Setting the Scene

Understanding student backgrounds as a method to enhance undergraduate teaching and learning in the mathematical sciences

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Departments of Mathematical Sciences in HE need to build effectively on students' existing knowledge, skills and understanding to get the most out of the student intake and to provide the most stimulating learning environment for them. This can only be achieved if the departments are familiar with, and understand, the backgrounds of their student intake cohort. Clearly, there is significant variation in prior learning. Some students enter HE through a standard A level route whilst others have alternative post-16 qualifications such as the IB or GNVQs. In addition to these "standard" students, there are still others who enter HE via foundation courses or access routes. Between them, these individuals possess a myriad of qualifications and experiences which combined, qualify them to embark on a degree program in the mathematical sciences. This makes the task of building on what students have learnt seem very daunting.

Over the past two years, the Department of Mathematical Sciences at the University of Bath has established and developed collaborations with local schools and an FE college which aim to develop and enhance the transition between school/college and undergraduate studies in the mathematical sciences. The collaborations have included reciprocal visits to schools and the university and discussion groups which were used to increase understanding of the challenges and problems encountered in teaching and learning mathematics at the two levels.

Currently in England and Wales there are four examination boards which offer A level qualifications. These are EdExcel, OCR, AQA and WJEC. Each of these boards may offer more than one A level mathematics specification (syllabus). For example, with AQA there are two choices – specification A labelled "Mathematics" and specification B, "Mathematics and Statistics" formerly the SMP 16-19 course. Within each specification there is further variability since choices can be made from modules in pure mathematics, statistics, mechanics and decision mathematics. The core material, however, must be covered whatever the board or specification which means that there is a minimum common content that any A level student must have studied.

It is not difficult to obtain copies of the A level specifications – what is difficult is to translate this information quickly into specifics for a given student cohort when they enter HE and to respond to differences.

Grade thresholds also vary according to which examination board is used. For example, a grade A may require students using one board to achieve a mark of 70% or above whereas the threshold for a second board may be higher. This difference may well reflect the nature of the examination questions or structure but it makes it difficult to gauge exactly what students can do well, even with the core material.

Many of these variations are not new. They certainly should not be criticized lightly. Indeed, there may well be more uniformity in the 16-19 mathematics education in England and Wales than in degree courses in the mathematical sciences and it is not clear that either Benchmarking or the National Qualifications Framework will act to reduce this variety. Variation at all levels seems necessary and appropriate.

There are several strategies currently in place across the country to tackle the

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problem of mixed-knowledge and mixed-ability intake. Amongst these diagnostic testing is now commonly used in many HE institutions. An alternative strategy is to assume a base level of knowledge and understanding from all students in a cohort and to use initial teaching to reinforce or *re-teach* material that has already been encountered by some students. A third approach is to "set" students in their first year and teach different material to different "sets" depending on their mathematical background.

The approach that we have developed in Bath complements these three by using discussion with school teachers to try and understand student backgrounds. There are two strands to this approach:

1. Understanding the A level specification and *how* it is delivered to the students and
2. Understanding problems that students commonly have with the course material.

Alongside the discussions with teachers, a small scale study of first year mathematics undergraduates at the University of Bath highlighted notational and language differences between school and university as a possible stumbling block for students during the initial phase at university. It is sometimes difficult to understand how such an apparently small difference, that of notation, can cause significant problems. But these sorts of differences can indeed confuse students and consequently cause a loss of confidence. Reciprocal visits by school teachers and university lecturers to attend lectures and school lessons respectively, led to discussions about increasing notation use and rigour in schools and about increasing explanation of notation and rigour at university. These goals were tempered by acknowledging that an increase in rigour may only be appropriate for some A level students for some of the time, and by deciding that a more gentle introduction to mathematical formalism *should not compromise* mathematical content.

At the same time as we were establishing the cross-sector collaborations, Curriculum 2000 was introduced into schools to replace existing 16-19 provision. With Curriculum 2000 came the re-introduction of proof into core A level specifications. This provided an incentive to use school-university collaborations to explore teaching and learning proof across the transition. A booklet has been produced [1] which is aimed both at staff and students in both institutions – as a resource to photocopy. It aims to help students learn how to

- approach proof both at school and university,
- provide rigorous arguments, and
- develop school proof to a higher level at university.

The process of producing this booklet was one valued by everyone involved. In 1995, the Association of Teachers of Mathematics (ATM) published a series of articles debating the teaching of proof in schools [2]. It appeared that there were significant differences in opinion across sectors, particularly when considering what constituted a proof. There was consensus that a proof should consist of a series of logical arguments or statements, general agreement that it should deal with general cases rather than specific examples but a reasonable amount of variation in the degree of rigour and mathematical exposition required. The discussions which were held between university lecturers and school teachers in Bath were not used to argue about different levels of formalism but rather as a constructive dialogue to facilitate transition to undergraduate studies by enthusiastic students. The idea of including more formalism within school teaching was enthusiastically received by teachers whilst the collaboration allowed lecturers to appreciate teaching issues and curriculum constraints in schools.

Work at the school-university interface is gaining impetus in many institutions of higher education across the country. What we believe we have established at Bath is a simple, cheap yet effective way to develop teaching and learning of mathematics across the sectors, that of talking with colleagues across sectors about current concerns. The scheme is easily transferable to all other departments, or consortia of departments, of mathematics and indeed, similar collaborations have recently been established in at least one other mathematics department as a result of this project.

Through the genuine collaboration between schools and the university and a good focus for discussions, there has been useful dialogue and an increase in the understanding of the problems faced by both schools and universities. It is this mutual co-operation and partnership between phases that will ensure smoother transition from school to university mathematics in the future – a goal in which everyone involved in mathematics education should have a keen interest.

References

[1] The proof booklet can be viewed online from the school-university transition home page at Bath, www.maths.bath.ac.uk/~kajw/Proof-Booklet.pdf or a hard copy can be sent by contacting the author directly

[2] *Mathematics Teaching* **155** 10-31.