Dialogue Concerning the Two Chief Systems of the World *(1632) Galileo argues as follows. Suppose we have two stones, the first being lighter than the second. Release the two stones from a height to fall to Earth. Stone 2, being heavier than stone 1, falls more rapidly. If they are joined together, argues Galileo, then the combined object should fall at a speed somewhere between that of the light stone and that of the heavy stone since the light stone by falling more slowly will retard the speed of the heavier. But if we think of the two stones tied together as a single object, then Aristotle says it falls more rapidly than the heavy stone. How do the stones know if they are one object or two?*

Whole class discussion often leads to the more confident or knowledgeable students answering, leaving uncertainties over whether all students have understood the material. Ongoing formative assessment and feedback may offer a solution but there can be disadvantages for lecturer and student workload and in terms of which students tend to engage with formative material. Crouch and Mazur (2001) advocate a teaching method they call "peer instruction" which has discussion at its centre. This involves students reading pre-prepared material prior to the lecture and within class they discuss answers to conceptual questions with their peers.

The commonality between these methods is the use of discussion to challenge misconceptions. Muller et al. use simulated discussion with actors, Perkins suggests questioning to challenge the implications of misconceptions and Crouch & Mazur use peer discussion; in none of these does an authority figure inform anyone of the correct answer wholesale. The reason this works could be that, in discussion, students are evolving their intuitive concept towards the formal definition rather than trying to memorise a second, formal definition in parallel (or in conflict) with their intuitive one. Alcock and Simpson (2009) suggest that "many mathematicians" use concept images to think mathematically but that they do so with "sophisticated images which they can rely on to closely match the [formal] definition" (p. 13).

Technology for making lectures more interactive

Mazur (2009) incorporates an audience response system in lectures, where the students vote for answers to multiple choice questions both before and after peer discussions. Mazur reports data "in a wide range of academic settings and ... disciplines" showing improved learning and notes the opportunity for students to "resolve misunderstandings about concepts" (p. 51).

Increasing the interactivity in lectures through peer discussion does not necessarily need to involve an audience response system but this technology may have advantages over non-technological methods. Anonymity may produce a more honest response, avoiding the masking that takes place when students go along with the majority response (Rowlett, 2010). Research has highlighted the positive effect on attendance (Caldwell, 2007), the increase in learner attention and engagement (Bergtrom, 2006; Siau et al., 2006), the increase in peer interaction (Freeman et al., 2007) and assessment benefits, such as regular feedback and improvement of grades (Abrahamson, 2006; Simpson and Oliver, 2007).

An encouraging result is presented by Barton and Rowlett (2011). On finding out that their answer to an audience response system question was incorrect, the less engaged of the mathematics students did not check lecture materials or work through the problem again, but they were willing to discuss the question with friends. This result from a small-scale study hints at the potential for interactive lectures involving discussion to benefit even those students who are less naturally inclined to engage.

Discussion

If we hope to encourage students to attend lectures and use video recordings as backup resources then increased interactivity in lectures may help, since a recording cannot then provide a faithful reproduction as an alternative to attending. If the interactive element is in the form of peer discussion, we may find that this considerably improves learning.

The use of peer discussion may also allow a method whereby students are encouraged to watch a video before coming to class, the concepts from which are then the subject of in-class peer discussion.

If videos are to be a primary source of learning, these might be designed to include discussion of common misconceptions and not just straightforward, concise presentation of correct information. Otherwise, there is a danger that passively watching videos which do not challenge students' intuitive ideas about the material may just reinforce confidence in misconceptions.

Overall, these issues challenge us to consider how information is presented in lectures and videos, and whether the methods used will encourage learning to take place at all.

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The Internet Librarian and Curator of Mathematics Videos

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In this pilot project we looked at the feasibility of creating a website linking to selected, reviewed and academically-validated mathematics video tutorials and we established criteria for filtering resources according to their mathematical, pedagogical and technical quality.

Background and Rationale

The motivation for the project is the difficulty students experience when looking for instructional mathematics videos online. The vast size and lack of discrimination in the results of an internet search make it hard for students to identify suitable resources and to know whether they are relevant and reliable. The first priority of the project is to design a schema for evaluating these resources that will set a standard for making recommendations and at the same time will be pedagogically valuable to the user and easy for them to understand.

There are a number of popular websites that provide reviews of their products and a framework for user commentary on them (for instance, *Amazon* on books and the *Internet Movie Database* & *Rotten Tomatoes* on film). A further objective is to investigate the practicalities of creating an equivalent online framework that allows students seeking video tutorial help to comment, pass judgment and share the user experience.

Implementation

We have written a standard for evaluation that is provided as the next chapter of this publication. We have commissioned a website that provides the desired framework. We have collected and evaluated a range of video tutorials on the topic ‘first-order differential equations’.

The project work involved the following stages:

(i) a preliminary investigation of the literature and search for websites offering services similar to those envisaged in the project proposal;

(ii) a search for suitable online video tutorials in the area of first-order ODEs;

(iii) the creation of a project website; and,

(iv) the development of the standard for evaluation.

Evaluation

This was a pilot project and has not yet been tested ‘live’ with students. Its impact is therefore mainly at the theoretical level at the moment. My own evaluation is that the project has produced some useful outputs:

- a framework for the evaluation of online tutorials;
- a collection of a rated videos on a given mathematical topic (first-order differential equations);
- a website with the functionality outlined in the project proposal.

There is scope for further development.

A Framework for the Evaluation of Videos Tutorials in Mathematics

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With the advent of easy access to video-based instructional materials on the internet through content providers like YouTube, iTunes U, the Khan Academy, and individual academic institutions like MIT, the supply of these learning resources has proliferated. An online search for tutorial videos on a particular topic can produce a bewilderingly-large number of results that often carry little indication of how relevant and reliable they are. A student seeking help in this way must to some extent take pot luck and use trial-and-error to home in on suitable material and, especially in the case of mathematics, may not be able to form a judgment on whether the material is correct, relevant to their course and taught at an appropriate level. It would therefore be of considerable value for a student to have access to a filtered repository of video tutorials that are nicely classified according the content and authoritatively evaluated according to suitability and quality. Our purpose here is to devise a standard for evaluating such material that can be systematically applied by the provider and easily understood by the user.

We begin this task by considering key questions that might be asked by a learner when offered a choice of online instructional material:

1. What is its mathematical content and how does it relate to my course of study?
2. Is the level of the material and its presentation suited to my present knowledge and understanding?
3. What the quality of the video and its content?

To answer Question 1 we need a succinct way to describe mathematical content and context; this must convey accurate factual information rather than value judgments. An answer to Question 2 must convey information that will enable the user to place a particular resource in the correct position in their programme of study; this is particularly important in a hierarchical discipline like mathematics. Question 3 can only be usefully answered when we have established criteria for various kinds of ‘quality’.

1. Mathematical Content and Context

Categorizing the pyramid of information and ideas that make up the body of mathematics with a few keywords is a difficult undertaking. For one thing, mathematical knowledge is more like a network than a pyramid, with connections and relationships jumping across the category boundaries and going in unpredictable directions. Moreover, the process of grouping mathematical knowledge into tight compartments, or ‘topics’, is at best pragmatic and offers a very narrow perspective of the nature of the subject. Nevertheless, we are forced to resort to a classification of mathematical knowledge that our users, mainly university students, will readily understand. Two authoritative schemes of classification that spring to mind are:

- The American Mathematical Society (AMS) Mathematics Subject Classification scheme [1], last revised in 2010;
- The Library of Congress Subject Classifications in the Mathematics Statistics [2].

However, both are unsuitable here. The AMS Mathematics Subject Classification scheme is designed to assist mathematicians in locating research paper reviews in a systematic fashion and the Library of Congress Classification is to help librarians put books into sensible shelving categories. Thus the first classification is at too high a level and the second is too coarse for our purposes.

A further complication is the close relationship between topics and tasks, where by ‘tasks’ we mean the various activities, questions and problems that students need to work through as a central part of the process of learning and understanding mathematics. These tasks have been interpreted in the light of Bloom’s celebrated taxonomy of the six stages of learning[1] (see, for example, Lindsey Shorser [3] and the links under [4]), but there seems to be no universal

[1]Ranging from Memory, Comprehension, Application, Analysis, up to Synthesis and Evaluation (the highest form of thinking according to Bloom’s analysis)

agreement on which tasks fall into which stages. This is not surprising in view of the vast spread of mathematical knowledge, starting with the introduction of elementary arithmetic in primary school up to the frontiers of research, as represented, say, by Wiles's proof of Fermat's Last Theorem. A task that is 'synthesis' to one learner is trivial 'memory' to another.

In order to get round these difficulties, we set some limits: first, we will confine attention to the areas of mathematical knowledge and learning materials that are to be found in the first two years of a UK mathematics degree, perhaps occasionally straying a little into the territory on either side, especially into the area of transition from secondary to tertiary education. And second, we will take advantage of the rough-and-ready division of material into standard modules that are common to many mathematics degree curricula. Nevertheless, we still need a finer classification for this level of the mathematics discourse. For this we are fortunate have a taxonomy [5] developed by Professor Tony Croft and his mathcentre team for, i.e., classifying the resources at www.mathcentre.ac.uk. It is well suited to transition and early undergraduate mathematics and has three levels of refinement, for example: algebra/linear algebra/vector spaces. By adding one further level, e.g. basis theorem, it will be adequate for most of our purposes. This type of classification tree is also useful for telling the user of the context of a particular resource, although more contextual information may sometimes be needed, for instance, this branch

calculus/single variable/functions/natural logarithm

of the tree should additionally convey whether the logarithm is defined as the inverse of the exponential function or as a definite integral of 1/t because which approach is chosen significantly affects the way the ideas are developed and understood.

2. The Level of Exposition

As always, sensible assumptions about a student's previous experience and present mathematical knowledge are crucial to the design of any teaching materials. There is no point in defining the determinant of an n x n matrix as the scalar multiple induced by a linear map on the nth exterior power or as a certain homomorphism from a linear group to a field, if the learner has not yet learnt the meaning of a vector space or a group. The background knowledge and level of mathematical maturity assumed in the making of an instructional video presentation should be clearly advertised. Fortunately, within the limits we have set, we know fairly accurately the entry level of the average beginning mathematics undergraduates because most will have taken an A-Level Mathematics or an equivalent qualification. Furthermore, the first-year curriculum of a UK maths degree is fairly consistent across the sector. In making recommendations of selected resources, these levels can be born in mind and made clear to the user with the labels: transition, first-year, second-year, perhaps augmented with a star to denote higher-than-average level of sophistication.

3. Evaluating the Quality of Video Tutorials

We divide our discussion of quality into three broad areas:

I. mathematical content;

II. pedagogical value;

III. technical production.

The first concerns the correctness of the mathematics and its context. The second is essentially about the effectiveness of the teaching. The third relates to the user experience of watching and listening to the video.

I. Judging the quality of the mathematics

The first and most important criterion is whether the mathematics presented in the tutorial is correct. But of course there are degrees of incorrectness: getting the statement or proof of a theorem wrong is clearly unacceptable, whereas minor transgressions like a typographical error or a slip of the tongue can be forgiven, as long as users are warned to be on their guard.

Another important issue is context. As a typical tutorial video might be quite short, presenting a single idea, example or result that forms a small part of a larger mathematical narrative, its significance may be lost if its place in the bigger picture is not fully explained. This issue also arises in our following discussion of pedagogy.

Finally, we need to assess how relevant the presentation is to the topic in contention and to give the user a clear idea of the mathematics covered and the approach taken (for example, abstract with rigorous proofs or concrete with illustrative examples and applications).

II. Evaluating the Effectiveness of the Pedagogy

We discuss the strength of the teaching under several headings:

Level of presentation: Are sensible assumptions made about the background knowledge and mathematical maturity of the audience? Are these assumptions explained at the start, perhaps with references or links to allow users to fill in their gaps? How much detail is given, are the relevant steps fully worked through, especially those involving algebraic manipulation? Is the pace right for the average viewer?

Interest and Appeal: A good teacher will be animated and enthusiastic, conveying confidence in their exposition and a love of their subject. They will have the ability to capture and hold the attention of their audience. They will leaven their account with anecdotes and humour, if possible creating a story to hang the mathematics onto and make the material easier to remember. These qualities are hard to pin down but usually evident when present – they are often encapsulated in the phrase 'inspired teaching'.

Insight and pedagogical intelligence: Here we mean conveying insight into the ideas the lie behind the mathematical symbols and equations, and having psychological insight into the natural thought processes of the learner, relating material to previous experience, illustrating theory with examples, counter-examples and applications.

Teaching Technique: These are the simple basics of good teaching: making sure the learner can see and easily read what is written and what is referred to; talking clearly with appropriate pauses and intonation; structuring the narrative by announcing intentions at the beginning and summing up at the end; good pacing, organising content to suit to the student's typical concentration span. Reminding the audience of the meaning of terms and symbols used, and providing the appropriate context for the student to place the material in the larger scheme of things.

III. Technical Production

First the user needs to know what kind of presentation is on offer. Here are the most common types we have come across:

- lecture excerpt before an audience with (a) chalk or white board (b) OHP slides (c) digital slides (e.g. Power Point);
- lecturer (talking head) writing simultaneously on (a) flip chart (b) chalk or white board (c) prepared slides;
- voice over prepared slides, possibly with synchronized annotations by the instructor;
- animation.

Second, we need to tell the user something about the video capture. Was it taken with a fixed or hand-held camera? Were separate cameras (or other sources) used for instructor and the material? Was it in focus and on target? Was the video well edited?

Third, we provide information about the sound track. Were the sound levels adequate? Was the speaker's voice clear and the accent easily understandable? Was there any background interference such as audience noise, echoes, or resonant feedback?

Finally, we need to describe any other factors that might come between the learner and the tutorial, for instance was there advertising? Was the compression incompatible with standard viewing software? Did it stream well without demanding excessive bandwidth?

4. Providing a score

To enable the user to see at a glance how far a given video approaches the standards described, we recommend providing a score out of 5 for its three quality headings above.

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The practice of doing mathematics and explaining this to others is necessarily very much embedded on pen and paper, or board; nevertheless, some have started to explore the potential of technology for augmenting this process. Writing mathematics using technology presents the opportunity to make recordings, and it is this prospect that this booklet seeks to explore.

Taking examples from mathematics and other disciplines, this theme is explored through making recordings of teaching and learning content – lectures and supplementary material – and use of recordings in assessment and feedback. Questions are asked about the use of recordings and whether these are effective for learning. Overall, this booklet aims to give an account of this emerging area of practice.

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