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TransMaths
Research Briefing

June 2011

The transitional gap between school and university

Summary findings

- The transitional link between school and university systems is structured as a market place where certificates for qualifications such as A level or BTEC provide 'exchange value' for access to university rather than information/learning that is useful:

  - The A-level system, considered as an assessment-for-learning system, is not 'fit for purpose'. It does not adequately support progression to university, in much the same way that GCSE does not support progression to A-level. This is because it is primarily directed at providing the grade needed for the University market, which leads to teaching and learning that is focussed almost exclusively on examination performance.

  - Misunderstandings of what contemporary students with A-level or BTEC qualifications know, understand and can do on arrival at university can make 'responsive' pedagogies and curricula difficult for university managers and lecturers. This is particularly important for mathematics because it supports a wide range of other university subjects, and also because at this level mathematics teaching tends to build on what is assumed or believed to have gone before, whereas other subjects may begin 'from scratch' (e.g. engineering).

- The transition from school to university mathematics presents a classic 'transfer problem' for the learner (e.g. a 'function' in A-level is not the same as a function in University mathematics). Furthermore the transition from mathematics classes to science or engineering workshops or classes causes an additional transfer problem, particularly when mathematics is taught 'purely' as mathematics by lecturers with little or no grasp of the problems and field in which the mathematics will be expected to be applied.

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

Purchasing power of qualifications in the educational market place

The transitional link between school and university systems is structured as a market place where certificates for qualifications such as A-level provide 'exchange' value for access to university rather than information about learners that is useful.

Summative assessment such as A-levels should provide not only accreditation for study but also useful information about what students know, understand and can do. The present formulation of A-level focusses on providing the grade needed for the University market; this in turn leads to teaching that is aimed almost exclusively and narrowly on examination performance. This results in tightly controlled 'teaching to the test' that values procedural competence with a narrow range of techniques rather than deep understanding of fundamental concepts and problem solving competencies. Text books that are closely aligned with the particular examinations that students will sit maintain this narrow focus on procedures and performance. Although many students on university courses obtain the same grade at A-level, individual students have very different understandings of important concepts, as well as different dispositions towards further study and attitudes towards learning mathematics.

E: Because, you know, at school every time, you know, you're asking more questions, the teacher's just like "you're going into far too much detail you don't need to know that".

First year engineering student

Understanding prior attainment and experiences

University lecturers' often lack understanding of what contemporary students with A-level or BTEC qualifications know, understand and can do on arrival at university. This can make transition difficult for students, because major discontinuities in curricula progression go unacknowledged: students may assume something is wrong with them. This is particularly important for mathematics at University because it supports a wide range of subjects, and also because at this level mathematics tends to build on what is assumed and believed to have gone before whereas other subjects may start 'from scratch' (e.g. engineering). Designing appropriate programmes of study and ensuring that pedagogies are responsive to students' needs as they make the transition into university is hindered by this lack of understanding, which in extreme cases extends to lack of knowledge of the syllabuses covered.

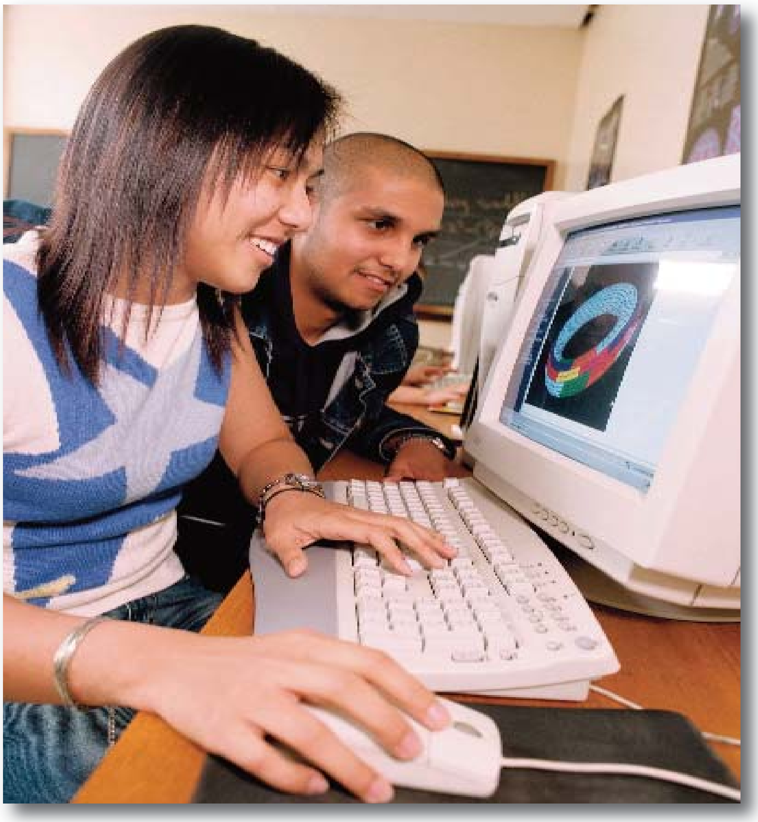
J: I think a lot of university lecturers think that A-Level is still the A-Level it was when they did A-Level maths and... I think it was only last year we were having a discussion about maths, I think, we had a university dinner or something, we were having a chat about maths and somebody said something about complex numbers and how awful the students were at complex numbers and I said 'well it's not in A-Level maths, you know, it's in further maths A-Level and most of them won't have done further maths A-Level' and their reaction was 'isn't it?' and I thought well, they're expecting the students that to be their base line whereas actually they know nothing, well they know a bit from what I teach them but ...

A-level teacher working at a university lecturing on a first year engineering mathematics course

The diversity of students' needs, resulting from a wide range of different prior attainment and learning experiences, is not always catered for on transition to university. For example, some students with a good conceptual understanding of mathematics may find some programmes to be disappointing because they find mathematics at University boring, unchallenging, uninspiring or 'too easy'.

B: I was always fairly competent in maths, yeah I was always top end (at School). (...) I enjoyed it a lot and I found it very challenging so I started again and I passed it that year with a C. (...) So that's why I wanted to come and do some more (at University) it's just seemed like a, not really a waste of time but kind of, seems like a bit patronising to be there, being taught maths at a very basic level and I can still do all the questions and things.

First year computing student



However, students whose mathematical experiences have been different (e.g. mathematics within a vocational qualification) sometimes find university mathematics programmes very different academically to what they were used to previously. Such students may perceive the mathematics at university as 'too hard'. It might be the case that a programme leading to the same degree at a different university would suit their learning style better, because teaching practices are more closely aligned to their previous experiences than those on more traditional courses. The type of teaching they will encounter at different universities is not clear to students when they select courses. Jon, an engineering student changed universities due to his experience of maths and had very different experiences in the two different universities.

J: It was, erm, too much maths based and not practical enough (at Riverside University). (...) And I come from, yeah I come from a more practical background, I did a year in industry as a gap year. (...) I did have the support but I just, found it too difficult I didn't, it wasn't interesting me to do that level of maths, that's not what I want to do as a career, that height of maths, I'd rather do the practical side.

So far it's, the maths is a lot simpler which is favouring me and I'm finding it a lot easier (at Modern University). Well I can do maths up to a certain level and I'm happy to do that and obviously, whilst I can do it then it's enjoyable when you're successful. But when it's, when it's extreme it's, it's just too hard and it's not enjoyable.

The transfer, or transformation problem

The transition from school to university mathematics presents a classic 'transfer problem' for the learner since what might be assumed to be common knowledge between the two different communities may have to be re-negotiated with different objectives and ways of working (for example, a 'function' in A-level is not understood in the same way as a function in University mathematics). 'Transformation' of existing knowledge might be a better description of the process of transfer, as it implies action and work is needed to produce new knowledge. In this regard rigour and formality have particularly important roles to play in the students' success or failure to transfer and in their attainment of conceptual understanding in mathematics.

For example, at A-level a function is an expression of the form y = $f(x)$. To find f^{-1}, the inverse of a function, students "rearrange to get x = ... then swap x, y." (revision notes for module 'Core 3'). At University, students face a definition of function that requires a more abstract understanding of the concept (a relation between two sets that satisfy certain conditions), and finding an inverse is not only a procedural matter anymore e.g. not every function has an inverse.

Another important issue for students is the disconnection of the teaching of mathematics from the subject in which it will be applied e.g. science or engineering. The knowledge and understanding they develop in mathematics courses has to be transformed to support their developing knowledge and understanding in other subject areas. This can prove much more demanding than appears to be recognised by lecturers. In mathematics this can be because there is a lack of understanding of what and how mathematics has been developed at A-Level. In other courses mathematics is often taught in a way that seems abstract and disconnected from other subjects: students have to make the structural connections between algebraic representations that they have to learn to manipulate (in maths) and the reality these represent (in the subject context). Where mathematics is applied to solve problems in other disciplines the cognitive demand on students as they make connections between mathematics and new concepts can be underestimated and not well supported.

Int: Which bits of it are you having difficulty with? All of it? The Maths of it, or the Physics of it?

S: No, I understand the Maths of it, but the application, and I'm not entirely sure where I'm going with it.

Int: So you've got these equations in Physics, and you're supposed to try and solve these equations or something?

S: Yes. We're given different problems, and they kind of say, "Find this", and you have to figure out, right, do I need to find the grad or the curl of it, or, how do I do this? I personally find it really confusing, but, it's one of those things where you have to practice at it, and wait for it to click I think.

Physics student after one year of university study

Implications and recommendations

- A fresh look at mathematics qualifications at advanced level, (e.g. AS and A-level), is needed to ensure that they are 'fit for purpose', by ensuring that students who continue into mathematically-demanding courses at University are better prepared than at present.
- This assessment needs to be aligned with and support appropriate teaching and learning as well as providing useful formative and summative information for both students and lecturers. For this purpose, teaching at this level should be responsive to individual needs in ways that encourage deep, conceptual understanding and the development of self-directing skills.
- There is a challenge for University lecturers to develop practices that support 'transfer' in order to bridge the gap between (i) mathematics as constituted in different ways in school and university and (ii) mathematics as an object of study in its own right and in its application in problem solving in other subjects. This requires the development of practices that support this work of 'transformation', such as mathematical modelling and problem solving, or other practices that encourage also deeper approaches to learning and conceptual, theoretical understanding.

Where next?

During 2011 the team, with ESRC Follow-on funding, are working with key partners, including the National HE STEM Programme, the National STEM Centre and the National Centre for Excellence in Teaching Mathematics (NCETM) 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:

Hernandez-Martinez & Williams, (under review) Against the odds: resilience in mathematics students in transition, British Educational Research Journal.

Hernandez-Martinez, P., J. Williams, L. Black, P. Davis, M. Pampaka, and G. Wake. (2011). Students' views on their transition from School to College mathematics: rethinking 'transition' as an issue of identity. Research in Mathematics Education

Pampaka, M., Williams, J. and Hutcheson, G. (under review) Measuring students' transition into university and its association with learning British Educational Research Journal

Pepin, B. (2012) Student transition into university mathematics education: a transformation of 'Didactic Contract' In: Rezat, Hattermann, & Peter-Koop, Transformation - A Key Idea in Mathematics Education. Springer.

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:

www.education.manchester.ac.uk/research/centres/lta/ltaresearch/transmaths/into-he/

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