TEACHERS' REFLECTIONS ON THE CHALLENGES OF TEACHING MATHEMATICS BRIDGING COURSES

Sue Gordon, Jackie Nicholas

Presenting author: Jackie Nicholas (jackie.nicholas@sydney.edu.au)
Mathematics Learning Centre, The University of Sydney, Sydney NSW 2006, Australia

KEYWORDS: mathematics, bridging courses, teaching, reflection, email interviews

ABSTRACT

The past fifteen years has seen a drift away from mathematical options in year 12 in which higher-level mathematical skills are taught (Brown, 2009), and an increase in the number of students enrolling in mathematics bridging courses. Effective teaching and learning in mathematics bridging courses are more important than ever. In this paper we present empirical data collected through a series of email interviews on the perceived challenges of teaching or coordinating these courses and strategies some employed to meet these challenges. We engaged educators in structured reflections on their approaches to teaching and learning in mathematics bridging courses, and created opportunities for participants to explore and potentially improve their own practices. Our findings suggest directions for future research and opportunities for reflection and debate about pedagogy in this important, yet little researched, context.

Proceedings of the 16th UniServe Science Annual Conference, University of Sydney, Sept 29th to Oct 1st, 2010, pages 35-40, ISBN Number 978-0-9808597-1-3

INTRODUCTION

Mathematics bridging courses have been a part of the tertiary preparation landscape for many years, yet data on teaching and learning in these courses are scant. Recent reviews (Galligan & Taylor, 2008) of the limited research into bridging mathematics in the Australasian region have indicated consistent areas of investigation. These include evaluation of specific courses, diagnostic tests and other ways of determining students' needs and overcoming mathematics anxiety.

In ongoing research we investigate teachers' and students' views and experiences of mathematics bridging courses using email interviews. In this paper we focus on findings from participating academics about the perceived challenges of teaching or coordinating these courses. Through engaging educators in structured reflections on their approaches to effective teaching in mathematics bridging courses, the study created opportunities for participants to explore and potentially improve their own practices. Hodkinson (2005, pp. 117-118) postulates that although "our broad conceptualizations of learning can be fairly general, understanding how these conceptualizations can be applied in practice requires attention to the specifics of each location". Our aims are to alert educators to the diversity of views about mathematics bridging courses and to stimulate reflection and active debate about pedagogy in this particular and important context.

MacGillivray (2009) defines mathematics bridging programs as any preparatory program that enables a prospective student to obtain prerequisite or assumed knowledge in mathematics *before* commencing their degree program. We restrict this to preparatory courses that are intensive, 40 hours or less of instruction (in late January and/or February).

At The University of Sydney the number of students enrolling in mathematics bridging courses has increased by 53% from 2001 to 2010. This reflects a national trend away from mathematical options in year 12 in which higher-level mathematical skills are taught (Brown, 2009). Brown (2009) quotes alarming statistics about subject choice at senior secondary; namely that the proportion of students in Year 12 whose highest level is Intermediate or Advanced mathematics has declined by 22% and 27% respectively from 1995 to 2007 (see Rubenstein, 2009, Appendix 1). Brown (2009) points out that Advanced mathematics is not esoteric pure mathematics, but mathematics widely regarded as necessary background for a first year Engineering student at university.

Concerns about the changes between learning mathematics at school and university have also been raised in the literature. Factors cited by Jennings (2009) that relate to transition issues in mathematics include: less prepared students, the fast pace of university mathematics courses, examination systems, the ever expanding curriculum and expected mathematical rigour. Leviatan (2008) refers to different 'cultures' in mathematics, with tertiary mathematics involving more abstract concepts and formal proofs.

In NSW, seven universities run bridging courses in mathematics annually, an indication that these are considered a valuable resource for helping prepare students who have not studied the required level of mathematics prior to entering university. Hence information about teaching and learning in bridging courses is significant to the efforts to ameliorate our students' difficulties with mathematics and help reduce attrition in first year for 'at risk' students.

METHODOLOGY

The project draws on methodology developed by Gordon and colleagues (Gordon, Petocz & Reid, 2007) that collects data by means of asynchronous e-interviews with at most three returns. In these e-interviews the original set of questions are open-ended and designed to be specific to the respective respondent group, with the second and third interviews tailored to probe, in depth, participants' responses from earlier rounds.

In this project, teachers (and/or coordinators) of mathematics bridging courses at universities in NSW and students studying a mathematics bridging courses at The University of Sydney in 2010 were invited to take part in the qualitative research. Ten teachers and 15 students completed email interviews before our cut-off date. In the case of teachers, 7 completed the full round of at least two interviews and the remaining 3 responded to one interview. All participants gave informed consent and excerpts from transcripts are quoted in this paper under pseudonyms chosen by the participants themselves. In this paper we focus on specific aspects of teachers' responses. Further work is in progress analysing students' expectations and experiences of their mathematics bridging courses.

The first email included a welcome message and a set of initial questions. Question 1 asked for background information such as teaching experience including teaching or coordinating mathematics bridging courses in 2010 or in the past. The remaining questions were deliberately open ended with the intention of enabling teachers to explore and articulate accounts of their own practice. These questions included the following. *What are the most important things you expect students to achieve by studying a mathematics bridging course? What is a good mathematics bridging course? What teaching approaches or methods do you use, which are particularly helpful? What makes a good teacher in mathematics bridging courses? What are the most important challenges you have encountered in teaching and/or developing a mathematics bridging course?*

Follow-up email interviews probed and asked for clarification and amplification of respondents' initial answers. Some examples are: *Are there any teaching strategies that are particularly important for maths bridging courses over and above generic qualities you have described? What advice would you give to a colleague about to teach a maths bridging course for the first time?*

In previous projects using this methodology we have found that responding to our questions prompted participants to articulate their reflections with some care. In this way participants engage overtly with ideas about their own teaching that may have been in the background of their minds. As a participant of a previous study commented about the process of taking part in the email interviews: *"such activities act as a source of enthusiasm and motivation/inspiration juice".*

In this paper we focus primarily on teachers' and coordinators' responses to the following question and follow-up discussions: *What are the most important challenges you have encountered in teaching and/or developing a mathematics bridging course?* However, each transcript was considered in full by the researchers. Interpretations were prepared independently and then discussed by the researchers to ensure accurate accounts of teachers' perceptions.

FINDINGS: CHALLENGES OF TEACHING IN A MATHEMATICS BRIDGING COURSE

A number of themes emerged in response to our questions. While most educators referred to several of these themes in their e-interviews, we have separated the themes analytically and illustrate them in this section with short excerpts from the transcripts in italics.

1. CHALLENGE OF TEACHING A DIVERSE STUDENT GROUP IN A BRIDGING COURSE FORMAT

Almost all teachers expressed views indicating that the distinctive environment of a mathematics bridging course presented singular challenges for developing appropriate teaching approaches. They discussed the challenges they faced in teaching a group of students with diverse mathematical backgrounds in such a short time frame.

Hamlet spoke for many when he summed up:
I suppose the key strategy particularly important for teaching a maths bridging course is being able to teach complex and new ideas to students who are weak in the subject in a short, compact time. And indeed this is the most difficult task in teaching!

Jancsi commented that the diversity in the students' backgrounds made it difficult for any one strategy to work: *Sometimes you need to go beyond the course because you have all good students who are not challenged by the material*, *other times you have to spend a lot of time going over really basic examples on the board.* Adam concurred with this when he said: *A major challenge for me, then, is to pitch lessons at a level which won't be too slow to cover the material, or to leave the advanced students merely revising topics they know reasonably well, but will not leave the less-prepared students behind*.

A coordinator of mathematics bridging courses, Hypatia2000, endorsed these views: *that students arrive with a very wide range of backgrounds* and that a good bridging course is: *one that is at least twice as long as ours*. Hypatia2000 found the most challenging students were: *Students with even less than year 10 skills. Students who have not taken ANY maths since year 10 at school.* Hamlet agreed that: *there seems to be a significantly growing number of students appearing that do not even have a year 7-10 basic arithmetic/algebra skills*.

Like Hypatia2000*,* Selena thought the task would be hard if the class had many students with weaker mathematical skills. In her bridging class, Selena found that: *[a] small number of students required greater assistance and this can mean that much of my time is dedicated to a small group. This was okay as students also help each other out and it was a small number.*

These excerpts revealed that developing appropriate teaching approaches for the wide range of student abilities in their classes was seen as a priority, and that the demands for skilful teaching were exacerbated by the short time frame of a bridging course.

2. CHALLENGE OF TEACHING COMPLEX MATHEMATICAL CONCEPTS

Teachers' responses indicated that they spent considerable time and effort finding ways to teach specific mathematical concepts. This theme overlaps with the first but with the focus shifted to the mathematics itself.

Hamlet again spoke for many when he reported*: In my teaching, I often spend time (often too much!) thinking of the optimal way of teaching a concept in a given time period.* He believed that thorough and thoughtful preparation was essential so that: *when a topic is taught, the delivery should be short and concise, yet so elegant that it flows like a coherent story and is easy to follow.*

Adam thought that an important strategy to meet this challenge was to simplify things if excluding the technical details made it: *easier to understand the important ideas, at least at first*. E found a particularly helpful strategy was focusing on the big picture first so that students get a grasp of that: *before attempting to be technically precise or accurate*. E recognised, too, that the symbolic language of mathematics could act as a barrier to students' understandings, saying that: *students can often find a lot of difficultly in understanding and expressing themselves in the appropriate syntax*.

An added challenge articulated by Piper was: *trying to get students to unlearn false mathematical notions and relearn correct mathematics*. Selena mentioned that a common algebraic mistake included: *the rearrangement of the equation to make a certain variable the subject. (e.g. 3x+4=0 => 3x=4). Students seem to forget this from time to time until I point it out.*

Sometimes the teachers were surprised at the level of students' misconceptions or lack of knowledge about seemingly very basic mathematics. Selena observed: *in my first lesson I had to explain that 3/3=1 and not 0 and tried to reinforce the concept so that the students will not make the same mistake by explaining that sharing 3 pizzas among 3 people would mean 1 for each person.*

The teachers stressed the importance of not assuming the students know too much, which for E meant that the teacher must be careful and: *not assume 'obvious' steps.* Selena gave the following example: *Also when I ask some students to find the y-coordinate of a stationary point after they have the x-coordinate, some do not know which function (y=f(x), f'(x) or f''(x)) to substitute the x into. The above problem appears trivial so sometimes it is hard to anticipate the problems they would face.*

3. CHANGING STUDENTS' PERCEPTIONS ABOUT MATHEMATICS AND THEMSELVES AS LEARNERS

Teachers were in unison that helping students change their perceptions of themselves as learners of mathematics was another major challenge.

E thought that: *the hardest challenge teaching wise is in trying to undo twelve years of self reinforcement that a person is inherently 'not good' at mathematics within a short time frame.* Piper's approach to this challenge was: *to give the student a feeling of being in control over their studies and equipping them with the strategies and tools to 'get stuck in'*, for as Coolamon remarked: *maths is all about doing*. As an empathetic teacher Piper tried to: *walk the very fine line between trying to break through student's maths phobias and not coming across as patronizing or trying to trivialize the student's past poor maths experiences*. Adam calculated that this was an issue for between a third and half of his class and pointed out that if students did not have a 'can do' mind set: *the rest is rather pointless*.

Always Hopeful reported on another aspect of students' perceptions and experiences that teachers in mathematics bridging courses needed to overcome. This was the perception by students that: *they do not need mathematics to study their program and therefore have a resentment of mathematics*. *If students were set in their view that maths is too hard and useless to their degree,* proposed Jancsi, then there was little to be done to facilitate student engagement with the material. He saw that there was a wider societal arena to consider and observed that: *essentially we are not a society that prizes education or learning. At the end of the day maths will not be relevant to most people. To change that perception would require a huge change in our society and economy.*

One of the possible reasons for the existence of bridging courses, conjectured Hypatia2000, was: – *many students have not been challenged or stretched at school and expect there to be an easier path. Attitudes (only of some students) that if something is difficult you just drop back to an easier level - instead of working harder to learn something new that is initially confusing.* This might help explain Jancsi's comment that working outside of the course seemed to be: *a big mental jump for students*. He believed that students: *do not seem to truly understand that the course requires work outside of contact hours*. E felt it was important to be mindful of the fact that a lot of students had just finished high school, and were not as independent or mature as students just finishing first year second semester: *It may be easy to trivialise this difference, but I think it is important to keep in mind.*

Chris rated the most important things he expected students to achieve by studying a mathematics bridging course as these:

- *An increase in mathematical understanding*
- *A change in attitude towards mathematics*
- *An increase in confidence in doing mathematics*

Our three themes above summarise the challenges inherent in meeting each of these expectations.

4. ORGANISATIONAL AND LOGISTIC CHALLENGES

We turn now to respondents, whose role included coordinating mathematics bridging courses. Coordinators reported that staffing issues were a major challenge for them as Hypatia2000 outlined. Some challenges were: *finding staff who will teach creatively; finding staff who have enough sound mathematical knowledge to explain concepts and not just teach maths as exercises; finding staff who know where the maths is used in a variety of uni subjects from engineering to economics.* Hypatia2000 took into account students' needs, saying: *as a co-ordinator I like the way we run things with a set amount to be covered in each daily session. This gives maximum flexibility to students who want to change classes for some reason or another.* She added another challenge for those developing the bridging courses: *finding suitable online resources for students to test themselves and get instant feedback.*

Other logistic and organisational challenges were described by the aptly named Always Hopeful. These included budgetary constraints, developing a format that fits the timeframe available and promoting the program to new students. In short: *providing different levels and areas of bridging mathematics in the timeframe and be able to staff these.*

Chris narrated his story of initiating and co-developing statistics bridging courses some years ago. *I drew on people who were more skilled and qualified in teaching stats than me to be co-developers of the materials for the bridging course. This was helpful as they knew the problems students face and could develop well-constructed worksheets and practical teaching sequences.*

We have reported the challenges experienced by teachers and their reflections on how they tried to meet these challenges.

DISCUSSION

It is clear from the documented trends (Brown, 2009) in students' choices of mathematics at the senior secondary school level in Australia and studies of issues regarding students' transition to university mathematics (Jennings, 2009) that the need for mathematics bridging courses at university is increasing and will continue to do so in the foreseeable future. Effective teaching and learning in mathematics bridging courses are arguably now more important than ever. Our paper provides preliminary information from one group of stake-holders in these courses, the teachers, by asking them directly about their views and concerns teaching mathematics in this singular environment. Participants identified challenges that are central to mathematics education in this specific and important context.

Student diversity in mathematics background, motivation, conceptions of mathematics and approaches to learning mathematics are common challenges in all junior mathematics subjects at university, but the short time frame and expectations of students as to what can be achieved in a mathematics bridging course arguably increase the intensity of these challenges in the bridging course context. One area that warrants overt focus by teachers and developers of mathematics bridging courses is student engagement in the courses. As Coolamon points out: 'maths is all about doing' and without this, as Adam reminds us, 'the rest is pointless'. Our findings indicate that student engagement in mathematics bridging courses may be an issue for a relatively large group of students. Indeed questions have been asked (Wood, 2001) about the effectiveness of bridging courses in helping very weak students cope with first year mathematics. This suggests a clear need for research monitoring the progress of students who participate in mathematics bridging courses.

Our research has implications for teaching. Data about experiences of mathematics bridging courses could inform advice given by teachers and careers advisors at secondary school and decision-making by students; perhaps discouraging at least some students at school from taking the easier level of mathematics when the going gets tough, as Hypatia2000 reported.

The accounts of our participants and their willingness to engage in reflection on their practice indicate these teachers' commitment to improve teaching. As one respondent commented on our project: *It is a busy time but it is also a good time to ask these questions as we have just finished our program and are reflecting on some of these points.* Further, our findings provide a basis for reflection that goes beyond a focus on teachers' actions and approaches in mathematics bridging courses. At university, the mathematical concepts themselves — a focus on disciplinary knowledge — will always be a

priority of effective teaching. We argue that reflection and discussion is needed on teaching concepts at the appropriate levels and whether some simplification, as argued by Adam, is sometimes necessary even at the expense of rigour. A question raised by our research is: Are there effective teaching approaches for bridging mathematics that are distinct from those used in junior mathematics courses? This in turn relates to a question raised by Taylor and Galligan (2006) who ask: What constitutes success for students in mathematics bridging courses?

A focus on the goals and constraints of mathematics bridging courses, the logistics of running courses within a budget and surrounding issues like staff flexibility, resources and time management, are areas where experienced coordinators can offer suggestions to individual teachers as well as others starting to develop mathematics bridging courses. Respondents' ideas in this project suggest that debate could be fruitful as to what skills and strategies are important for bridging teachers and what proportion of time could be devoted to student led activities or group problem solving.

Finally, we suggest that forums for teachers of mathematics bridging courses to interact informally and exchange ideas as well as formal pedagogical support and training are two ways of increasing a reflexive approach to teaching mathematics bridging courses that could benefit both teachers and students. Chris articulated a common problem. *The challenge these days is I have little down time to do improvements as I am so heavily engaged both during semester and semester breaks in teaching.* We hope to provoke a conversation about just that.

ACKNOWLEDGEMENTS

We gratefully acknowledge the time and insights of the teachers and coordinators who participated in this research. The research was funded by a Small TIES Grant from The University of Sydney.

REFERENCES

Brown, G. (2009). Review of Education in Mathematics, Data Science and Quantitative Disciplines. Report retrieved from http://www.go8.edu.au/go8media/go8-media-releases/2010/184-group-of-eight-releases-maths-review

Galligan, L. & Taylor, J.A. (2008). Adults Returning to Study Mathematics. In H. Forgasz, A. Barkatsas, A. Bishop, B, Clarke, S. Keast, W. Seah & P. Sullivan (Eds.), Research in Mathematics Education in Australasia 2004-2007 (pp. 99-118). Rotterdam: Sense Publishers.

Gordon, S., Petocz, P. & Reid, A. (2007). Teachers' conceptions of teaching service statistics courses. International Journal for the Scholarship of Teaching & Learning, 1(1). Retrieved from: http://academics.georgiasouthern.edu/ijsotl/v1n1/gordon_et_al/index.htm

Hodkinson, P. (2005) Learning as cultural and relational: Moving past some troubling dualisms. Cambridge Journal of Education, 35(1), 107-119.

Jennings, M. (2009). Issues in bridging between senior secondary and first year university mathematics. In: R. Hunter, B. Bicknell and T. Burgess (Eds.), Proceedings of the 32nd Annual Conference of the Mathematics Education Research Group of Australasia. MERGA32 (pp. 273-280). Wellington, New Zealand: MERGA.

Leviatan, T. (2008). Bridging a cultural gap. Mathematics Education Research Journal, 20 (2), 105-116.

MacGillivray, H. (2009). Learning support and students studying mathematics and statistics. International Journal of Mathematical Education in Science and Technology, 40(4), 455 – 472.

Rubinstein, H. (2009). A National Strategy for Mathematical Sciences in Australia. Strategy document written in consultation with the Australian Council of Heads of Mathematical Sciences. Retrieved from http://www.amsi.org.au/pdfs/National_Maths_Strategy.pdf

Taylor, J. A., & Galligan, L. (2006). Research into research on adults in bridging mathematics: The past, the present and the future. In M. Horne & B. Marr (Eds.), Proceedings of the 12th International Conference of Adults Learning Mathematics, ALM (pp. 11-19). Melbourne: ACU National.

Wood, L. (2001). The secondary-tertiary interface. In D. Holton, (Ed.), The Teaching and Learning of Mathematics at University Level: An ICME Study (pp. 87-98). Dordecht: Kluwer Academic Publishers.