Supporting students in their transition to university mathematics

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Our *Transmaths* projects aimed to understand how different practices in mathematics during the transition to higher education impact on students' dispositions and identity and influence their future success in mathematically demanding subjects. In this paper, we discuss three examples of university transition support mechanisms and how these seem to be helping students, in particular those who are considered mathematically weak, to make a successful transition into university. We discuss implications for pedagogy, curriculum and institutions.

Keywords: transition, undergraduate mathematics, boundary crossing, resilience, learning to learn

Introduction

Our *Transmaths*[1] projects take a socio-cultural theoretical perspective to try to understand how different educational practices in mathematics at College and in transition to University impact on students' dispositions and identity, hence influencing their choices and future success in subjects that demand high levels of mathematics.

In this paper we draw particularly on three of the projects' papers (Williams et al. under review, Hernandez-Martinez and Williams accepted, Farnsworth and Williams under review) to elicit a discussion on different university transition support mechanisms and how these seem to help different students to achieve a successful transition. The papers take different theoretical concepts, such as 'brokering', 'third spaces', 'resilience' or 'learning to learn', to explain how learners interact in different ways with the socio-cultural contexts in which they participate and in particular during transitional moments which pose challenges and obstacles to students, especially in relation to mathematics.

In the following, we briefly describe these papers and discuss the implications that our conclusions might have for pedagogy, curriculum and institutions.

Practices that support the transition to University

Boundary crossers, brokers and third spaces

The Williams et al. (under review) paper approaches the subject of first year university mathematics provision from the perspective of different 'boundary crossers', those who experience moving between two different activity systems like school and university. Some of these can also become 'brokers' (in the sense of Wenger 1998) or facilitate the creation of 'third spaces' where elements of both systems meet and new meanings are created (in the sense of Gutierrez, Baquedano-Lopez and Tejeda 1999). The paper describes the cases of James, an engineering

student, Joanne, who teaches mathematics at school and university, and Lilian, a tutor responsible for the mathematics support centre at her university.

James dropped out of an 'elite' university engineering course because mathematics was "too hard". He switched to a less 'prestigious' engineering course in his local post-92 university, where he found himself doing very well: the mathematics was "a lot simpler" and his relative maturity, he said, "favoured" him. At the end of his first year he got 'first class' grades. It seems that several elements contributed to James' successful transition from one university to the other: although mathematics remained something of a problem in a few courses, his perception in general was that it was "a lot easier, more understandable" and "more enjoyable" because mathematics was taught more slowly, in smaller classes and, in general, the course contained more practical work and projects than that in the 'elite' university, something that is closer to how James sees himself professionally, "a more practical engineer". However, it seems that on reflection James regrets the loss in status and the exchange value associated with a qualification in a less prestigious university, and also that he now considers mathematics important: it is difficult, but this makes it valuable.

Joanne teaches mathematics part-time at school (Advanced level Calculus) and university (first year mathematics for engineering), but remarkably the topics are very similar. The university has employed her to 'teach' students that are mathematically weak, mainly those coming with a vocational qualification. Our observations and interviews with her led us to identify several differences in her practice at school versus university: (a) the pace of the work at university is much faster but given that her class is small (around 20), students feel that they are getting a quality, one-to-one time with the lecturer; (b) the expectation that students at university should be more independent in their learning, which was shared both by Joanne and her students, but also the realisation that this independence is harder to obtain in mathematics than in other subjects and that the gap in the mathematics to be learnt was just too big; (c) Joanne's use of formative assessment, by being aware of individual needs and constantly reinforcing students' understanding; and (d) the constraints at school about performance in lessons and exams and how these pressures were totally different at university. We see Joanne's work as one of brokering by introducing elements of school teaching (perceived as good quality teaching by her university students) into the university system.

Lilian works at the same university as Joanne in the mathematics support centre. Her work there involves not just teaching mathematics to anyone that needs help but also helping them "learning how to learn". She is also proactive in dealing with more than just a "sticking plaster job", but talking to lecturers and making them aware if a group of students are having problems in understanding certain topics, and giving lecturers some feedback on their teaching. Crucially, the institutional status of the support centre provides Lilian with the authority to 'broker' between students and staff, making the centre a 'third space', where developmental work takes place.

From the experiences of these three 'boundary crossers' we conclude that many students appreciate extra help in transition, which includes amongst other things smaller, interactive classes, a slower pace when focussed on critical difficulties, a more expert teacher who knows how to identify students' problems and "take them on from there", but perhaps more important, institutional spaces where brokering work is made possible, and that have the potential to generate a cultural change and professional development, and not just a quick fix.

Building resilience

The Hernandez-Martinez and Williams (accepted) paper focuses on the concept of resilience and how some students that are statistically considered 'at risk' because of their cultural and socio-economic background are able to build resilience and persist to achieve a successful transition.

In this paper, we define resilience as a dynamic process of interaction between sociocultural contexts and the agency of developing individuals. Taking Bourdieu's notion of social and cultural capital as representing the capacity to exercise agency in a field, we add a note on reflexivity: that students can develop capital through reflection, particularly on 'critical moments'. This capital can allow for agency in new fields (for example, during transition), and the possibility to negotiate successfully their habituses with the conditions of the new field.

We illustrate this concept with the cases of two students in transition: Jenni and John, who have acquired some capital during their schooling which became valuable during their transition. Both of them had negative experiences of mathematics at school, Jenni being in a disruptive class and John being in a "shit school" with no provision for further mathematics. Jenni experienced a 'critical moment' when she reflected on her situation and decided that she had "had enough now", blocking out her disruptive classmates and becoming a more independent learner, changing her 'hate' for mathematics into 'love' for the subject. This reflective development of such educational capital provided her with the necessary agency during transition to make her habitus resonate with the new field and take full advantage of what the new institution had to offer to students that have a more mature and independent approach to learning. In the case of John, his experience of having to undertake distance learning through the Further Mathematics Network provided him with the necessary capital (through a process of inner reflection) to persist during transition at moments where "nothing makes sense", especially in the case of mathematical proofs. His more mature approach to learning (as opposed to his peers that still expect to be 'spoon-fed') ensured that his habitus aligned with a new field that values such capital. In both cases, we emphasise the importance of different sources of capital, in Jenni's case a supportive and encouraging family and in John's case a special teacher who advised him and helped him see what it means to become a 'good' mathematician at university.

Therefore, we claim that resilient students are those who actively engage with a reflective process (which can be a critical moment) in which individuals become consciously aware of their need to break with what is taken-for-granted and therefore are able to develop certain social, cultural (and specifically educational) capital that they can bring to bear in a new field, giving them a certain agency to negotiate the transition successfully. Despite the poverty and other factors that put these students 'at risk' statistically, they show how significant social capital from their family, school or peer group can make the difference in their conscious acquisition of this educational capital.

We conclude that processes that encourage reflexivity in students should be incorporated in school pedagogical practices. This requires spaces to discuss, argue, question, think and connect mathematical ideas, but also spaces where learners can relate appropriately with a peer group, teachers, family and community, which are the sources of valuable forms of capital.

Learning for understanding and self-regulation

The Farnsworth and Williams (under review) paper approaches a first year university Medicine case study, where the main feature is a 'problem-based learning' (PBL) approach. This study provides insights into how students change habits, perceptions and beliefs about learning as they transition into their university studies.

By the nature of their degree, students in this case study reported themselves to be highly motivated to complete the course and to have an imagined future in medicine firmly in mind. The PBL approach to teaching/learning meant that some of these students found the 'transition gap' greater than other types of students who experienced a more 'traditional' teaching approach. In brief, PBL means that students are not directed to particular texts and that they are not directed by a tutor but only mentored and steered if they are going off track. Discussion with peers, more experienced students and tutors, are essential to learning through this approach, and some students realise that talking "about something from the top of your head (…) pushes you to learn it". Students experience a change in the way they see learning and really appreciate that "all that matters is whether I understand it or not and I can explain it to my colleagues". Mathematics learning, in particular, becomes for some an independent, self-directing task as one student expresses:

> Maths, for example, I found I learned a lot better by going on the Internet and looking up things like long division. Somehow, if you do it yourself you actually read it and you actually assimilate the knowledge.

The fact that PBL appeals to students' identification as future doctors, and how this influenced their learning, is clearly expressed by a student:

> [We were] trying to be almost, like, mini doctors when they're looking at the case the first time, because I think that's PBL, but try and diagnose something when you first see it and then linking them together as opposed to going home and say, "Oh, I don't [know] something and someone will pick it up".

The analysis identifies a learning system that is structured around the PBL curriculum and found that, for some students, the different aspects of the system worked together to support their transition. From this case study we conclude that a learning system that aligns students' goals of becoming professional doctors (engagement with future identities) with the norms and rules of the community of practice is better suited to encourage the acquisition of 'learning to learn' skills and a 'self-directed' approach to learning (Gallagher 1997, Rawson 2000). This in turn promotes shifts in students' dispositions and relationships towards knowledge, supporting the transition to higher education where an emphasis is placed on understanding and applying knowledge. We propose that students would benefit from: a) a curriculum that structures the learning system around a common goal, and b) explicit representation of the ways the different aspects of the learning system work together and complement each other to help them reach their goals.

Discussion

There is a concern in Higher Education about high rates of failure in first year courses that are highly mathematically demanding. Almost all universities in the UK have implemented certain mechanisms to alleviate the transition from school to university. However, some of these mechanisms seem not to be effective, or have little effect for those students who are considered mathematically weak but that nevertheless have the potential to become good professionals.

Here we have presented three examples of such mechanisms of support: (1) brokering and 'third spaces' of more school-like 'teaching' practices, such as small(er) classes or mathematics support centres, where effective, more student-centred learning may take place, whether these are institutionalised or not; (2) processes where reflexive work takes place, allowing students to consciously build capital that can give them agency in negotiating challenges such as later during transition; and (3) learning systems that support learning for understanding, 'learning to learn' and engagement with students' imagined future identities in a coherent way.

We believe that these mechanisms of support have important messages to contribute to the discussion of how best to support students in their transition to mathematics at university.

In the case of our 'boundary crossers', the key message we want to put across is that 'third spaces' should serve not as a 'sticking plaster' solution but as a mechanism of cultural change. Such spaces should become a source for professional development and for change based on research and practical experience within the institutional community. For example, Joanne's brokering work is evidently helping students to cope with the multiple changes that occur at once during transition, but because her status within the institution (as not a full-time member of the lecturing staff) does not allow her to influence the practice of the community, the success of her work is limited. In contrast, Lilian's brokering work reaches the community further because of the status that the support centre has within the institution. She is able to provide feedback to lecturers, influencing in this way the practices of some of them.

In the case of our resilient students, an important message is that the 'risk factors', which make these students 'vulnerable', can become central to their development of important educational capital. What we are suggesting then is that learning should incorporate conscious reflective work, and that this work can be best achieved by activities that are challenging, by discussion of different and perhaps opposing ideas, and by teaching content that is authentic and useful. We wonder if this could be possible in a system that prioritises 'exam results' and 'league tables', and if one day this might change to allow the majority of our students to be(come) resilient?

In our medicine students' case, our key message is that pedagogies should be able to 'speak' to students rather than alienate them. Here the notion of identity is vital: 'real' doctors solve problems by discussing with colleagues, by independently researching solutions, by striving to conceptually understand. PBL tries to replicate this and engage students into the community of practice. Students then feel that what they are learning is useful, that they are becoming 'mini-doctors', and that they are being enculturated into the practices of the career that they have imagined themselves doing. We should ask then if this could be applied to other subject areas where future imagined careers are not as clear as those of our medicine students, and where pedagogies might not be able to 'speak' as directly to students' identities? We then must ask ourselves, how much of what we expect students to do needs to be made explicit, and where we can structure the curriculum in ways that encourage students to learn through discovery and self-directed learning (which is actually directed towards a particular goal or imagined future and not a solitary process of the 'self')?

Our current 'knowledge transfer' project is attempting to synthesise our work to impact on policy and practice by creating 'tools' (e.g. policy briefings, new projects, think pieces, etc.) that can inform, persuade, influence and help our project partners and others in implementing changes. The project has been designed around the goal of sensitively transforming substantial research findings, such as the ones

presented in this paper, so that they are best positioned to make a difference in mathematics education.

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End notes

[1] For more information about our projects go to www.transmaths.org

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