“I’m worried about the correctness”: Undergraduate students as producers of screencasts of mathematical explanations for their peers – lecturer and student perceptions

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Undergraduate mathematics is traditionally designed and taught by content experts with little contribution from students. Indeed, there are signs that there is resistance from mathematics lecturers to involve students in the creation of material to support their peers – notwithstanding the fact that students have been successfully engaged as co-creators of material in other disciplines. There appears to be little research into what issues may lead to reservations to using student created content in mathematics learning.

This paper takes a case study approach to investigate the reasons for lecturers’ resistance to undergraduate student contributions to learning material, in particular with a view to the production of screencasts of mathematical explanations. It also investigates the views of students producing mathematical screencasts. This study is part of a larger research project investigating undergraduate involvement in mathematics module design.

Four second-year students, who were producing mathematics screencasts as part of an internship, and five academics, were interviewed to gain an understanding of their views of the value of student screencasts. The interviews focused on the particular contributions students make to screencasts, outcomes for the students and level of lecturer acceptance of these resources.

We argue that students benefit from creating screencasts for their peers by gaining deeper mathematical understanding, improved technological skills and developing other generic skills required of today’s graduates. In contrast, we confirm lecturer resistance to using student-generated screencasts in their teaching materials. Lecturer reservations pertain to students’ lack of mathematical maturity and concerns over the mathematical integrity of the content that students produce.

We conclude that close collaboration between students and lecturers during the design and production phases of screencasts may help lecturers overcome reservations, whilst preserving the benefits for students. In addition we provide evidence that the process is also a valuable professional development opportunity for the lecturers themselves.

Keywords: Screencast, students as partners, co-creators, mathematics learning resources

Subject classification codes: 97U50, 97U80, 97D40

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1. Introduction
There is growing interest in engaging students as partners in shaping their learning and contributing to the process of course design in general [1, 2]. This is due to the belief that students bring to bear on the planning process their own perspective on teaching and learning. When lecturers plan teaching and learning alone, they may not have an awareness of this student perspective. They may impose on the students the ways that they were taught. However, what worked for arguably the top-performing students (university teaching staff have invariably completed higher degrees) in the past may no longer be appropriate for a new generation of students with different demographics and expectations. However, there appears to be little research on student involvement in producing or improving course content for their peers in undergraduate mathematics education.

In this paper, we report on one aspect of a larger research project investigating undergraduate involvement in mathematics module design [3, 4]. Four second-year undergraduate mathematics major students worked with lecturers on an internship to enhance the two second-year modules Vector Spaces and Complex Variables. As part of this work, the interns decided to produce screencasts (screen video of handwritten explanations with narration) of mathematical concepts that students in the past had found difficult to comprehend. The interns were mentored by teaching staff during the production process.

To produce screencasts requires both technological skills and the ability to present oneself, conveying the mathematics clearly in both written and audio form without the use of physical gestures. The extent to which second-year undergraduates have the academic and personal resources to do this is not obvious and is an area for investigation. Likewise, the extent to which academics are willing to let undergraduates contribute to the design and production of learning materials is worthy of exploration.

The aim of the research described herein is to understand better the contribution that undergraduates can make to the production of screencasts in a mathematical context. We are interested in the perceptions of staff – both lecturers who have worked with the interns, and others who have not. We wanted to know more about the interns’ views of screencasts, the contributions they think they can make, what actually happened in practice and the benefits accruing to the interns through engaging with the project.

This paper adds to the literature on student-generated screencasts for mathematics learning by analysing student and lecturer views of the benefits to students who produce material for their peers; the new contribution that the students can make to the course material; and the barriers to lecturer acceptance of student-created material.

These form the research questions to be answered in this paper. We begin with a review of the relevant literature and follow with an outline of our methodology. The case study setting of the internship is described before we provide a discussion on our findings.

2. Literature Review
2.1 Lecturer-created screencasts

Screencasts are digital recordings of movement on a computer screen and are often accompanied by audio commentary [5]. In mathematics education in particular, screencasts are usually narrated recordings of handwritten communication on a computer screen. “It is this visual representation that separates screencasts from traditional podcasts which are mostly aural” [6].

In this paper, we regard a screencast as a podcast with audio and screen video that is distributed and shared over the web. Sutton-Brady et al. [7] discuss the value of using short podcasts to enhance student learning and point out that the short and focused format of the recordings enables dissemination of just-in-time, highly relevant information and that to increase the benefits “there is a need to focus on the pedagogical design of podcasts, rather than just repeat lecture content”. At the same time, podcasts allow lecturers to “design learning activities and resources that allow students to individualise their learning”, and allow mobile learning where the student can study from anywhere, anytime. Heilesen [8] points out that the success of podcasting may be due to the technology supporting “well known techniques for improving academic performance, such as active engagement and revision”.

Following the increased popularity of podcasting in higher education due to simplified production and inexpensive hardware, several research studies have looked at the effectiveness of podcasts created by academics as pedagogical tools and their impact on student learning at university. Often these studies evaluate the impact of student use of the technology on their performance and engagement with a subject, for instance in engineering [9]. In undergraduate mathematics student perceptions of the effective use of lecture (screen) recordings and the impact on grades of planning to watch the recording of a skipped lecture, but not actually watching it, are analysed [10]. At Masters level mathematics screencasts have been used to refresh undergraduate core concepts [11].

Other studies focus on student perceptions of the usefulness of mathematics screencasts, see for instance [12] where screencasts were seen to help students identify at what point they have gone off-track in their solution; [13], where one of the strengths of screencasts is highlighted as allowing “communication through multiple channels: writing, visual aids and speech”, like live lectures; and [6] where short, targeted “MathsCasts” are provided for students to revise prerequisite topics. Extending the research reported in [11], Loch, Jordan, Lowe and Mestel show that while screencasts are very well received by students, they may also have a positive effect on performance [14].

2.2 Student-created screencasts

More recently, researchers have shifted their efforts towards the study of student-generated podcasts [15-17]. Advocates of student-generated podcasts cite constructivist theory [18] and the advantages of peer tutoring as the basis for universities to involve students in creating podcasts and screencasts for their peers. Thus, when students are involved in educational activities such as screencast production or peer tutoring, they are provided with a constructivist learning environment which enables them to create and share knowledge. Students who create screencasts will “learn by doing” and gain
deeper understanding through the exposition they give in their screencasts [17]. When students produce screencasts, benefits have been observed such as higher student engagement and enhanced performance on the final exam, as demonstrated in an accounting context [19].

Although it is suggested that there may be “resistance and uncertainty, both with staff and students” [20] when students contribute to material and become “change agents”, Bovill, Cook-Sather and Felten [1] identify the possibility of reduction in lecturer resistance in student involvement as co-creators and describe examples where students have been partners in the successful co-creation of course material.

Creating podcasts or screencasts involves the development of technical, personal, organisational and also communication skills, especially if teams of students create screencasts. The development of such skills throughout a degree programme is increasingly considered to be important, as there is impetus for academic programmes to nurture the acquisition of graduate attributes that could lead to successful employment. Wood and Smith [21], for example, report on activities that academics can create to develop graduate attributes in undergraduate mathematicians. Hence this study contributes to the knowledge base on how activities involving students creating their own screencasts can help develop generic skills besides those required in a specific curriculum area.

However, very few studies have looked into the outcomes of student–generated screencasts for both lecturers and students because screencasts are a recent addition to educational technology tools [19]. In particular, there is a dearth of studies focusing on screencasts at an undergraduate level. This paper aims to start a discussion among the mathematics education community about the involvement of undergraduate students in the production of mathematics screencasts for their peers.

3. Methodology

To investigate the perceptions of students creating mathematical screencasts, a case study approach was taken using both a descriptive and explorative focus. As such an investigation has not been undertaken before, we are interested in “process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation” [22].

We employed a qualitative research design methodology to gain insights into lecturers and students perceptions. Data were collected through an interview with all four interns around half-way through their six-week internship followed by individual interviews with five lecturers. The interns were interviewed together to hear each intern’s responses and reactions to those responses from the others. This enabled us to ascertain if there was consensus or if there were differences in the interns’ views. Lecturers were interviewed individually for pragmatic reasons and also to provide the privacy that would allow each member to give an honest view about the screencast as a learning tool and about student involvement in the production of screencasts. Interviews were audio-recorded and transcribed for analysis. A thematic analysis of the data was undertaken with a focus on answering the research questions:

- What are the benefits to students who produce material for their peers?
- What new contributions can students make to course material?
• What are the barriers to lecturer acceptance of student-created material?

In addition, we looked at access data to the student-created screencasts in the following semester to provide an indication of the level of acceptance of this material by a new cohort.

4. The case study

Four second-year undergraduate mathematicians were recruited to work with lecturers on the SYMBoL project, http://sym.lboro.ac.uk, during a six-week paid internship in summer 2011, funded by the UK HE STEM Programme. The interns collaborated to enhance two second-year modules (Vector Spaces and Complex Variables) that had a history of proving particularly difficult for students. Whilst all the interns had previously studied and passed the modules, they were not necessarily among the top performers in these modules. Before the official commencement of the internship period, the future interns ran focus groups with students who were taking the two modules to elicit ways in which they might be improved. Drawing upon the focus group findings and their own experience of taking these modules, the interns were in a unique position to input to the course design process. One finding that emerged was that students thought that, in a different module, screencasts of mathematical examples produced by the lecturer were particularly helpful in supporting their learning [6]. The interns expressed the view that they would like to produce their own. Since undergraduate mathematics is a technical subject that requires designers of learning materials to have advanced content knowledge together with pedagogical knowledge sufficient to communicate difficult ideas, students were mentored by teaching staff. By the end of the internship, they had produced five screencasts for Vector Spaces, and eight screencasts for Complex Variables (Figure 1).

5. Results and Discussion

We present the results of our analysis and include quotations from the interview transcripts and pseudonyms. The interns are referred to as Nicola, Ray, James and Marcus; the five lecturers as Jayson, Trevor, Ellen, Belinda and Tim.

5.1 Benefits of Student-created Screencast Content for Interns

The interns reported that they benefited from creating screencasts in many ways: they rapidly improved their technological skills, developed transferable ‘graduate’ skills, improved their study habits and gained increased mathematical understanding. For example, they learned to use the mathematical typesetting program, LaTeX, a skill that “will benefit the final year project” (Nicola). Ray noted that his “multi-tasking has improved – writing and speaking at the same time”. Also, they commented that they will change the way they study and prepare for examinations by “going more for relational understanding rather than learning how to do questions” (James); “not question spotting in preparation for examination – I don’t think I will do that anymore” (Ray).
More importantly, the interns realised that in their efforts to find better ways of explaining the content to their peers they had undertaken a deep learning process and understood the material for the first time, as indicated by this comment:

*I have learned so much about the module that I didn’t know before; I kind of wish the exam was like today. I would have completely aced it. Just through reading all notes backwards and just reading up books on it, trying to find applications, stuff like that. I kind of wish I did this module again.* (James)

While it was to be expected that students recognize that teaching a topic requires more understanding than they had mastered when they were focusing on assessment, we were positively surprised to learn that the students were planning to change their approach to study for deep learning in the future.

### 5.2 Interns’ Contribution towards the Production of Mathematics Screencasts – Student Perspective

The interns were asked how their screencasts differ from those developed by a lecturer, what aspects of a screencast they think they are able to do better than their lecturer, and vice versa, and what they brought to the project that a lecturer could not have done.

The interns pointed out that their perspective is different from that of their lecturer: “I guess the level would be different if they [the lecturers] had [created the screencasts]. We are going from a level where we have done the module - we have been through it”.

Two interns suggested that a mathematical procedure presented by the interns is more likely to provide scaffolding to help students understand the procedure fully while lecturer-produced content is likely to miss steps for the sake of brevity: “Filling in the step-by-step bits instead of doing like ‘because it is’”.

Students also considered their own struggles with the subject and created content to meet the needs of students whom they believe could be at risk of failure. They said they aimed “at students who could possibly fail while the lecturers were probably aimed at people who are getting 100%”. This seems to indicate that students believe that students and lecturers take opposite views of the target group and level of difficulty of screencasts. As Ray commented, “[It] depends on the lecturer really; some lecturers prefer to get the 30%is up to 50%is; some prefer to get the 60%is to 80%is. I think screencasts should be used as a way of stopping people from failing rather than pushing 2.1s to high firsts”. Maybe the student perspective is not surprising, given their brief was to seek to improve module pass rates as an important aim of the project. It would be interesting to see if students who are not given this brief take a similar viewpoint.

However, the interns also acknowledged that the job of creating screencasts should not be entirely theirs but should be undertaken in collaboration with lecturers that have the experience and advanced mathematical knowledge to provide feedback on how to improve the content and the presentation of the screencasts. The interns said that lecturers would be able to provide better technical explanations, they would have a deeper understanding than students do “so maybe something like the slightly harder stuff they are always going to be able to explain better than [students] can”.

The interns also said that they thought they can explain better on a student level – “once we do understand it we are probably better at explaining it to another student than
possibly they might be”. Nicola suggested “making them alongside the lecturer.” The interns, through the production of screencasts, provided supplemental “tuition” whereby they provide alternative ways of explaining concepts to aid comprehension. This, according to Ray and Nicola, they could do under the supervision of a lecturer.

5.3 The barriers to lecturer acceptance of student-created material - Lecturer Perspective

The interviewed lecturers fall into two categories: those with experience of producing screencasts or working with the interns to produce screencasts and those who have no such experience. Three of the five lecturers had direct contact with the interns and provided feedback to them on their screencasts while two had no direct contact with them.

All five lecturers expressed positive views about screencasts as teaching and learning resources. However, their views on the production of screencasts by students for students differed. Belinda and Tim, who have extensive experience producing screencasts for teaching, were the strongest advocates for student-generated screencasts to be used by peers on mathematics courses. Belinda offered the following response regarding student contribution to screencast production:

Belinda: [Students probably have] more knowledge of where exactly the students are struggling. Pointing exactly at the right places where the lecturer might think the students have understood when they haven’t actually because the feedback loop is not as closed as it should be.

This view is similar to that expressed by students. Ellen who closely worked with the interns offered this response:

... students I think sometimes can help the lecturer identify what is confusing about something. Maybe it’s just the notation, or maybe it’s a word. Like, I was explaining something on the board and I was talking about ‘holomorphic functions’ and they just had no idea what I was talking about. Turns out because they called them ‘analytic functions’.

In effect, working with the interns was a valuable professional development experience for Ellen, as she became aware that others may be using different terminology in teaching. In response to the question whether lecturers within the mathematics department would support and encourage the use of screencasts in their teaching, Ellen said, “I think most staff in the department would feel that it would be great to have some screencasts for their module. But they are not going to take the time to learn the software to do it because that’s not an effective use of their time.”

Interestingly, Trevor, who has worked with and seen the interns create screencasts, was supportive of the use of screencast in teaching and learning mathematics and students creating their own screencasts. However, in response to the question of whether he will ask students to create screencasts for their peers for use on his module, he appeared sceptical as evidenced by this quotation: “Um... Probably not. But possibly. I’m not ruling it out.”
Not all lecturers supported student-generated screencasts despite the pedagogical benefits that could be derived from the constructivist learning experience for students who create them. For example, when asked if students should be allowed to create their own, a member of staff without experience of creating screencasts, Jayson, offered the following response:

*Why should students create them? No. I would have said not. I don’t think they’d have enough background knowledge to produce a decent screencast [...] That commentary couldn’t be given by anybody. It’s got to be given by someone with a lot of background knowledge of the subject area so they can talk intelligently about what’s on screen and also make a few comments about what’s not on screen.*

In fact, the following statement on student-created screencasts from Jayson indicates his distrust of the quality of students’ work: “I’m worried about the correctness.” We believe that Jayson spelled out what many mathematics content experts think: undergraduates may not yet have the mathematical maturity to create material to help other students.

### 5.4 Student acceptance of screencasts created by their peers

More work is needed to ascertain the specific gains from intern-produced resources, but we do know these were used by students. For example, four of the five *Vector Spaces* screencasts were made available on-line via a Virtual Learning Environment (VLE) to students studying *Vector Spaces* from October 2011 to February 2012. The Table shows VLE reported statistics on the frequency with which the four *Vector Spaces* screencasts were either viewed or downloaded by the 83 students registered for this module. We have no way of knowing whether screencasts that have been downloaded to students’ own computers have been watched multiple times.

<table>
<thead>
<tr>
<th>Screencasts</th>
<th>Number of Views or Downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solving Linear Equations over a Finite Fields</td>
<td>104</td>
</tr>
<tr>
<td>Eigenvalues of Differentials of R[[x]]</td>
<td>137</td>
</tr>
<tr>
<td>Matrices of Inner Product</td>
<td>72</td>
</tr>
<tr>
<td>Example of Gram-Schmidt Process</td>
<td>106</td>
</tr>
<tr>
<td>Inner Product</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Mean number of views or downloads</strong></td>
<td><strong>104</strong></td>
</tr>
</tbody>
</table>

The screencast on Inner Product had an error in the mathematical content and was withdrawn from general view by the module leader. This highlights a difficulty that can arise when students produce learning resources, and substantiates the concerns of Jayson who was "worried about the correctness". At the same time we note that the lecturer was happy for his students to access four of the five screencasts. Moreover in the collaborative effort, the lecturer had the overall responsibility for quality control and duly exercised this in removing the flawed screencast. This data indicates that the second year undergraduates are willing to access the screencasts to support their learning.
More work is also needed to evaluate the actual usefulness of the screencasts for new cohorts of students, for example through the collection of qualitative feedback on the perceived value of the videos for improving student understanding.

6. Conclusion

This study was undertaken to investigate the value of student-created screencasts to support their peers. We conclude that lecturers and students think such screencasts are suitable for explaining mathematical content that requires the practice of algorithms. Time-poor academics alone need not produce the content of mathematics screencasts. Students can be encouraged, but should be guided by content experts, to create screencasts for their peers. Advantages of this approach are that students can highlight areas that learners find particularly difficult. They may add detail to explanations and provide exposition to mathematical content in different ways from lecturers. Whilst the interns seemed to think their explanations could be better than those by lecturers, none of the academics expressed this view.

We have found that the students who created screencasts for their peers took this task seriously and (for the first time) devoted sufficient time to mathematical study to gain a deep understanding and appreciation of its content. This is an important outcome that should be emphasised in times where it is difficult to capture students’ attention as university study conflicts with other interests and many are superficial and opportunistic learners [23, 24]. We have identified several benefits to students though the process of producing screencasts for others: increased and deeper understanding of mathematical topics, improved technological skills, improved study habits, improved personal and organisational skills, and enhanced communication skills as these students had to explain mathematical concepts in a clear, coherent way to others for the first time. This confirms that the findings from other disciplines as described in the literature review also apply to a mathematical context.

While we acknowledge that payment may be a contributing factor for students to engage at high levels with the content and the project, we believe a much stronger driver for motivation for the four students was the fact that they knew they were creating something useful as their resources would support future students in their mathematics learning; but also that they felt “special” as they had been selected via a competitive process for their internships, and through this project were given the chance to work directly with academic staff.

While not a recipe that will suit all students, we see a need for further investigation of student-produced mathematical content – for instance as part of assessed or non-assessed coursework, or as part of special projects similar to that described here. Although for some students, the learning curve for learning to use screencasting software and hardware may be steep, students can be encouraged and trained to create screencasts on a shoe string [24, 25] for their own learning and for the learning of their peers. Indeed, with ongoing improvements to software and hardware and also a general rise in related computer literacy witnessed by the explosion of video objects which are readily incorporated in social media, this learning curve is unlikely to be a barrier in the future. We may even go as far as to suggest a “flipped” flipped classroom – where students rather than lecturers produce the screencasts that then form material to be studied outside class to allow lecturers to focus on concepts students find difficult.
Although both lecturers and students stand to benefit from collaboration in screencast production, some academics may find it difficult to relinquish their expert and authoritative status to become guides and facilitators of student-produced screencasts. Nevertheless, as we saw from Ellen’s comment above on terminology, there is evidence that getting involved with students in this way is a valuable professional development opportunity for lecturers themselves, and one which can lead to general improvements in the learning experience for students.

Our study has raised a number of questions which will be of interest in future research. In future studies the perception of students who use these student-created resources will be of interest. Specifically, is there evidence that **insight** provided by such resources has particular resonance with the students in ways that lecture-produced resources might not? A fine-grained analysis might bring to the fore specific instances where this insight is evident.

We have alluded to the ways in which the professional development of the lecturer might be encouraged as a by-product of this environment where staff and students are working together in resource creation. Future work could usefully explore this avenue further along with the extent to which there is a ripple effect into other modules they teach, and to other colleagues. Finally, the learning benefits accruing to the interns could be systematically analysed by comparing their subsequent module grades with what might have been expected given their prior achievement levels. Of course, many factors may cause students to improve their performance in later years of their degree, but an attempt to measure the consequences of being involved in a project like this would be worthwhile.

In summary, our study has found that students can make a valuable contribution to the development of mathematics learning resources and that peers will download them although future work is required to drill down and get student opinion on student produced resources. We have also found that lecturer reservations could be overcome through close dialogue between the lecturer and students. The benefits to the student producers themselves are immense, in terms of developing mathematical understanding and a broad range of transferable skills. Similar to the results from accounting in [19], we find that the use of the screencast technology in this way has engaged and motivated the students who produced the screencasts, and turned them into active learners.

**References**


*Figure 1: Complex Variables screencast on Laurent Series (left) and on contour integration (right)*