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The University of Manchester

TransMaths Research Briefing

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Learning to learn mathematics in transition to university STEM programmes

Summary findings and recommendations

Arguably, given the need for lifelong learning, the single most important outcome of university education is for students to know how to learn and develop themselves. Our analysis of the student experience of transition to university found that the theme of 'learning to learn' emerged as being central. A crucial aspect of transition involves understanding the university system and how it provides formal and informal opportunities to learn. Thus, learning to learn needs to be supported by the university system and a culture which values self-directed learning needs to be established early on in university programmes.

- **When students arrive at university from school they are expected to learn in new ways, in the new system, which is normally considerably more complex than that of the school. Students are unsure how the system – especially 'lectures' - work, what one is supposed to do in lectures, and how this fits in with their informal learning. This may also be the case for tutorials, workshops, online resources, support centres, and so on. However, academic staff themselves seem to hold diverse views of what lectures are for and how the formal system (including other elements such as tutorials) should work, thus presenting further complexity for students.**
- **Students and lecturers talk about the importance of developing students' 'independent learning' in university. Students expect to take responsibility and even relish this, but may believe this means they should learn 'on their own'. But again, students may hold different views from lecturers about what 'independence' means, e.g. with regard to what help they should ask for or can expect.**
- **Informal peer learning in groups can be very important, especially for some students who might otherwise struggle. For example, in some cases lecturers and teachers explicitly encourage and plan for students to work with peers in groups, sometimes in quite formal, structured systems e.g. Problem-Based Learning groups, engineering workshops and science labs - and occasionally in mathematics classes. This can assist the development of peer support networks, or at least the awareness of the importance of group learning.**

We recommend that courses explicitly value and design for 'learning to learn' in their curriculum and pedagogy. This should involve facilitation of informal and formal group work, discussion/dialogue, and formative, peer and self assessment involving metacognitive reflection. University teaching staff should facilitate a learning culture in which students are helped to become more self-directed, making use of new technologies to connect both inside their institutions and beyond, e.g. linking to virtual lectures and sharing with others in online discussion of their learning.

Mathematics learning, identity and educational practice: the transition into Higher Education

The Transmaths research projects investigated students' transitions from school through college into mathematically demanding degree programmes in Higher Education. The focus was on transitional practices and the projects investigated the effects on learner identities, choices and learning outcomes. Using a mixed methods approach, quantitative survey data were analysed alongside a longitudinal series of student interviews and case study data.

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Summary findings

Lectures can be the source of problems and conflict

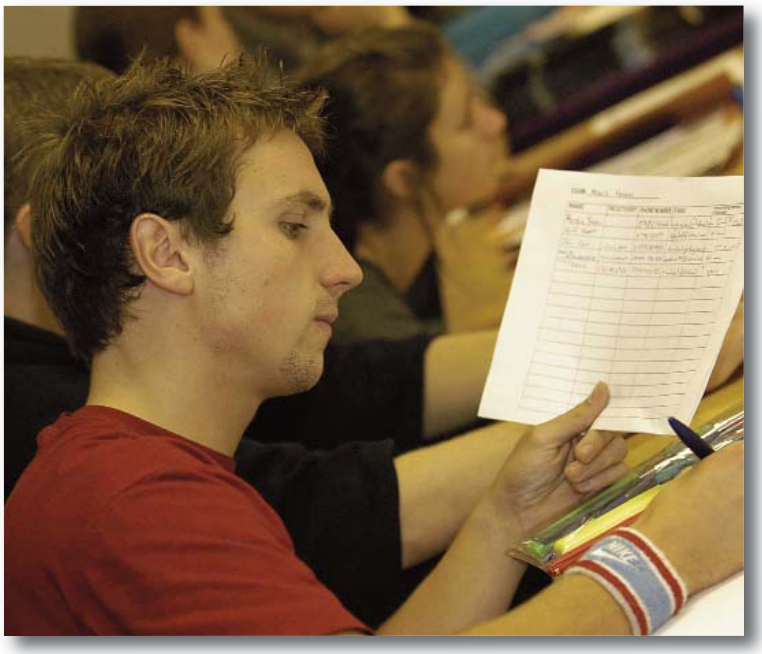
Students often experience lectures at university as intimidating places and are not sure how to learn in them. Claire's and Joshua's remarks are not unusual:

Claire: Uh, it's a bit overwhelming, so many people. I've got used to it now and sometimes the lecturer asks a question, you might maybe try and answer or if he's trying to get people to show hands if they think that's right or that, it's a bit intimidating but I'm getting used to it. *Chemistry, Modern University, semester 2*

Joshua: Well a lecture's there, to take things down- nothing should be understood in a lecture, I don't think. *Mathematics, Riverside, semester 2*

We also found that lecturers themselves held various views of what lectures are for. Chris (mathematics lecturer) takes a traditional view that lectures are where you go to get a good set of notes – based on his own experience of learning at university. On the other hand, Sarah (who has been a teacher and is employed to help students with their learning difficulties in mathematics) engages more interactively and responsively to need, i.e. via formative assessment:

Chris: my attitude was, as a student I always wanted a good set of notes so even if I couldn't follow what was going on in lectures, as long as I'd written everything down I could look at them easily and follow stuff and so I thought that's what I'd give my students,... and I told all the students if you don't want to take notes that's fine because all this material is in the notes, but they loved it and I got the feedback that said that's essentially what they liked. *Mathematics lecturer, Hillside*



Sarah: ... this week in particular, I asked them last week what they were struggling with and what they wanted help with and they said the lectures they enjoyed but they didn't know what they needed to know and they couldn't really answer the tutorial questions on it, so could I identify what they needed to get out of the lectures? So that's what I've tried to do. *Mathematics & Physics tutor, Northern*

Misunderstandings about 'independence'

Students and lecturers talk about the importance of developing students' 'independent learning' in university. Students expect to take responsibility and consider it as a challenge - a part of growing up that they anticipate with relish. But again it is not always clear what this 'independence' means, and many students like Jim think it means they are expected not to seek help from staff:

Jim: I don't expect too much support because they're like ... They (staff) are so busy themselves with whole other classes and research they're doing as well I suppose. *Mathematics, Riverside*

The importance of the peer group

Informal peer learning can be very important to some students. The development of peer support groups can be officially facilitated but this is not often the case. Huzaifa and Stephanie told us, for instance, that this was where they 'really learnt':

Huzaifa: It's different for each module but I think at university it's key that if you have a group of friends and if you can study with them, I think you'll be quite good 'cos you can then bounce off ideas off each other, and help each other on top, if one understands and the other doesn't, and vice versa. *Mathematics, Hillside, semester 2*

When asked how Stephanie's informal group of ten (that has really helped) had formed, it seemed almost by accident, and socially led:

Stephanie: I don't know. I think somebody ... we just kind of met during Fresher's. I don't really remember meeting them to be honest 'cos it's just kind of a haze. We wound up sat, sitting next to each other in lectures and stuff, and then, you know, if you've got an hour free, just be like, 'do you wanna do something instead of me wandering about by myself?' And yeah, a lot of them were already friends last year, because they did the foundation year. So, we kind of, a bunch of us kind of just jumped into this group — *Physics, Northern, semester 2*

In some cases, lecturers explicitly encouraged students to work with peers in groups, sometimes in quite formal, structured situations e.g. PBL in medicine, workshops and

labs in engineering and science. Strangely, mathematics was sometimes exempt from this informal learning opportunity: e.g. some engineering courses see engineering as essentially about 'practical work' in workshop projects, but nevertheless organise the mathematics teaching in large, formal lectures, marginalising mathematics as 'something else'.

Students' perception of the transitional experience: Some survey evidence

We asked students retrospectively to rate the changes that occurred in transition in 13 areas e.g. 'opportunity to ask questions' asking them to rate this as 'less', 'more', 'the same' and how positively they felt about any change (negative, mixed, positive). Interestingly, while most perceived the changes in the way we might expect for the 'amount of private study' (increased), 'teacher control' (decreased), and 'learner responsibility for learning' (increased), students reported no 'overall' significant increase/decrease in 'opportunity to ask questions' or 'opportunities to discuss'. However, as shown in the Figure below, students who were negative about their experiences of transitional change had negative feelings about their decreased opportunity to ask questions and discuss, and vice versa.

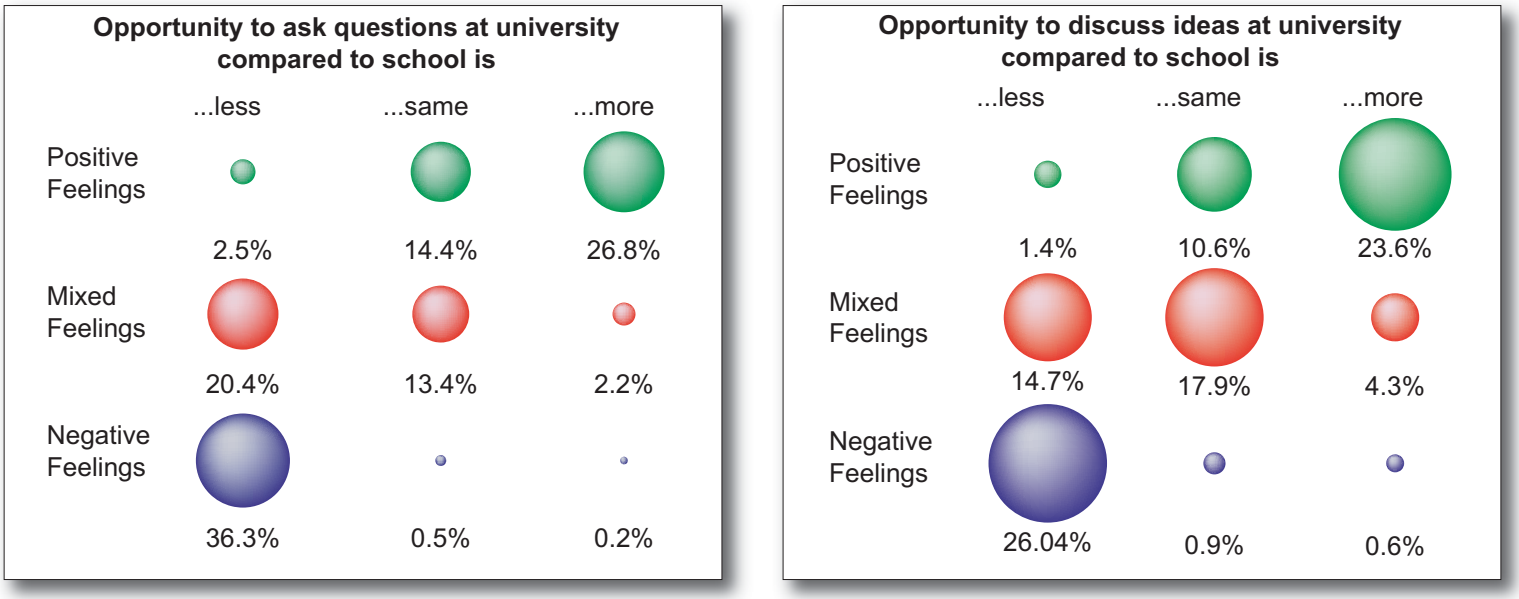
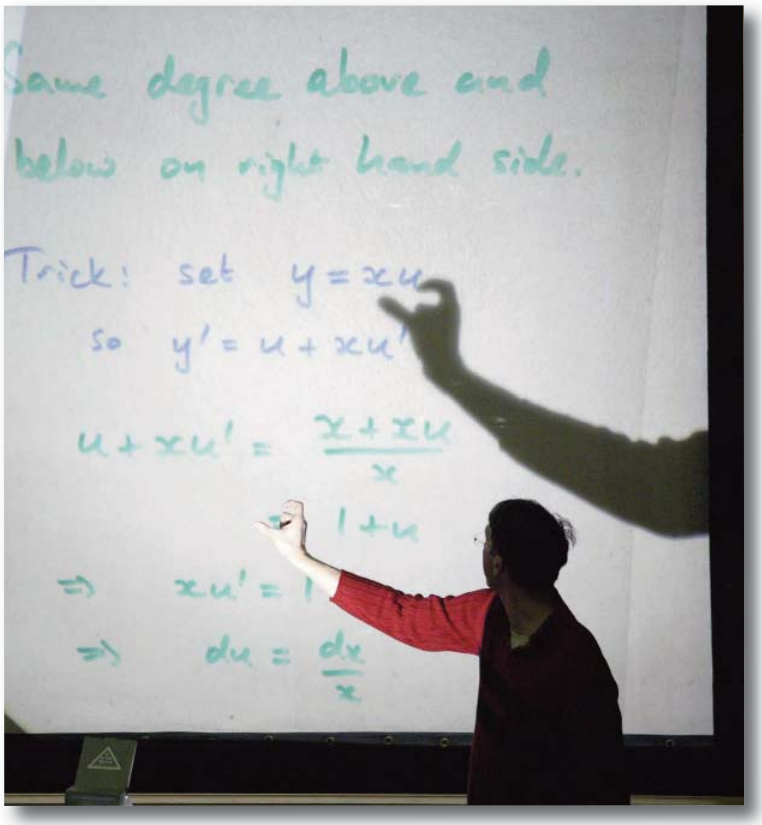


Figure: The graphs show how negative or positive students felt about the increase/decrease in opportunities for 'dialogue' across the transition.

Conclusion

We concluded that there is a need to explicitly address the transition in learning opportunities and typical approaches to learning for students entering university, especially the need for students and lecturers to discuss the different roles of lectures, workshops, tutorials and, perhaps most importantly, informal groups. There is a need for valuing and designing for 'learning to learn', and 'dialogicality', including the need for learners to work together informally, especially in some mathematically demanding subjects.



Implications and recommendations

- The new ways of learning expected at university need to be made explicit and discussed with students, and could usefully be referred to and exemplified in induction, but also subsequently in mainstream lectures, workshops and so on. Students might benefit from training materials, case studies, and tutor and peer (e.g. 'PASS') guidance on the diverse resources and systems available to them. Professional development of lecturers might then specifically address the potential benefits and drawbacks of formal and informal learning methods and how their systems can best support these. Pre-university preparation in schools and colleges should also play their part by introducing students to more diverse learning resources, formats, and ways of learning.
- We recommend that the concept of 'independent' be modified to 'self-directed' learning, so as to impress the importance of the learner not merely taking charge but also the importance of reflective, peer and self assessment of learning, and of seeking help and working with others when necessary. The gap between what students have experienced before university does vary, but it should normally be expected to be significant: this gap or challenge MAY be no bad thing, as long as there is manifestly adequate support to overcome obstacles. Note for instance, students who have experienced the Further Maths A-level network may have an advantage in having been used to self-direction: first year university and regular A-level teaching should be designed to support such student 'self-direction' and 'responsibility'.
- Although there are some students who prefer to work on their own, we recommend that ALL students should be introduced to the benefits of peer group learning, both in formal, structured formats (lectures, workshops and tutorials where groups are expected to collaborate) and in informal situations (this can be encouraged by managing time and space for informal groups to meet, and by means of group assessment).

Where next?

During 2011 the team, with ESRC Follow-on funding, will ?? work with key partners, including the National HE STEM Programme, the National STEM Centre and the National centre for Excellence in Teaching mathematics (NCETRM) to promote participation and engagement in post-compulsory mathematics education for STEM. This work will draw on and synthesise findings across all three research projects that investigated students' trajectories in and through mathematics programmes from compulsory school, through college to Higher Education. Further details of our ongoing work can be found at the project website. Additionally the team are involved with further research that builds on previous work. The ERSC funded project (grant RES-061-25-0538) 'Mathematics teaching and learning in secondary schools: the impact of pedagogical practices on important learning outcomes' will explore issues of teaching and learning in the secondary years of compulsory school.

Further information

The TransMaths projects have developed, and are continuing to work on, a range of publications and other dissemination resources that can be found at the project website: www.transmaths.org

Of particular relevance to the issues raised in this Research Briefing are:

Williams, J. (2011) Looking back, looking forward: valuing post-compulsory mathematics education. Research in Mathematics Education. 13, no. 2: 213-221.

Farnsworth, V. (2010) Learning to Learn in STEM Subjects: Lessons Learned from Problem-Based Learning in Medical Education. Paper presented at the British Educational Research Association Annual Conference, University of Warwick, 1-4 September 2010.

The warrant

One of the strengths of our project that investigated transitions into Higher Education is that it drew on a variety of methods. It used large-scale questionnaire surveys of students (n>1700) at the start of their university course and after the first semester, developed case studies of 13 university courses (mostly in STEM), and tracked a number of students in more depth through three longitudinal interviews (N>50). This provided a rich base of data for analysis.

In addition, we extended the conceptual framework already developed for our previous research project ESRC TLRP 'Keeping Open the Door to Mathematically Demanding Programmes in Further and Higher Education' which explored transition through college in much the same way.

Specially constructed instruments were developed and validated to measure important new affective learning outcomes in the transition into mathematically demanding (STEM) programmes in Higher Education.

The case studies were developed from mainly qualitative investigations and involved observations of lectures and tutorials with interviews of students and teachers. Triangulation was supported by the collection of other university degree course documents and data, and interviews with other stakeholders such as Heads of Departments. The series of longitudinal biographical style interviews about students' transitional experiences provided further deep description and insight into the transitional process.

Our methodological approach is imbued with the notion of generating practical knowledge in partnership with students and university teachers as informed and knowledgeable participants. This partnership approach also provides an ethical (and triangulating) basis for all the empirical, analytical and reporting work. A series of meetings with university teachers assisted in this respect. Finally, our warrant is also enriched by the project's advisory group, which consisted of academics and practitioners with relevant experience, and which met regularly with the project team.

Project website:
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