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Reshaping understandings of teaching–learning relationships in undergraduate mathematics: An activity theory analysis of the role and impact of student internships

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ABSTRACT

This article presents an analysis of an intervention intended to address an aspect of undergraduate mathematics education that is frequently described as a situation of deadlock, between second-year undergraduates who are disillusioned with their university mathematics experience, and mathematics departments which describe many students as lacking interest in, and awareness of, the nature of university-level mathematics and how it is learned: whilst departments strive to support such students, the extent to which they can do so is often seen as limited. The SYMBoL project was designed to address this situation in terms of improving dialogue between students and staff through the introduction of undergraduate internships which challenged traditional hierarchical roles and relationships. Using third generation activity theory to analyse the nature and impact of the internship role, we show how the project legitimised the student voice as channelled through that of the interns, created shifts in perceptions of the problem, and began a process of transformational learning about possibilities in undergraduate mathematics teaching. We consider the implications for developing university mathematics teaching within the wider context of tensions across university systems.

1. Background

This article presents an analysis of an initiative designed to break a longstanding 'deadlock' in undergraduate mathematics education through the introduction of student interns as mediators in second-year teaching and learning relationships. The nature of the deadlock is well-documented, involving high levels of student disillusionment and alienation from the nature, practices and constraints of university mathematics teaching on the one hand (see for example Daskalogianni & Simpson, 2002; Solomon, 2008), and staff complaints about students' lack of interest, understanding and preparedness for university-level study on the other (see Hawkes & Savage, 2000; Smith, 2004), a situation which reinforces staff perceptions that there are limits to the support that they can offer. The issues were highlighted in the Student Experiences of University Mathematics (SEUM) project (Brown, Macrae,

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Rodd, & Wiliam, 2005), which tracked students in two research-intensive British universities. Reporting from that project, Macrae, Brown, Bartholomew, and Rodd (2003) found that it was impossible to reliably predict students who would fail two or more modules in their second year on the basis of their pre-university entrance A level Mathematics or Further Mathematics grades, nor was it possible to predict outcomes on the basis of diagnostic testing upon entry. They concluded that "it is difficult to know what more the university could do to support these struggling students" (p.20). Others report similar findings, suggesting that the problem is widespread. Daskalogianni and Simpson (2002), in their study of undergraduates in a (different) prestigious UK mathematics department, refer to a 'cooling off' phenomenon as students lost interest, and became increasingly withdrawn in a vicious circle of disillusionment and personal disappointment. Similarly, Goulding, Hatch, and Rodd's (2003) survey of trainee teachers' experience of their mathematics undergraduate courses in 65 universities found reports of struggle and lack of support from staff.

Many universities have developed mathematics drop-in centres aimed at addressing the perceived deficit in school-leavers' knowledge (Lawson, Croft, & Waller, 2012), but their impact tends to be limited to first-years, whose problems can be addressed by a range of staff. Support for more specialist second-year material is more difficult to provide in a drop-in context, and problems supporting second-years remain (Croft & Grove, 2006). The perception noted by Macrae et al. (2003) that there is little more that universities can do to ameliorate the situation continues. Whilst students frequently criticise the nature of teaching and learning relationships in university mathematics (Pampaka, Williams, & Hutcheson, 2012; Solomon, Croft, & Lawson, 2010), instances of fundamental change in these relationships are few and far between. Addressing this, Croft, Solomon, and Bright (2008) suggested that student negativity might be ameliorated by improving opportunities for involvement in both peer and expert communities. The project reported here was designed to take this agenda forward by involving students in the expert community in an organised and integrated fashion in the form of internships focused upon developing teaching and learning by opening up a dialogue between students and staff and becoming involved in the development of resources. In this article we report on this attempt to break the deadlock, using activity theory (Engeström, 2001) as an explanatory tool in our analysis of the process and potential impact of this intervention.

2. University mathematics as interacting activity systems

Following Ashwin (2009), we suggest that teaching and learning interactions in university can be represented in terms of Engeström's (2001) third generation activity theory, that is to say, in terms of at least two interacting activity systems. An activity system consists of a collection of individual subjects with a shared object for engaging in what they do, achieved via the use of mediating artefacts, which include language and physical tools. Activity is characterised by a division of labour which denotes which members undertake which tasks and produces differences in power and status. Rules are an inherent part of the system, and relate to both explicit and implicit norms and conventions. An important aspect of activity-theoretical analysis is that it should explain and capture processes of continual change; inevitably, a collective involves multiple and potentially conflicting points of view, and the arising contradictions play a central role in development and change. Third generation activity theory focuses on the interaction between activity systems which, significantly, may not share the same object: the potentially contested nature of the object in this situation and the implications for division of labour are of central interest to us here.

As Ashwin (2009) points out, the application of activity theory to higher education requires making some decisions. Some researchers opt to depict the situation – a course module, for example – as a single activity system. However, this entails privileging either staff or student perspectives, or seeing both as part of the same system — but we share Ashwin's view that it seems unlikely that tutors and students share the same object, or that the same rules apply, or that they relate to the same community; for example, Solomon (2007) found that undergraduate mathematics students explicitly reported belonging to a community that was distinct from that of their tutors, an issue pursued more recently by Biza, Jaworski, and Hemmi (2014). Ashwin's adaptation of Engeström's (2001) illustration of two interacting activity systems is useful for our purposes in highlighting how the object of the interaction will be different for the academic (teaching object) and the student (learning object) and that during the course of their interaction perceptions of that object will change, and may – or may not – develop towards a shared object. Even more importantly for our current purposes, this adaptation points out and draws on the fact that these interacting activity systems themselves interact with other systems. We can view this from the perspective of identity, whereby, for example, an academic member of staff not only enacts an identity with respect to their role in the undergraduate programme, but also will have an identity as a member of the university, or as a professional mathematician in the international community. This complexity is mirrored in student identities which, as Jaworski, Robinson, Matthews, and Croft (2012) note, will also be based on membership of other activity systems and histories of earlier system membership (notably, schools).

There will be tensions both within and between activity systems. For undergraduates, a primary object may be developing disciplinary knowledge but it will also include being awarded a degree; Hernandez-Martinez et al. (2008) note that mathematics students had many different objects in terms of their aspirations for university. For professional mathematicians working in the academy, the object of their activity system will *include* providing learning opportunities for students but, as we shall see, this may not be their primary concern, being frequently subordinate to another object, *producing and publishing research*.

Finally, turning to the role of mediating tools and artefacts, whilst these play a central role in the teaching and learning situation, and may be shared across the two activity systems of students and staff, Ashwin points out a crucial difference in the relationships that each group has with these tools and artefacts: academics choose what topics students will learn, they control learning spaces, and they design and produce learning materials. Although students may also produce their own learning tools, these will not have the same significance.