The Assessment of Undergraduate Mathematicians: Recrafting Assessment of Learning to Provide Opportunities for Assessment as Learning

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This article considers assessment practices in the field of higher education mathematics courses. It argues that, within the potentially deleterious context of summative assessments, it is possible to re-craft the demands on students in order to incorporate some opportunities for educative assessment. Evidence, in the form of stories of students' experiences, is offered to suggest that such practices have a contribution to make to supporting students in making positive disciplinary relationships.

Introduction

Recent research into students' experience of undergraduate mathematics at an English university included an account of those who fail (Macrae, Brown, Bartholomew and Rodd, 2003). The university which was the object of that study is among the elite higher education institutions for mathematics in the United Kingdom, so entrants arrived there with a history of success with the subject; yet a minority of the participating students performed so poorly in their assessments that they were unable to complete their course successfully. For example, one student, coming to the University with four top grade Advanced Level passes, failed his final year and left without obtaining a degree. Tellingly, we suggest, he was from an ethnic minority background which was untypical of the institution's intake; he had attended at an inner city comprehensive school in Birmingham, again untypically; and he was the first member of his extended family to go to university.

This article reports on research data from a significantly different higher education institution, drawing on work currently taking place in the teaching of mathematics at the ex-polytechnic university in England where we work. It falls within an action research paradigm. We have previously reported an overview of this research project (Povey and Angier 2004). Further analysis suggested that assessment - the nature of the assessments undertaken and the students' response to them - was a key aspect of the students' experience: patterns were observed which will be reported more fully elsewhere. Here, we focus on just two of the students who participated in the study, Geoff and Anna (pseudonyms). Each had previously failed in university mathematics, but they both went on to become effective mathematicians, achieving first class honours standard in their final
mathematics assessments. Brief stories are told of these two students, pointing up how each of them engaged, more or less wholeheartedly and/or effectively, with the educative aspects of their assessments. We do not regard this research methodology as unproblematic, but nevertheless want to offer an alternative to ‘the limited approach of method- or technique-led research’ (Nixon et al 2003 p91), one which recognises ‘individuals as living storied lives on storied landscapes’ (Clandinin and Connelly 2000 p24). (See Angier and Povey with Clarke, in press, for a fuller discussion.) We conclude by discussing the positive disciplinary relationships that the students were able to create during their course.

**Assessment Purposes**

In recent years, there has been a great deal written about the importance of assessment in education (see Black et al, 2003, Broadfoot and Black, 2004 for recent contributions). Currently, formal assessment can come to dominate the student experience of education at many levels, including at the university. In common with most English universities, these students followed courses which are modularised. A typical pattern was comprised of six separate modules in an academic year, with a separate summative assessment required for each module. Summative assessment, in general, tends to have a negative impact on students, damaging student self-esteem and reducing the student engagement with self-assessment: both these in turn produce a deleterious effect on attainment (Black and Wiliam, 1998a; Harlen and Deakin Crick, 2003).

However, regular and repeated summative assessment is a current requirement at our institution.

Given this context, we try to offer the students as wide a range of assessment experiences as possible and, in the case of almost all summative assessment; we try also to provide opportunities for formative assessment and also for what we label educative assessment as well.

These three terms help us focus on three different purposes of assessment. The distinction between assessment of learning (summative assessment) and assessment for learning (formative assessment) is now a familiar one (see, for example, Black and Wiliam, 1998b). This paper also explores the notion of assessment as learning, educative assessment, where assessment practices are constructed to be part of the learning process itself. We argue that these educative aspects of assessment help create opportunities for previously lower attaining students, particularly those who come to the university with less social and cultural capital, to re-create their mathematical sense of self productively and in such a way as to support their personal epistemological authority.

Typically, summative assessment of learners has been concerned with certification, its purpose being to pass, fail, grade or rank a student; additional purposes may be to select students for future study or employment or to predict success in future study or employment (Earl, 2003). Summative assessment has also become very widely used as a policy tool (Broadfoot and Black, 2004), largely linked to quality assurance: in this case, it is still concerned with passing, failing, grading and ranking, but this time of institutions (or of teachers) rather than of learners (Barton, 1999).

On the other hand, formative assessment has been concerned with feedback from teachers to the learners themselves on their performance and their learning; and its purpose has been to provide information to teachers and students for the enhancement of learning (Black and Wiliam, 1998b).

In the case of educative assessment, the assessment practices are recognised as themselves being part of the learning process. Sometimes, the expression ‘assessment as learning’ is used to describe certain classroom practices which better support the educational development of students (Earl, 2003), emphasising the importance of classroom feedback on well designed tasks as a critical element in helping children learn. Whilst sympathetic to such an approach and sharing a concern with the nature of tasks which are set for learners, the focus of this article is rather different: it is concerned with changing summative assessment practices to make them, at least in part, educative too.

**Our Assessment Practices**

It will be helpful to have some sense of what assessment the students faced. In general, in our assessment practices we aim to devise tasks which are challenging learning experiences that develop skills and lead the student into new areas of mathematics, rather than closed tasks which take the student back over prior study. Details vary from year to year, but the mathematics assessments for these particular students included:

- conventional three hour examinations;
- oral presentations to their fellow students of independent mathematical research;
- posters reporting their own mathematical work on given topics;
- academic essays about the history of mathematics which included working in depth with the associated mathematical topics;
- individual mathematical projects on topics of the students’ choosing leading to individual reports;
- group projects on a given topic assessed by extensive written joint report and individual viva;
- academic essays about the nature of mathematics requiring an understanding of recent mathematical developments; and
portfolios of more open and/or more closed problem-based coursework tasks.

Those aspects of the assessments that we are labelling educative have a number of characteristics. Firstly, the students have the space to explore and find out about their mathematics, space in which to try out different approaches to the subject, space to develop their own ideas. The criteria for assessment allow a wide range of skills to be acknowledged, for example, posing problems as well as solving them or communicating their mathematics visually or orally. Mathematical imagination is valued. Secondly, the students have the opportunity to become aware of their own progress and to find out about themselves as learners of mathematics. For example, they are sometimes asked to give an account which includes: reflections on their attitudes and emotions or to elaborate the process of bringing their mathematical thinking to fruition; explaining and evaluating choices, approaches and methods. Thirdly, many of the assessments involve negotiation, either with their tutors or with their peers or with both. In some cases, this challenges standard conventions of where authority lies, for example, devising the criteria by which they are to be assessed or deciding, in part, how marks are to be allocated amongst themselves at the end of group projects.

The Study And Its Context

The participants in this study were the members of a small cohort of students following one of the longer routes into secondary mathematics teaching. On their course, they studied undergraduate mathematics for two years within the context of a centre for mathematics education; (this was followed by a professional year). They studied mathematics to honours level, but within a narrower range than would a cohort of students following one of the longer routes into secondary mathematics teaching. On their course, they studied undergraduate mathematics for two years within the context of a centre for mathematics education; (this was followed by a professional year). They studied mathematics to honours level, but within a narrower range than would a single honours student.

For the research project, we interviewed each of the students, sometimes alone and sometimes in pairs. The interviews, which were taped and transcribed, were fairly unstructured and were personal and informal in tone. We began working with these texts in a familiar way, each reading and re-reading the transcripts, immersing ourselves in the data and searching for themes. In addition we drew on other qualitative data: written reflections from one or two of the students and email conversations with one or two others. We had not expected the students’ experience of assessment to be a key issue, but it emerged as such from this initial data. In order to explore this theme, we decided to add to our data by looking at some of their written assessed work as well. We used narratives, extracts from two of which follow, to re-interrogate the data. (Unless otherwise stated, the data presented is from the interview transcripts. These have been subject to minor editing for clarity.)

Geoff’s Story

When he started his current course, Geoff was 32 years old and had spent most of the previous decade working as a heavy goods vehicle driver. Before this, he had performed moderately at mathematics at school, but had then, twice, failed the first year of a mathematics degree, once at a Scottish technical university and once at a London polytechnic university. Naturally, following these experiences, mathematics had felt very much like “unfinished business” for Geoff: he had made the very risky decision to return to higher education. In our interview, Geoff was asked to compare his previous experiences of mathematics with his current ones. The first thing he mentioned related to assessment.

“It’s a very different course. The others were predominately exams which make a big difference. … [Previously] you’re taught, you do an exam and you either pass or fail whereas here it’s like "Well now you go and find out something" or you work something out for yourself. We have done a couple of assignments where you start without looking at any reference material at all, it’s just your own – you’re given a starting point and go off and work it out for yourself sort of thing. It’s just completely different.”

We asked him to consider the role of examinations on his current course, particularly the conventional examination with which the pure mathematics strand of the degree finishes at honours level.

“It’s quite bizarre really saying that I don’t like exams. I’ve only done two on this course so far and I did really well in both of them that - having said that, I don’t particularly like them. I got back a little bit into the old style which was get all the information in the sessions and then, a week before the exam or a few days before the exam, you then think about organising your notes and seeing whether you can actually remember any of it. So it was a bit of a cramming session really. That’s not to say that I didn’t pay attention in every other session because I did and I enjoyed a lot of the work that we did, but it was very much of a “I can put this thing aside until I really need it just before the exam” which is not necessarily the best way to do it.”

He compared this with his active and personal involvement with coursework assignments.

“For that [exam module], I admit that I didn’t do any extra work, I didn’t follow it up. I did far too much work in other units which were less credit. But that’s because it was coursework, it was an ongoing thing, and I kept going back to it and, you know, sharpening it up and adding extra bits and so on and - that’s probably what happens when it’s an exam thing, an exam at the end, you can put things aside and not look at them again. So the coursework keeps you actively involved in the subjects.”

He had found that the method of assessment significantly affected his relationship with the subject, how he worked,
and his level of engagement. Whereas coursework assessment was educative, examinations not only were not educative in themselves, their influence also spilled over into less productive ways of working within the module itself. The issue of authoritative knowing (Povey, 1995) was a central one for Geoff. Being assessed on his own ideas, on work he had had to structure for himself and defend to himself, was of fundamental importance to him. He was drawn into this in such a way that his relationship with mathematics and his understanding of himself as a mathematician changed. As he neared the end of his course, Geoff was able to see himself not just as a receiver of other people's mathematics, but also as an author and originator of mathematics as well.

Anna's Story

Anna was in her early twenties when she joined the course. She had previously started a degree in Systems Engineering at a Scottish technical university, but left after three months. Last minute pressure from her mother had led her to enrol on the current course and she was very ambivalent about her decision. The central problem in her previous university studies had been the teaching style adopted and the concomitant model of knowledge and assessment.

“We had lectures in bulk. I think it was up to 300 people in the lecture and then the tutorials were about 20 to 25. I knew that I couldn't go back to that kind of learning ... because it wasn't personal. All they were doing was they gave us good notes … it was very directed, like one guy literally said at the beginning of term "If you sit here and write down every single note that I make on the OHP then you will do fine" - and that was all we had to do.”

Anna claimed that, in contrast, she found the processes to which she had been introduced as part of her assessed work on her current course helpful in developing her mathematical thinking. But she also found our way of working difficult to come to terms with. For example, some assessments require the students to reflect on the mathematics they are presenting and on how they came to know it.

“I find it strange that tutors care enough or find it important enough to find out what we think and get us to write these strange ramblings. It's even funnier that the more honest and completely blunt I am, the more excited the marker seems to get. I still find it odd when tutors are excited about a project we are going to do – it's almost as if they can't wait for the results. It's great to have such a high degree of choice … we are encouraged to take part in 'airy fairy' investigations, but tutors don't seem to be fazed by the fact that I get frustrated and take it out on everyone else, which often frustrate me even more! I remember shouting at [one tutor] about the ridiculousness of doing [a particular] assignment … while she sat excitedly talking about all the different lines of enquiry and possible variables … (notes sent to us)”

It is clear that the educative aspect of the assessments is not universally welcomed and enjoyed by the students. Anna had some positive experiences to relate about engaging with assignments, but could find the openness of the approach and the lack of overt structure frustrating in the extreme. Anna consistently produced coursework of a very high standard indeed, but she always claimed to be surprised when her work was valued by other people - her peers and her tutors - and she found it hard to recognise and appreciate her own achievements. She still struggled with thinking about mathematics in a broad and creative way.

“I think I liked having the choice, but at the same time I find it hard, especially getting started, because I'm never sure what I want to do. And I think it's hard as well at the end because I don't necessarily feel that I have learnt anything, whereas looking at other people's work I think "wow". You know, they've done so much and they must really understand it now. And I look at what I've done and think "well, you know, this is quite good, but I really don't think I've done that much"  ... all the time I'm understanding that my definition of maths is too narrow and so you know people say “oh that's good" when I think I haven't actually done any maths. So it's confusing that they think that what I've done is so amazing when actually I don't think I had a lot to do with anything. So it's kind of like how I perceive maths.”

Anna seemed to us to revel in her mathematical studies, but she leaves us challenged by our ineffectiveness in engaging her fully in educative assessment. Nevertheless, despite her difficulties, she asserted strongly that her relationship with mathematics had changed significantly, that she had learnt to appreciate mathematics more and that she had had “the privilege to be involved in some “wow” moments as a result of her creative engagement with the subject.

Discussion

We have used student stories to try to capture something of the experience of what we have termed educative assessment. Our students struggle and we expect them to do so. They struggle with the mathematics, they struggle with our definitions of mathematics and they struggle with the forms of assessment that we practise. They may not necessarily agree with our stance – indeed the evidence suggests they often do not – but they are consciously engaging in the debate about what is of value. We recognise the description given by a teacher supervisor of students in Denmark for whom the learning of mathematics in higher education was entirely structured around their assessed project work. In the early stages of their learning,

“the students feel ‘overloaded’ and experience a mild form of hopelessness. They have to work a lot on their own without the usual, small, reassuring problems. This is fully intended because it, to some extent, stimulates the researcher’s state of mind.” (Vithal et al, 1995: 204)
We believe that that ‘researcher’s state of mind’ is developed by educative assessment practices, where the students have to engage in doing mathematics, in creating the mathematics for themselves, rather than simply meeting the results of the mathematical activity of others.

In many countries, few people choose to study mathematics in post-compulsory education and, of those who do, many are reported failing and/or dismissing the subject (Mann, 2003; Macrae et al, 2003; Boaler and Greeno, 2000). Jo Boaler found students were unwilling to pursue mathematics because “they did not want to be positioned as received knowers, engaging in practices that left no room for their own interpretation and agency.” (Boaler, 2002:115)

Many undergraduates find current practices which emphasise a “performance” route (Mann, 2003:20) to success, with mathematics being “a kind of competition you train for” (Mann, 2003:19), alienating and oppressive. We suggest that conventional assessment practices in mathematics in higher education, currently almost exclusively individual timed examination performance (Rodd, 2002), contribute in no small measure to this. The two narratives indicate that students’ assessed work is an important site for the building of their relationships with the discipline of mathematics and for their work on their developing identities as mathematicians. They give evidence that re-crafting assessment practices to allow frequent opportunities for educative as well as formative and summative assessment impacts on ways of knowing and contributes to allowing the development of both epistemological authority and agency in learners of mathematics; and that these things happen in ways which open up the subject to wider participation and make successful engagement with mathematics not just the prerogative of the few.

References
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