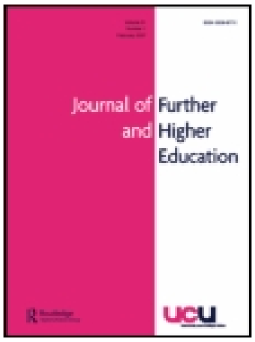

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Students' conceptions of mathematics bridging courses

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In this study we investigate the conceptions of mathematics bridging courses held by students enrolled in these courses at a major Australian university. We report on the participants' responses to email-interview questions about the mathematics bridging courses to describe a two-dimensional outcome space of variations in awareness about the bridging courses. On one dimension the conceptions relate to cognitive functions: the course bridges students' difficulties with mathematical concepts, helps develop strategies for learning mathematics and extends skills in thinking and reasoning. Categories on the other dimension reflect ideas on how the bridging course advances personal goals and enhances self-development. The findings show that students are aware of the value of the bridging courses not only to ameliorate prior difficulties with mathematics and improve their approaches to learning mathematics but, less transparently, as an important opportunity to facilitate their transition into higher education, meet fellow students and help realise their potential.

Keywords: conceptions; mathematics bridging courses; transition; higher education

Introduction and literature review

Mathematics is in crisis in many countries. In Australia, fewer students are studying mathematics at the higher levels in the senior year of secondary school (Barrington 2010). Yet the study of mathematics at university is essential for a wide range of undergraduate programmes, including science, medical areas, engineering, agriculture, pharmacy, economics and business. Although there is some state variation, Australian students can choose to study mathematics in senior secondary school at essentially three levels: elementary, intermediate and advanced. Brown (2009) quotes alarming statistics about subject choice at senior secondary school; namely, that the proportion of students in the final year of school who are studying mathematics at intermediate and advanced levels has declined by 22 and 27% from 1995 to 2007, respectively, while the proportion of students enrolled in elementary (pre-calculus) mathematics has increased by almost 30%. Unfortunately for

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the latter group, their mathematics preparation is inadequate for almost all programmes requiring mathematics at university. The widening divide between mathematics that students study at school and mathematics needed at university is also well-documented in the UK and internationally (Hoyles et al. 2001; Luk 2005).

Thomas et al. (2009) argue that, while mathematics is used to solve problems in many industries, its contributions are often invisible, making it difficult for the community to see its value. They report that negative community attitudes towards mathematics and the perceived difficulty of its study make students less likely to select mathematics over other subjects at school. Failure to choose higher-level mathematics courses in high school can have serious consequences both for a student's success in university mathematics and on whether a student continues with his or her mathematical studies. In a transition study conducted at a Canadian university, Kajander and Lovric (2005) found that time spent learning mathematics in the final years of high school was crucial for students' success in university calculus courses. Varsavsky (2010) reports that students who take advanced mathematics levels in their senior secondary years show higher levels of engagement with mathematics and are more likely to continue with their mathematics studies to a completion of a mathematics major.

In Australia, the situation concerning the mathematical readiness of undergraduate students is exacerbated by university entry structures. Many universities, including the university featured in this study, do not have subject prerequisites for entry into their degree programmes. Rather, the 'assumed knowledge' for each programme is published, including the mathematics subjects that students are 'assumed' to have studied at school. However, students may be accepted into a degree programme, such as engineering, science or economics, even if they do not have that assumed knowledge. Consequently, the mathematical under-preparedness of commencing undergraduate students is an important issue for university teachers not only in mathematics itself but for many other disciplines.

A number of universities offer mathematics bridging courses – short preparatory courses available before students commence their degree programme – as one of the ways to provide students with a way forward with their chosen degree programme, and to ameliorate students' difficulties with mathematics (Croft et al. 2009; MacGillivray 2009). Recent reviews (Galligan and Taylor 2008) of the limited research into bridging mathematics in the Australasian region have indicated consistent areas of investigation, including evaluation of specific courses, diagnostic tests and other ways of determining students' needs and overcoming mathematics anxiety. Yet there is little research about what bridging courses mean to students studying them. What is the focus of a student enrolled in a mathematics bridging course? What are students' experiences of these courses?

In this paper we report on the perspectives of students enrolled in a mathematics bridging course at a major, research-intensive university in Australia with the aim of revealing the variation in awareness about mathematics bridging courses.

This project provides data about a particular cohort of mathematics students: students-in-transition. Students have completed their secondary school studies, either recently or some years back, and in most cases have not yet encountered higher education. Further, students enrolled in a mathematics bridging course have been advised to improve their mathematical knowledge and competence or recognise this need themselves and are voluntarily acting on this information. Investigating students' perspectives at this stage provides a singular opportunity to inform mathematics education at school level and at university.

There has been considerable research in the area of students' transition to university. One area of investigation concerns the fit between students' prior context of education, such as school, and university education. Important aspects that have been cited (Nicholson 1990) include continuation of the pedagogical-didactical approach, continuation of curriculum knowledge, adequate advice about study choice and comparable workloads. Torenbeek et al. (2010) have shown empirically that at least two features of the fit – resemblance between learning environments and the degree of adjustment – are significant factors in students' achievement in the first year. The extent to which self-motivation and independent learning are required at university can be particularly problematic for students coming to university for the first time (Murtagh 2010) and has been shown to be a source of concern to many incoming students, particularly in view of the widening participation of 'new' demographic groups in higher education (Leese 2010). A further area of research concerns students' well-being as they enter higher education, with levels of strain shown to be generally highest during the first semester of university life (Bewick et al. 2010).

Various factors have been identified that ease the transition of students into university, enhance the early student experience and appear to contribute to improved rates of retention. These include activities that help students find their feet, make friends and get to know other students on their programme (Trotter and Roberts 2006); learning-to-learn programmes (Zeegers and Martin 2001) and workshops facilitating the early formation of social networks and peer groups (Peat et al. 2001). A mathematics bridging course is often a student's first experience of learning in the university environment and offers the chance to meet other students and university teachers. Hence, the ways in which students experience a mathematics bridging course could be instrumental to students' performance in first year mathematics topics and could also play an important part in supporting students during a difficult period of transition, potentially helping to reduce early attrition at university.

Methodology

Our report is set in the context of a project aiming to research teaching and learning in mathematics bridging courses, with participants being students, teachers and coordinators of these courses. Our definition of a mathematics bridging course is a course of intensive instruction of 40 hours or less undertaken prior to the beginning of the academic year. Fifteen students and 10 teachers/coordinators completed email interviews before our cut-off date. We have previously written about the teachers' reflections on the challenges of teaching mathematics bridging courses (Gordon and Nicholas 2010). In this paper we focus on students' responses regarding their experiences and analyse their conceptions of the mathematics bridging courses.

Students studying in a mathematics bridging course at the authors' university in 2010 were invited to participate in the research. Students were enrolled in one of the two levels of bridging courses available: intermediate (called 2 Unit) or advanced (Extension 1, also called 3 Unit level). Sixty per cent of the participating students were male (nine students) and ages ranged from under 19 years old (six students) to over 30 years old (seven students). Our university ethics committee approved the study and all participants gave written, informed consent. We make no claims as to the representativeness of participating students; rather, we endeavour to explore students' varied understandings regarding their experiences.

The data collection was through asynchronous interviews by email with, at most, three returns. This methodology was developed by Gorden and colleagues (Gordon, Petocz, and Reid 2007) and critiqued in Reid, Petocz, and Gordon (2008), with the overall conclusion that thoughtful, considered, high-quality data can be obtained from such interviews.

The first email to students included a welcome message and a set of six initial questions. The first question asked for background information, including background in mathematics, gender, age and details about the degree for which the student was enrolled. The remaining five questions were deliberately open-ended to enable students to articulate their own views. These questions are below:

(1) What did you expect to achieve by studying this maths bridging course?
(2) A friend asks you to tell her/him about the maths bridging course. What would you say?
(3) What were the most important challenges you encountered in the mathematics bridging course?
(4) What is good teaching in a mathematics bridging course?
(5) What approach or approaches to learning maths did you find helpful for the maths bridging course?

After studying the initial reply, we sent a second interview with questions following up and probing each participant's responses. Some examples are: Why was practising problem-solving an important challenge? How did you go about your independent study? Why were the tutor's examples and explanations helpful? What advice would you give to a friend or colleague who was preparing to start a maths bridging course? Now that you've started semester 1 at university, in what ways has the maths bridging course affected your approach to learning maths?

In some cases, a third interview was sent to elicit further clarification and in-depth explanations of the previous responses. The interview process was in many ways a written version of the usual face-to-face interview, but at each point in the process participants had access to all previous parts of the interview, and both interviewers and respondents could continue the dialogue in their own time. Importantly, this meant that neither interviewer nor respondent had to rely on recall to pose and respond to questions and the method provided both researchers and respondents with time to reflect. The students' transcripts provided rich and detailed data and the full interview set (questions and students' responses) was well over 20,000 words.

We adopted a phenomenographic approach for our analysis, as this method has been fruitful in revealing participants' awareness of a phenomenon in context (Marton and Booth 1997). The aim of the phenomenographic procedure is the 'discovery' of a range of qualitatively different categories of descriptions or conceptualisations (Trigwell et al. 1994: 76). These categories are usually hierarchical in the sense of increasing scope from the narrowest conceptions to the most expansive. This means that expressions included in reports in the 'higher' categories may indicate awareness of previous categories but the reverse is not the case. The outcome space is the 'system of categories of descriptions' (Marton et al. 1997: 35) depicting the qualitatively different ways in which the phenomenon – in this case the mathematics bridging course – is experienced or conceptualised and the relationships between the conception categories.

As for previous phenomenographic studies, the method used here involved attending to the similarities and differences between students' statements and selecting the themes or ideas that differentiate categories of conception (Marton and Booth 1997). This involved iterative readings of participants' descriptions and discussing and reviewing the categories until a set of clear statements defining each category of conception was agreed upon. Hence, the categories are illustrated by quotations from transcripts, but do not represent a phenomenological (that is, a rich, lived) experience of any single individual. That is, the outcome space describes the total variation of awareness in the group and we are not attempting to classify conceptions of individual respondents.

Findings

Description of outcome space

Two dimensions of students' awareness about their mathematics bridging courses are proposed. The first aspect refers to how students conceive of the function of the mathematics bridging course. What does the student think the mathematics bridging course is about? What is the student's focus? The second dimension concerns students' personal goals for studying the mathematics bridging course. What does the student hope to achieve by studying the mathematics bridging course? We discuss each dimension below.

Conceptions: bridging the gap

Three categories emerged here, each one more expansive or inclusive of the previous category or categories:

(1) The mathematics bridging course bridges the gap in specific mathematical concepts and processes taught. Here, the student's focus is on the content of the mathematics bridging course.
(2) In addition to content, the student reports awareness about extending his or her approaches to learning mathematics.
(3) The most expansive category includes ideas about how the mathematics bridging course helped the student to extend capabilities in thinking analytically. This may include thinking analytically within the context of mathematics itself but also may include thinking and reasoning analytically in more general contexts.

Conceptions: bridge towards achieving personal goals

On this dimension, three categories are proposed; again, these are hierarchical in the sense of expanding the scope of the conception:

(A) Here the student reports ideas about how the mathematics bridging course advances skills and knowledge needed immediately for degree units.
(B) In this category, there is a conception of the mathematics bridging course serving as a stepping-stone to higher education – a transition from school to university. This includes degree-specific knowledge (category A), adjustment to university life and generic skills, such as time management, that are part of becoming a university student.
(C) The most expansive category encompasses personal development; the bridging course also provides ways of transforming oneself.

Hence one dimension is concerned with ideas about the mathematics bridging course that relate to cognitive aspects – associated with the content

Bridge gaps in: → To help achieve personal goals in: ↓	specific mathematical concepts and processes 1	approach to learning mathematics 2	thinking and reasoning 3
A. Advancing skills and knowledge for degree			
B. Making the transition to university			
C. Self-development			

Figure 1. Outcome space of students' conceptions of mathematics bridging courses.

and learning of mathematics and beyond this to thinking and reasoning, while the other dimension is more concerned with how the mathematics bridging course impacts on personal elements: becoming a student, self-confidence, identity formation and development. The two aspects are linked logically and empirically. We represent the outcome space in Figure 1. The grid shows the full range of possibilities.

We report on the empirical findings below. In some categories there were few reports that fitted with a grouping. The shaded areas of the grid in Figure 1 represent combinations that were not supported empirically; that is, we did not find illustrations of these (shaded) elements in the data. Logically, too, these categories seem less likely, although it may be possible for such conceptions to exist.

In the next section we illustrate each element of the array with short excerpts from students' transcripts, using the notation // to indicate non-contiguous quotes. The excerpts are reported under pseudonyms chosen by the students themselves in accordance with information about participation that was made available to all respondents. We emphasise that we are not categorising participants. Rather, we are separating elements of the grid analytically and clarifying these with excerpts from the transcripts. In some cases we have used different parts of a student's transcript to exemplify different categories; in this way we indicate the inclusive nature of categories from the narrowest to the most expansive on each dimension.

Illustrations of categories

1A: Focus on mathematical concepts and processes/as needed for degree

In this conception, students' focus was on the mathematics itself and its applicability to their academic study units in their degrees. For example, Bea Arthur reported that: ‘a good bridging course is tailored to what students will need to know for their degree courses’. Monkey reported that he expected to be able to ‘have an insight to mathematics processes I would need to use in Biometry in my first year’.

1B: Focus on mathematical concepts and processes/making the transition to university

In this category, there was an added goal and awareness about the mathematics bridging course, perhaps one that was opportune rather than planned in the design of the courses. As expressed by Boris Grishenko, the mathematics bridging course was: ‘not only good for improving our understanding of maths, but it also helped us new first year students to ease into university life’.

Joey, who was enrolled for B Engineering (Aeronautical) expected to ‘gain an understanding on the maths needed for my course’; he also felt it was ‘a good time to understand cost and transport to uni’. He also hoped to gain ‘a small insight to workings of uni classes’ and noted that the mathematics bridging course helped him with ‘getting used to transport to and from university, building locations, teaching methods and university notation’. Jane added that the bridging course: ‘got you back into the “study” mindset after a long break form school. Plus, it is a chance to meet people who might be in the same classes as you.’

Statements in this category illustrate a focus not only the content aspect of the mathematic bridging course but also on how the course ameliorated the ‘shock’ of going into university ‘cold’, in Jane’s words.

2A: Attending to approaches to learning mathematics/as needed for degree

In this category a new aspect is added to the conceptions illustrated in 1A: not only is the focus on what is learned but also on how it is learned. Volvo explained:

> Through the Maths bridging course, not only have I gained knowledge in mathematics, I have learnt new study techniques, e.g. constant revision is extremely vital. As a result, I adopted all the skills I have gained from the Maths bridging course and incorporate into my units from Mathematics that I am undertaking this semester.

PJ affirmed that the mathematics bridging course was excellent revision of the content. His approach was to ‘practise problem solving’ and ‘careful calculation’, and he advocated doing ‘as many of the set questions as possible, and ask questions if problems. Prepare for each lesson by reading ahead if time.’ Aura2 highlighted that: ‘everyone has a different way of learning. Some people are visual, others [algebraic]. I am a step by step, visual person. I need to see exactly how something works. Brick on brick.’

Conceptions in 2A are focused on the short term: content that would be needed immediately and how to go about learning it.

2B: Attending to approaches to learning mathematics/making the transition to university

Many students reported ideas about the bridging course that fitted with this grouping. The category extends the ideas of both 2A and 1B, capturing a more complex awareness about a mathematics bridging course.

In the excerpt below, Carly first explains her aim to learn the mathematics needed for her degree (illustrating 1A) and then expands on her approach to developing a 'routine' for studying mathematics:

> I hoped to gain a good knowledge of the topics covered in the 2 Unit HSC course so that I had the assumed knowledge for the mathematics courses I will be studying over the duration of my first year of university. // I was able to get back into a routine of working through questions independently, and becoming more comfortable with not always understanding new concepts straight away. As I wasn't always finishing the work set for each day, I was able to get into a pattern of doing extra, catch-up work at home.

Carly found that the bridging course challenged her assumptions about university and made her transition 'a lot less terrifying'. She was expecting:

> a much stricter environment. Then again, this was my assumption about university as a whole, and so participating in the maths bridging course made starting uni a much less stressful and anxious experience for me. I knew what to expect in some respects.

Importantly, Carly reported that the bridging course helped to build a community of learners and this enhanced her approach to learning mathematics. She reported.

> Often, the tutor's explanation/examples were clear to only one person in the group, and so they were able to 'teach' the others in the group who hadn't completely understood it. It allowed friendships to form, which lead to a more relaxed tutorial session, and so we were able to work more efficiently in helping out each other in each of our weaknesses.

Boris Grishenko concurred with this cooperative approach, saying:

> I often found that the students who knew their work better would help out the others by giving them hints first, which would stimulate the other students' thinking, and if they still couldn't solve it, then they'd work through the problem together step by step.

His approach also involved 'self learning', including working through the bridging course notes independently at home to revise what had been taught that day and also to prepare for the next class:

> In summary I suppose 'self learning' was more about self-reliance in understanding and applying the information that was given to us, rather than constantly asking the teacher to clear it up.

We see from the above students' reports that their approaches to learning mathematics during the bridging courses emphasised both independent learning and peer interactions.

We now quote two excerpts providing further insights into why the bridging course was perceived as a good transition from high school to university. Lemon said she:

> got used to the notation and the faster pace of university maths in comparison to high school. Also getting to meet people was a good experience, I find lectures a bit alienating but in the bridging course it was really easy to make friends and I've kept in touch with a few of them.

Jane added that:

> since starting uni, and particularly in my maths units, I have realised that it is up to you to make sure that you understand the work. I find that the lecturers don't go that deep into detail when explaining some concepts but they are always willing to help you or answer questions after the lecture, but again, it is up to you.

In summary, students' ideas in this category show attention to developing ways of learning mathematics and helping students adjust to university.

2C: Attending to approaches to learning mathematics/promoting self-development

In this category, we see new ideas emerging on the personal development dimension – about how the bridging course advanced students' personal goals. We first illustrate this category holistically with some extracts from Volvo's interview and then add to the ideas about promoting self-development with a brief illustration from Hagrid's transcript.

As reported in 2A, Volvo commented on how the bridging course helped develop her approaches to learning mathematics, which she would apply to her degree units. She found the course to be very demanding and aimed to do an extra four hours of productive study at home. As a result, Volvo reflected that: 'I have learnt how to manage my time more effectively and methods to study a demanding course.'

Volvo's longer-term aim and reason she needed to do a mathematics bridging course was that she wanted to teach secondary mathematics: 'I know that if I am able to become a qualified mathematics teacher, I can make a great difference to future students.' Volvo regarded the bridging course as a 'test', 'to see if I should further pursue teaching mathematics.'

The bridging course not only facilitated Volvo's decision to pursue studying mathematics, but also helped change the way she saw herself:

> I have always been a shy student in class. I didn't have the confidence to ask questions. Due to the small class size in the bridging course, I had the confidence to ask questions in which I wanted to ask. This not only allow me to give me the confidence of asking questions, but it also allowed me to have a sense of self-satisfaction, knowing that I have achieved my personal best of understanding the course within a short time frame.

Hence the bridging course helped Volvo improve her strategies for learning mathematics as well as advance her personal development.

As a personal challenge, Hagrid, a mature student, needed to overcome his reluctance to engage in mathematics, saying that: 'I have always felt that such maths was irrelevant to my work and that I could ignore it. I no longer can.' Hagrid acknowledged that the bridging course had transformed his outlook on work: 'I feel a lot more comfortable and not as alienated as in the past when I try and read say papers on financial risk.'

The excerpts above illustrate an increasing awareness regarding how the bridging course impacted on students' sense of themselves as learners of mathematics.

3B: Thinking and reasoning/making the transition to university

This category traces an expanding awareness of the cognitive role of the mathematics bridging course. An unusual perspective was provided by Matt, who was a mature student and not enrolling for any degree. He said: 'I'm doing this basically for fun and relaxation (strange but true – I find the clarity and logic of maths a refreshing change from the daily hustle of the corporate world).' Matt was not sure how he would apply his new-found knowledge, but thought that 'just being in a "study groove" again hopefully will keep the brain ticking over.' He felt that the bridging course would be a good introduction to what life will be like at uni:

> One needs to learn to prioritise and schedule one's time 'outside' of the mainstream lecture hall (assignments, pre-test revision, etc.) in order to maximise the time 'inside' the lecture room. So tonight do I work on that assignment due next week, or can I go out? It's a taste of the big time, if you like.

Kannen, too, was interested in mathematical thinking and found new concepts exciting, adding that he 'liked to understand why a theorem holds rather than learn that it just works'. He characterised good teaching in a mathematics bridging course as follows:

- Explaining a deeper understanding rather than an operational process.
- Explaining the context in which the mathematics is usually applied.

- Letting students know that they will have to work hard on maths in first year.
- Emphasising that the bridging course will seem quite difficult and will include doing maths the 'uni' way, which will be unfamiliar at first. Also emphasise that the more the student works at it, the easier the transition will be to study maths at uni.

Hence ideas in this category highlight the potential of the bridging course to enable mathematical understanding and application as well as to help students adapt to university study.

3C: Thinking and reasoning/promoting self-development

A report from Volvo introduces ideas illustrating the broadest category. On the cognitive level, the bridging course helped her develop a more analytical way of thinking and reasoning:

> Since the maths bridging course I have learned that getting the answer is not as important as why I get this answer and the theory or method behind it. This not only allows me to understand the topic properly, but helps me to improve on asking myself better questions. For example, if I get a question wrong in an exercise question, I would look at the answer, and work out the reasons why I had it wrong and what methods led to that answer.

As described earlier in 2C, Volvo had gained self-confidence and achieved her personal goals through tackling the bridging course. She summed up that, 'this would definitely give me motivation to continue working hard doing mathematics. I really hope this would have an everlasting impact on me.'

To illustrate the most expansive category more broadly, we now consider more extensive excerpts from just one transcript.

Susan is a mature student in her second/third year of an economics degree. She had last studied mathematics more than 10 years previously. Susan indicated that learning mathematics in the bridging course enabled a way of thinking and problem solving that would be important in her professional life:

> From an educational point of view, a strength in numeracy problems and equations is a gap in my abilities that hinders my understanding of subjects with equations and mathematical concepts.

She added that, on a more day-to-day level:

> you don't need to use the specific learning, e.g. differentiation, algebra to what you are doing but rather, not so much the maths per se, but the thinking around how you approach a problem. For example, in the workplace, modeling and graphing for pricing, negotiating deals – being able to move fluently through number problems.

Susan recognised that her approaches to learning mathematics and the reasoning ability and analytic thinking skills she was developing during the bridging course had currency beyond the context of mathematics. She continued:

> I have found I have been using this technique of breaking something down into smaller parts to approach not just equations but other things too. Breaking questions or situations down into parts, looking at what I can do with them with the knowledge I have, and then dealing with the parts I don't quite know what to do with. // I don't know if I have given a solid example of how my thinking has changed. I feel like it has, which is the most important thing, I think.

The above excerpts from Susan's interview illustrate an awareness of the 'thinking and reasoning' category on the cognitive dimension.

Susan also described how the mathematics bridging course advanced her self-development by enabling her to overcome her fear of doing mathematics. To her the greatest challenge was overcoming this fear:

> because I have never really understood it and thus believe I cannot do it. I just wanted to learn how to do it and understand how to do it – not just do it because that's what I was shown how to do it but really understand what I was doing so if faced with a problem that was a little different to what I had learnt I was still able to find a solution using the knowledge I had.

Thus, Susan's conception of a mathematics bridging course included a powerful and enabling self-development dimension – the transformation from someone who believed she could not understand or use mathematics to someone with the ability to approach problems in economics 'with the confidence that I can work it out'. Susan had not only gained the confidence to tackle the quantitative units in her degree that she had previously been 'too scared' to do, but she also reported that, 'I want to learn more mathematics' to 'cement the information'.

Summary

In this section we have illustrated categories of students' conceptions. The 'higher' categories indicate students' expanding awareness of both cognitive and personal features. On the first dimension, students' awareness about the bridging course increased from a focus on the mathematical concepts per se to include approaches to learning mathematics, such as independent study, and on to a broader awareness of logical and analytic thinking or problem solving. On the second dimension, students' conceptions of the course developed from a focus on their perceived immediate needs for their degrees towards encompassing an awareness of how the bridging course facilitated progress into university, both in 'uni ways' (Kannen) of learning mathematics and more generally. Most broadly, the experience enabled self-development.

In some cases we have illustrated the expanding awareness from ‘lower’ to ‘higher’ categories by reporting excerpts from the same interview. For example, excerpts from Volvo’s transcript illustrate 2A, 2C and 3C.

Discussion: looking back – looking forward

The data show that students recognised many benefits of studying a mathematics bridging course. In the first instance, many students’ reports were about ameliorating previous difficulties with mathematics and reducing anxiety about learning mathematics or reluctance to engage with mathematics. For example, Susan overcame her belief that she could not do mathematics and before the mathematics bridging course Volvo did not have the confidence to ask questions about mathematics. More proactively, students’ experiences in the bridging courses helped students gain some understanding of the concepts they would need to study mathematics at university, become more capable learners of mathematics and even, in a few instances, stimulated them to consider what it could mean to think logically or analytically within the context of studying mathematics and in their professional lives.

On a different plane, and perhaps less predictably, many students reported seeking or realising the value of their bridging courses that went beyond the published aims of the courses. These benefits showed the importance of the bridging course to students’ transition into university – an opportunity to get, as Matt put it, ‘a taste of the big time’. The exploratory outlook of students applied not only to school leavers but also to students returning to study after being in the workforce. Hagrid’s recognition that he could no longer ignore the need for mathematics in his work and Matt’s seeing his study as a ‘refreshing change’ from the corporate world are examples of participants’ efforts to change their situations and perspectives through a course in which fellow students are primarily school leavers. Bea Arthur commented: ‘It was surprising and funny to be back in a room full of seventeen year olds! I think they called the teacher “Sir”.’

Perhaps most significantly, some respondents affirmed the value of the mathematics bridging course in their self-development. Volvo’s testifying to a sense of self-satisfaction and increased confidence, knowing that she had achieved her personal best, is one example of this.

Our findings have pedagogical and theoretical implications. The methodology has enabled the recognition of a diverse range of experiences and awareness about mathematics bridging courses, providing a basis for reflection and discussion by students and academics. In particular, the data show the role of mathematics bridging courses to promote not only mathematical knowledge and approaches to learning it but also more positive perceptions and improved attitudes towards mathematics. This is critical for the study of mathematics in higher education. The students’ perspectives reported in this paper could help improve advice for future students, and enhance information for teachers and advisors at secondary school.

The interviews show the value students place on interaction with peers and teachers during the bridging courses. As reported in our introduction, social and interactive aspects of learning in early university education are formative in students' adjustment to and retention in higher education (Peat et al. 2001; Trotter and Roberts 2006). This could be particularly critical for students where family or friends are unfamiliar with the discourse and ways of learning in the university context (Leese 2010). Our findings indicate the importance for teachers and developers of university bridging courses to ensure appropriate opportunities for interaction during a period when the pace of teaching is slower than during semesters and tutors have more time to interact with students as well as smaller classes. In addition, group discussions and problem solving could challenge students' perceptions that solving mathematics problems is an isolated task and enable them to view mathematical activity as cooperative.

Students' collective construction of mathematical knowledge – what Vygotsky (1978) calls co-knowing could enhance students' confidence and enjoyment of learning mathematics and increase students' persistence in tackling complex problems, an outlook shown to stand them in good stead in ongoing mathematical study (Carlson 1999). Mathematics bridging courses could play a role in enhancing students' well-being during first semester and increase their engagement with mathematics so that they 'want to learn more' (Susan) – a direction of our current research with a large sample of students. Further, a mathematics bridging course provides an opportunity to shift students' conceptions towards the more expansive ideas about studying mathematics at university before the pressures of assessment and a crowded curriculum constrain their learning.

Acknowledgements

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Notes on contributors

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Jackie Nicholas is head of the Mathematics Learning Centre at the University of Sydney. She specialises in teaching calculus to students who have not previously studied calculus and statistics to economics and public health students. Her research investigates how mathematics and statistics are learned at university level.

References

Barrington, F. 2010. Updated Year 12 mathematics figures. *Science News*, Australian Mathematical Sciences Institute. http://www.amsi.org.au/index.php/science-program/science-news/123-updated-year-12-mathematics-figures.

Bewick, B., G. Koutsopoulou, J. Miles, E. Slaa, and M. Barkham. 2010. Changes in undergraduate students' psychological well-being as they progress through university. *Studies in Higher Education* 35, no. 6: 633–45.

Brown, G. 2009. *Review of education in mathematics, data science and quantitative disciplines*. Report to the Group of Eight Universities. http://www.go8.edu.au/go8media/go8-media-releases/2010/184-group-of-eight-releases-maths-review.

Carlson, M. 1999. The mathematical behavior of six successful mathematics graduate students: Influences leading to mathematical success. *Educational Studies in Mathematics* 40: 237–58.

Croft, A., M. Harrison, and C. Robinson. 2009. Recruitment and retention of students – an integrated and holistic vision of mathematics support. *International Journal of Mathematical Education in Science and Technology* 40, no. 1: 109–25.

Galligan, L., and J. Taylor. 2008. Adults returning to study mathematics. In *Research in Mathematics Education in Australasia 2004–2007*, ed. H. Forgasz, A. Barkatsas, A. Bishop, B. Clarke, S. Keast, W. Seah, and P. Sullivan, 99–118. Rotterdam: Sense Publishers.

Gordon, S., and J. Nicholas. 2010. Teachers' reflections on the challenges of teaching mathematics bridging courses. In *Proceedings of the 16th UniServe Science Annual Conference – Motivating Science Undergraduates: Ideas and interventions*, ed. M.D. Sharma, 58–64. Sydney: The University of Sydney.

Gordon, S., P. Petocz, and A. Reid. 2007. Teachers' conceptions of teaching service statistics courses. *International Journal for the Scholarship of Teaching & Learning* 1, no. 1.

Hoyles, C., K. Newman, and R. Noss. 2001. Changing patterns of transition from school to university mathematics. *International Journal of Mathematical Education in Science and Technology* 32, no. 6: 829–45.

Kajander, A., and M. Lovric. 2005. Transition from secondary to tertiary mathematics: McMaster University experience. *International Journal of Mathematical Education in Science and Technology* 36, no. 2: 149–60.

Leese, M. 2010. Bridging the gap: Supporting student transitions into higher education. *Journal of Further and Higher Education* 34, no. 2: 239–51.

Luk, H.S. 2005. The gap between secondary school and university mathematics. *International Journal of Mathematical Education in Science and Technology* 36, no. 2: 161–74.

MacGillivray, H. 2009. Learning support and students studying mathematics and statistics. *International Journal of Mathematical Education in Science and Technology* 40, no. 4: 455–72.

Marton, F., and S. Booth. 1997. *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum.

Marton, F., D. Watkins, and C. Tang. 1997. Discontinuities and continuities in the experience of learning: An interview study of high school students studying in Hong Kong. *Learning and Instruction* 7: 21–48.

Murtagh, L. 2010. They give us homework! Transition to higher education: The case of initial teacher training. *Journal of Further and Higher Education* 34, no. 3: 405–18.

Nicholson, N. 1990. The transition cycle: Causes, outcomes, processes and forms. In *On the move: The psychology of change and transition*, ed. S. Fisher and C.L. Cooper, 83–108. Chichester: Wiley.

Peat, M., J. Dalzeil, and A.M. Grant. 2001. Enhancing the first-year student experience by facilitating the development of peer networks through a one-day workshop. *Higher Education Research & Development* 20, no. 2: 199–215.

Reid, A., P. Petocz, and S. Gordon. 2008. Research interviews in cyberspace. *Qualitative Research Journal* 8, no. 1: 47–61.

Thomas, J., M. Muchatuta, and L. Wood. 2009. Mathematical sciences in Australia. *International Journal of Mathematical Education in Science and Technology* 40, no. 1: 17–26.

Torenbeek, M., E. Jansen, and A. Hofman. 2010. The effect of the fit between secondary and university education on first-year student achievement. *Studies in Higher Education* 35, no. 6: 659–75.

Trigwell, K., M. Prosser, and P. Taylor. 1994. Qualitative differences in approaches to teaching first year university science. *Higher Education* 27, no. 1: 75–84.

Trotter, E., and C. Roberts. 2006. Enhancing the early student experience. *Higher Education Research & Development* 25, no. 4: 371–86.

Varsavsky, C. 2010. Chances of success in and engagement with mathematics for students who enter university with a weak mathematics background. *International Journal of Mathematical Education in Science and Technology* 41, no. 8: 1037–49.

Vygotsky, L.S. 1978. *Mind in society*. Cambridge, MA: Harvard University Press.

Zeegers, P., and L. Martin. 2001. A learning-to-learn program in a first-year chemistry class. *Higher Education Research & Development* 20, no. 1: 35–52.