Chapter 14
Screencasts in Mathematics:
Modelling the Mathematician

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ABSTRACT

A screencast is a video recording of a computer monitor display, together with voice-over. This teaching technique has multiple advantages including the ability to model the thought processes of a mathematician in a context in which content may be repeated at will. Anecdotal evidence suggests that screencasts can be a very effective teaching tool, especially for providing model answers. Here, screencasts are discussed from a pedagogical and curriculum perspective using student feedback statistics as data. Specifically, screencasts offer a teaching resource that has value for many traditionally difficult groups of students. For example, poorly engaged students are well-served, as the barriers for participation are low; and high-achieving students benefit from the directed narrative. All students valued the ability to view material multiple times at will. The chapter concludes with some observations about how the overall learning environment might be improved in the context of undergraduate mathematics.

INTRODUCTION

In the teaching of undergraduate mathematics, one commonly stated aim is to explicitly model mathematical thinking, that is, to provide an example of a working mathematician. This is relatively easy in the discipline of mathematics because, uniquely, a mathematics lecture involves the lecturer actually *doing* mathematics, rather than merely *talking* about it. In this chapter I will discuss the issue of specimen answers in the context of modelling.

BACKGROUND

The educational value of a traditional lecture has been questioned many times in the literature on various grounds by Biggs and Tang (2011), Bergsten (2007), and others. Criticisms of the lecture format include: the tendency to turn the audience into passive listeners rather than active participants; the dishonest presentation of mathematics as a linear predetermined progression rather than a "social activity coloured by creativity and struggle"; and poor comprehension of the material by the audience.

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Mathematics, however, appears to be qualitatively different from other subjects in the sense that the essence of a mathematics lecture is a mathematician *doing*, rather than *talking about,* mathematics. Consider, for example, a lecture on survey engineering. This will comprise the teacher discussing, explaining, and perhaps illustrating various aspects of surveying. At no point does a lecturer actually perform any action that might be described as surveying: he does not even go outdoors.

It is also interesting to observe that, when a mathematics lecturer does talk *about* mathematics (for example, mentioning the history of the subject), such discussion is invariably short, and presented "for interest"; it stands out like a sore thumb; the students stop writing. They know that it's not real mathematics, it's just the lecturer making light conversation by way of a break. Hartley and Hawkes (1983) – a standard mathematics textbook – illustrates this perfectly. Chapter Five opens with a gentle and chatty introduction: "a *module* . . . turns up in many seemingly unlikely guises . . . such an apparently all-embracing object will suffer from some of the defects of great generality . . . the reader's progression will be from the specific to the general and back to the specific again". The chapter introduction culminates in a sharp "Now down to work!" and the style immediately reverts to the default: formal, axiomatic mathematics.

Thus, during a mathematics lecture, the mathematician actually *performs* genuine mathematics. The teacher will actually prove mathematical statements and explicitly creates (or at least verifies) knowledge in front of the students as part of a live performance. It is worth noting that the process of mathematical proof used in a lecture is *identical* to that used by a professional mathematician. It is also worth noting that, when performed correctly, the audience members will perform genuine mathematics along with the lecturer in the sense that they actually prove mathematical statements.

One might characterise lecture-style proof as being more familiar to the lecturer than the proofs used in research, but the idea is the same. The criteria for acceptance are identical. It is here that Bergsten's (2007) criticism of lectures as pre-formed linear sequences becomes evident; genuine mathematics research as a process is generally characterized as being frustratingly iterative and bedevilled by confusion and other cognitive impairments.

It is a common philosophy of teaching (Shulman 2005) to model the behaviour of a mathematician; this is made easier by the fact that mathematics teaching is, at least in theory, perfectly aligned in the sense of Biggs and Tang (2011). Consider Cauchy's theorem, a crucial requirement for many branches of modern mathematics; its proof is regarded as the highlight of many undergraduate courses in complex analysis. The Cauchy's theorem component of a course will have the following features:

- Learning objective: prove Cauchy's theorem.
- Teaching activity: prove Cauchy's theorem.
- Assessment task: prove Cauchy's theorem.

While the above exhibits perfect alignment, observe that an additional alignment exists: the Teaching Activity, if properly performed, involves the *student* proving Cauchy's theorem. This is a good example of functioning knowledge for a mathematician (Biggs & Tang, 2011, p. 162).

In most subjects, controlled examinations are not aligned with high-level learning objectives (Biggs & Tang, 2011, p. 227) and place the student under strict time constraints. This has led to suggestions that where learning objectives include the need to work under pressure, conventional examinations are more suited to performance assessment. However, observe that a *mathematics* examination is arguably a peculiar type of performance assessment: an examination question asking for a proof of Cauchy's theorem obliges the student to undergo the internal experience of proving the theorem; the student is assessed on their ability to furnish evidence that they can indeed experience, at will, the sudden shocking flash of insight that mathematicians call "proof". This evidence is typically provided through a highly formalized written performance. Observe that the performance itself is not assessed, as it is an internal experience: it is only the written evidence that the learning objective has been achieved that is assessed.

Given that a mathematics lecture is a performance of genuine mathematics, how does the mathematician model mathematical thought in such a way as to be visible to 200 undergraduates simultaneously? The answer, for hundreds of years, has been to use a blackboard or more recently its functional equivalent, a whiteboard. Most teaching institutions instinctively appreciate the pedagogical value of whiteboards in the context of mathematics, but occasionally one encounters pressure to "modernise" and eschew whiteboards in favour of multimedia technology. The signature pedagogy (Shulman 2005) of whiteboards in mathematics is well-described in the following quote, which was part of an institution-wide discussion of teaching technology:

The key delivery of the material is to interact with the students using a whiteboard. The proof of a result or a theorem, or the solution of a problem, all need take place on such a secondary medium. Students seeing the "master at work", explaining his or her thought process, is in itself a major component of the learning process. Without such freedom to interact with students by using a whiteboard, we are denied an opportunity to present our craft in a suitable way (J. E. Hunter, personal communication, April 15, 2013; slight copyediting)

Specimen Answers

One standard component of many university courses, including mathematics, is the setting of assessment questions, followed after the students' attempts by a set of *model answers* (or *specimen answers*) which show the desired answer. Specimen answers are defined by Huxham (2007) as ideal responses [to examination questions] which would receive 100% of the marks, generated by the tutor. Huxham points out that specimen answers furnish, in addition to a 'correct' response, the level of detail required for course credit. Given that whiteboards afford a very satisfactory medium by which to model mathematical thoughts, how does the provision of specimen answers sit in this context? Biggs and Tang (2011, p87) argue persuasively that providing specimen answers is counterproductive from the perspective of deep/shallow learning; specifically, they encourage activities at the lowest levels in the SOLO taxonomy such as memorization or simple identification; they encourage "learning to the exam" in that they encourage a surface approach to examination questions (for example, they indicate precisely the level of detail required for course credit, not something generally associated with deep learning). However, such specimen answers can, at least in theory, stimulate higher-level activity (an example would be a student wondering how the lecture content would lead to that particular technique).

Provision of *augmented specimen answers* goes some way to mitigating these defects. This teaching resource comprises a specimen answer [ie a minimal-full-credit response], conventionally written in red ink, together with additional text (in blue) provided "for revision", not needed for full exam credit. This division is itself conducive to higher-level learning: the student is forced to ask where and why the red text ends and the blue begins (of course, the demarcation is revealed by the student (re-) reading and understanding the question, not a bad outcome).

Even augmented specimen answers suffer from one defect. They are polished pieces of work; the creation process is invisible to the student. As Smith and Hungwe (1998) point out: "if guessing and the resulting cycle of inquiry does not become visible to students, they are left with only public mathematics—the carefully crafted propositions and polished arguments they see in their texts".

Creating specimen answers in front of students, perhaps during a lecture, goes some way to remedying these defects. The students see the thought processes, explicitly discussed. They see the mistakes the mathematician makes and how they are dealt with: detecting and correcting errors, both computational and cognitive, is a big part of many intended learning objectives.

Combined with the advantages of augmented specimen answers, this is a potent teaching tool. I can wonder out loud (and ask the students) whether a certain piece of text should be red or blue. Borderline cases are fascinating—and instructive, as they focus attention on the precise relationship between question and answer. The educator can make public the flash of insight that constitutes a proof, and this is a very valuable modelling exercise. However, the creation is still defective in that the process is modelled only once, and students can miss details or important points. A screencast, discussed below, nullifies this defect.

SCREENCASTS

A screencast is a video recording of a computer monitor display, together with voice-over. With increasing accessibility of technology, screencasts are becoming easier both to create and to view. Screencasts appear to be a popular teaching resource with viewing figures for one large first year course at AUT standing at around 77%: that is, over three-quarters of the class actively downloaded the screencasts. This agrees with Winterbottom (2007) who reported figures in the 58-88% range. It is more difficult to assess the number of students who actually *viewed* the screencasts. However, the number actually viewing the screencasts is likely to be high on the grounds that the default action, on clicking the screencast link in a browser session, is to view the screencast immediately. Further, each screencast is at most 5 minutes long (many are much shorter), and not too onerous to view, at least casually. Yee (2010) considers sub-five minute screencasts and states that "such an approach has multiple benefits, including a more narrowed focus and increased likelihood that students will find time to *view* the videos" [my emphasis].

Learning of all types is much more effective when it involves active participation rather than consumed passively (Pratton & Hales, 1986) and one potential pitfall of screencasts is that they are, like lectures, easy to watch and not engage with. Although the easy style of screencasts does have advantages (large percentage of student uptake, see above), a screencast is not nearly as effective if watched passively.

One good indicator that the students are not passively watching is their taking active control over the timeline of the video (Sugar, Brown & Luterbach 2010). The students value the ability to pause the recording while watching, and rewind; this allows them to review material at their own pace. Having said that, one clear advantage of the screencast is the low barrier to participation: even the most poorly-motivated student can passively watch a five-minute screencast.

Biggs & Tang (2009) suggest that such issues be considered using the "Robert and Susan" device: Robert and Susan are respective personifications of the stereotypical under- and properly- motivated student. In a lecture situation we have "Susan working at a high level of engagement . . . Robert taking notes and memorizing" (Biggs & Tang, 2009, p. 6). I would suggest that screencasts help the Roberts *and* the Susans in different ways:

Robert can at least passively watch, while Susan reproduces the underlying thought processes.

Screencasts Elsewhere in Education

Screencasts occur elsewhere in education; one notable example would be the *Khan Academy* (Thompson 2011) which is a freely accessible online resource comprising educational screencasts covering a wide variety of topics (Noer 2012). Other providers would include *Coursera* and *Alison*, among many. These and other online resources are noted as providing high-quality source materials to students. However, in the current context, such resources are typically not tightly coupled—in either content, notation or approach—to specific undergraduate units of study.

Issues, Controversies, Problems: Unexpected Outcomes of Distributing Screencasts

As discussed above, screencasts can help the Robert and Susan problem. Falconer, deGrazia, Medlin, and Holmberg (2009) consider this and state:

Screencasts of example problems can be superior to written solutions because students can listen to the instructors explain the problem-solving strategies that they use. Research has shown that when given just the final written solution to a problem, good students use the solutions differently than poor students. The good students use the solutions to justify the individual steps in the solution to gain a deeper understanding, whereas the poor students tend to just follow the steps without connecting the solution to the concepts. With screencasts, all of the students are able to hear an expert's explanation and understand how each step in the solution relates to the underlying principles. (p. 286)

Mathematics examinations are typically closed in the sense that there is only a very narrow range of responses which can give full credit. There is little scope for creativity. Students clamour for model answers to assignments and in-course tests, as well as to previous examinations.

It is possible to produce model answers of varying sophistication. The straightforward model answer has yielded to an augmented model answer, which contains colour-coded notes for revision, usually verifications that an answer is correct (via cross-checking with a different method); it is possible to consciously model a professional research mathematician by analysing a different, unasked, question.

Unexpected Negative Outcomes of Distributing Screencasts

Many authors such as Winterbottom (2007) express concern that screencasts could decrease lecture attendance, and state that screencasts should not be viewed as a replacement for face-to-face teaching. Here I discuss whether this has in fact occurred and, if so, whether it matters. There is an important distinction between screencasts and *webcasts*. A webcast is a video recording of a lecture; not discussed here.

Massington and Harrington (2006) consider whether availability of online material depresses lecture attendance. He concludes that it does not, stating that students' attitudes to teaching and assessment is a more important determinant of attendance.

Pondering this issue highlights a long-standing uncertainty about the purpose of lecture attendance, especially in the presence of online course material such as screencasts but also including streamed video-recording. Many authors consider university lectures from a pedagogical viewpoint but there is almost nothing published which considers the function of a lecture from a sociological perspective. T. Clear (personal communication, October, 2013) is one of the few thinkers who considers the conventional lecture in this context and states that a lecture, viewed as a social construct, has four functions which cannot be achieved by online delivery:

- A lecture structures the student's working day and creates a regular timetable during which the subject is at least thought about.
- A lecture requires physical presence; it brings together a large number of people, all in a similar position and with a similar relationship to the subject, and thereby creates a student group identity.
- A lecture is a live theatrical performance, and can be enjoyed as such.
- A lecture is an interactive teaching medium: students can ask questions in real time.

These are valuable functions for a lecture to perform and, even though authors such as Phillips (2005) assert that lectures are "inconsistent with fundamental principles of learning", the lecture format will likely be with us for a long time to come.

FUTURE RESEARCH DIRECTIONS

Although the efficacy of screencasts appears to be reasonably well established, many aspects of their pedagogical use are uncertain. For example, do screencasts model mathematical thinking more effectively than live lectures? If so, are there any beneficial aspects of live lectures that may be incorporated in to screencasts? Does screencasting of specimen answers mitigate the deficiencies of specimen answers, as discussed by Huxham? Future research might include experiments on gaze behaviour to elucidate individual responses to screencasts.

CONCLUSION

The primary consideration is whether screencasts achieve anything that regular lectures do not. I think they do. First of all, students watch them (77%), and appear to do so as active, engaged learners. Students can, and do, watch the screencasts as active participants, and active participation is generally held to improve learning. Students have the opportunity to observe genuine thought processes of a professional mathematician, together with the ability to view the material multiple times at will. In this sense at least screencasts are, I suggest, an unqualified success.

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KEY TERMS AND DEFINITIONS

Modelling: A process whereby a student changes in response to observing an instructor; the emphasis is on the instructor demonstrating appropriate professional behaviour.

Screencast: A video recording of a computer monitor display, together with voice-over.

Signature Pedagogy: Forms of instruction associated with preparation of members of particular professions.

Specimen Answer: Ideal responses to examination questions generated by the tutor, which would receive 100% marks.