TEACHING MATHEMATICS TO PRIMARY TEACHERS IN AUSTRALIA

Gail E. FITZSIMONS

Faculty of Education
PO Box 6
Monash University, 3800
Australia
gail.fitzsimons@education.monash.edu.au

ABSTRACT

Primary teacher education is a relatively low status option for school leavers in Australia, when judged by competitive rankings of university entry scores. Although undergraduate primary education students have completed 12 years of study in mathematics, their knowledge is not always secure and their understandings are largely instrumental. Although most students are continuing from school, there are also mature-aged students (mostly women) among this cohort who have been out of education for many years. Not surprisingly, mathematics anxiety is manifest among many students, young and old. This paper will give details of an innovative approach to strengthening the foundation of mathematical knowledge as well as broadening the students' perspectives on the nature of mathematics itself, with a view to influencing the pedagogical approaches that the students will eventually adopt. The course content is based upon Bishop's (1988) 'six universals': counting, locating, measuring, designing, explaining, and playing. As with all educational endeavours, the paper represents a work-in-progress. It will outline the theoretical foundations of the course structure, describe student responses, and evaluate the progress of this course which has run since 2000.

Keywords: Teacher education, Curriculum, Culture, History, Adult learners

1. Introduction

Internationally, the preparation of primary (elementary) school teachers appears to be faced with the problem of teaching students who are insecure in their mathematical knowledge and frequently lack confidence in the subject; Australia is no exception. Primary teacher education is a relatively low status option for school leavers in Australia, when judged by competitive rankings of university entry scores. At Monash University the course *Exploring Mathematics* is attempting to address the issue of broadening and deepening students' knowledge of the discipline. Typically, students who are continuing from school have studied the less demanding options in the final years; others (mainly women) are returning to study after decades away from a mathematics classroom. Indications of mathematics anxiety are common — exacerbated by the requirement that 50% of the assessment is a written examination. Not surprisingly, students exhibit preferences for an instrumental approach to learning (Skemp, 1978): "Just give me the rules and I will memorise them" is a common plea from those less confident.

This paper will detail one approach to strengthening the foundation of mathematical knowledge as well as broadening the students' perspectives on the nature of mathematics itself, with a view to influencing the pedagogical approaches that the students will eventually adopt. It will outline the theoretical foundations of the course structure, describe student responses, and evaluate the progress of this course, which has run since 2000.

2. The Course Structure

Theoretical foundations.

Grugnetti and Rogers (2000) assert that school mathematics should reflect aspects of mathematics as a cultural activity:

— from the philosophical point of view: mathematics must be seen as a human activity, with its cultural and creative aspects.

— from the interdisciplinary point of view: when mathematics is linked with other subjects, the connections must be seen not only in one direction. Students will find their understanding both of mathematics and their other subjects enriched through historical liaison, sympathies and mutual aid between subjects.

— from the cultural point of view: mathematical evolution comes from a sum of several contributions. Mathematics can be seen as having a double aspect: an activity both done within individual cultures and also standing outside any particular culture. (p. 61)

In Australia, although there are national and state-based curriculum statements supporting these aims (e.g., Australian Education Council, 1990; Board of Studies, 2000), the reality is that they are peripheral in terms of the implemented and assessed curriculum; this is reflected in the range of commonly used textbooks. The three aspects listed above provide a summary of the theoretical foundations of *Exploring Mathematics*. However, it should be noted that in Australia, with less than 300 years of European settlement and where policies of economic rationalism prevail, the history of mathematics is not a major area of study in universities where departments of mathematics (and history) themselves are struggling to survive (Thomas, 2000).

Course content and assessment.

Rather than attempting to match directly the mandated curriculum strands — algebra, chance & data, number, measurement, and space — the course content was based upon Bishop's (1988) 'six universals': counting, locating, measuring, designing, explaining, and playing — in order to better gain access to the metacognitive perspectives listed above. Nevertheless, we remain cognisant of the content our students will be expected to teach, as well as the kind of mathematical/statistical written and graphical texts, emanating from ministerial and other research sources, that they will be expected to interpret and act upon as professional teachers. These six broad topics provide a sociocultural-historical basis to underline mathematics as a human construction (including its explicit and implicit values), with particular emphasis on non-European cultures such as those of Asia, the Pacific region, and Australian Aborigines. Lectures were predominantly focused on transmission of these aspects, with intermittent whole-group activities to keep students engaged. Tutorials were focussed on worksheet activities to be completed during the week. One aim of the course was to develop in students a sense of exploration through a problem-solving approach and the encouragement of appropriate web searches.

The course was presented over 10 weeks, with a one hour combined lecture and a one hour tutorial for two groups of approximately 30 students. The assessment consisted of a major project (20%), a folio of completed mathematical activities together with weekly reflective journals (30%), and a final examination (without calculators) (50%). In the reflective journal, students were required to address four items:

1. A list of mathematics content I learned for the first time, or had forgotten about. [Note anything that is still unclear, or that you are worried about, or you would like further work on.]
2. How I felt this week as a learner of mathematics. [Give reasons.]
3. How the topic relates to the primary school curriculum [mathematics **and** other subjects].
4. One teaching idea that I have developed from this week's work. [Give details of activity and approximate age level.]

The examination dealt with the mathematical processes that the students would be expected to be competent in (no higher than the upper secondary curriculum but attempting a greater depth of understanding through explanation), as well as questions concerning their knowledge of historical and cultural aspects of mathematics. For the latter, the questions were more open-ended. For example: "A primary student says to you: 'Where did our numbers come from.' How would you respond?" Problem-solving was assessed through tutorial work only — to the great relief of many.

The first two weeks were focused on revision of arithmetic and statistical knowledge supposedly covered in school, but which can never be taken as assumed knowledge. A .pdf file was loaded on to the Monash University intranet, detailing arithmetic algorithms with annotations and calculator keystrokes; students could use it as a self-paced module to update their skills. Both weeks included problem-solving or investigative work. The final week was revision, and all other weeks were devoted to one of the six themes listed above, with Counting given two weeks. Each weekly worksheet had about six activities, each developed through a range of increasingly open-ended or abstract questions.

3. Responses from Student Journals

As mentioned above, mathematics anxiety is a significant feature of students enrolled in courses such as these, and may be portrayed in emotionally-charged behaviours in tutorials, or through considered written reflections. However, in both years of presenting this course every student who made a sincere effort ended up gaining a pass mark, or higher credential (around 97% of students). It also happened that mature-aged students, initially among the most anxious, actually achieved excellent results on account of their serious attitude towards the study of mathematics (see FitzSimons & Godden, 2000). In the (non-random) selections from student journal entries below, two students are mature-aged [M1 & M2] and two are young, around their early twenties [Y1 & Y2].

Journal responses have also been used as supporting evidence for the three categories listed above as offering a theoretical framework for the course. In addition, there are entries, which highlight shortcomings in the course to date, and signs that it might be achieving some of its goals.

Anxiety

How have I felt this week as a learner of maths? Confused, dumb, like [I] have a mountain to climb, insecurities about teaching maths when I [have] feelings of being incompetent. … Because I have forgotten much of the terminology and formulae, this adds to my insecurity. However, I do not want to pass on any self doubts to the students I will teach in the future, and intend to work hard at this subject to improve my maths on a personal scale, as well as my confidence in teaching maths to others. [M1, week 1, Arithmetic revision]

I still find myself becoming anxious whenever the word 'problem solving' is mentioned. I lack the confidence to 'have a go', perhaps [a] legacy of the days when getting the wrong answer meant punishment. [M2, week 3, Counting, part 1]

I am beginning to think that Mathematics can be an enjoyable experience, especially when shared with others. I have found that by talking about my investigations with my colleagues in the staff room, I realise that I am not the only person who experiences difficulties with some concepts. [M2, week 9, Playing]

Again this week I felt confused as a learner of mathematics, simply because I was learning about things that I had never considered to be maths or maths related before. As I began to see the relationship, though, I felt comfortable with what I was learning. [Y2, week 6, Designing]

Mathematics as a human activity.

I often like to make and construct things for fun for my home. It has occurred to me that when I make something I usually consciously consider the logistics and aesthetics of whatever project I am undertaking, but after this week's activities I feel more appreciative of the significance of mathematical properties that come into play when designing and creating something. Similarly, as a learner of mathematics, I feel more appreciative of the significant role mathematics plays in daily activities. [Y1, week 6, Designing]

I also learnt that explaining is universal (all cultures use explanations), however we all explain in different ways. [Y2, week 8, Explaining]

Before this week I was unclear about the connection between maths and playing, therefore both the lecture and tutorial were able to help me feel more comfortable as a learner of maths because they helped me see the relationship — "playing is often valued by mathematicians because rule-governed behaviour is like maths itself" (lecture). [Y2, week 9, Playing]

Interdisciplinary aspects of mathematics.

I did enjoy doing Fibonacci numbers, especially once I researched Fibonacci and how this principle can be applied to many patterns in nature. [M1, week 3, Counting, part 1]

During teaching rounds I like to have a look at mathematics software available for children to use in the classroom. Much of the software I find features games that require the use of problem solving and logic. Children seem to enjoy them without realising that the games have foundations in mathematics. [Y1, week 9, Playing]

The topic of locating obviously related very strongly to the school curriculum through the maths strand of space. However, the unit also has relevance to probably every other KLA [Key Learning Area] because the ability to locate and use corresponding terminology are valuable in everyday life and language. In particular I think it relates to SOSE [Studies of Society and the Environment] (geography), Art (drawing and painting), English (understanding the terminology) and Technology (construction and info tech). [Y2, week 4, Locating]

I could also see how the study of design could be integrated with other subjects. For example, studying Ancient Egypt in SOSE could see the students investigating the properties of the pyramids. Students studying the cultures and practices of different countries could investigate and practice the art of origami, or make a range of Chinese influenced tangrams to create pictures. [M2, week 6, Designing]

Mathematics and culture.

I found the information about cultural differences in classifying and representing information pertaining to Maths fascinating. In particular, I have tended to simplify the actions of Aboriginal people, only seeing the physical connections they have with their land and people, yet the overhead of the Family Tree of the Yolnu people shows a complexity of mathematical information. [M2, week 8, Explaining]

In a way, Mathematics can be considered an art, demonstrating an ordered way of presenting and viewing information and using its own distinctive language including signs, symbols and terminology.

Mathematics is part of our everyday activity, so can be considered as a tool for daily life. Problem solving, investigation, inquiry can all be assisted through mathematical knowledge. [M2, end of semester introduction to journals]

Complaints from students.

As noted in previous weeks, I wish we spent more time during the lectures and tutorials going over some of the basic mathematical principles for the topics … as this would give us a basis to build upon. [M1, week 5, Measuring]

I felt less comfortable as a learner of maths this week for a number of reasons. The first of which is that I didn't know if I was in a maths lecture or a history lecture. I don't mean to sound disrespectful, I just felt that today's lecture wasn't overly relevant to what I need to know to be a primary teacher. [Y2, week 5, Measuring]

I have researched the internet for some helpful information, but there seems to be an abundance of information on how to make a box plot or stem and leaf plot, but nothing on how I can describe or interpret the information. [M2, week 2, Statistics]

Making progress.

Whilst on teaching rounds over the last three weeks, I taught students maths and enjoyed it. I researched before each lesson making sure that I used the correct terminology etc. [M1, week 6, Designing]

I needed help from my classmates with the 'fractions to decimals' as I was unsure how to do this and was not familiar with the terms 'terminating, repeating, recurring'. However, once I realised what they meant, I tested out various fractions on th e calculator. I felt I had accomplished something when I saw fractions that were repeating, recurring or terminated and my confidence with these fractions to decimals increased. [M1, week 7, Counting, part 2]

It's strange to think this is possible, but I feel that this week I learnt a lot about my own views and understandings of mathematics. When we were asked to write down what maths is in the lecture, I found it challenging to determine all the things that this subject entails, even though I studied it throughout my entire schooling from Prep to12. Often the word maths is solely related to computation, and I think that in order to make the subject interesting and fun for children we need to start seeing maths as much more than that, so that we bring some variety into our classrooms. [Y2, week 3, Counting, part 1]

I actually enjoyed my role as a learner of maths this week. I like problem solving that requires a bit of thought and time, and many tutorial and lecture questions relied on working out processes and working towards a solution. I was challenged to think for quite some time about a number of the investigation questions, and therefore when I discover the answer it gives me a sense of achievement and satisfaction. I also felt comfortable with the new knowledge I was learning about combinations and with the revision on probability because it made sense to me. It's so easy to change how one feels about themselves as a learner of maths from week to week, because it's one of those subjects that if you don't get it, it will just drive you insane. Thankfully, this week I am understanding. [Y2, week 7, Counting, part 2]

4. The Projects

For their major projects students were asked, in 2000, to design and model an adventure playground suitable for primary-aged children. In 2001, they were asked to design a 'mathematics trail' for primary children, utilising a real or hypothetical site, including activities relating each of the six 'universals,' with questions of varying sophistication according to criteria such as Bloom's (1956) taxonomy. In both years there were many outstanding projects, as well as a few of doubtful quality reflecting minimal effort. Many had actually been trialled by students on their teaching rounds, which took place for three weeks around the middle of the course. Many projects indicated that the students had taken serious account of the intentions of the course as a whole, and will provide them with an excellent teaching resource in years to come; perhaps even a folio item for future job applications.

5. Conclusion

For a variety of reasons, no formal evaluation of the course took place in either year. Clearly it is easy for the author, who co-designed the course with Alan Bishop, to highlight the positive aspects and present selective journal entries. The major serious complaint appears that the lectures were too heavily weighted on the side of illustrated narratives of historical and cultural aspects to the detriment of mathematics theory and worked examples. This point is valid. However, there are also problems associated with lecturing on technique when the range of abilities of students (not previously known to the lecturer) is very wide, both in terms of courses studied and results achieved, and in terms of length of time away from formal study of mathematics. Obviously there is still some fine-tuning to be done. Other criticisms, not expressed here, are that this series of lectures and tutorials does not model good teaching practice, according to the theories espoused in students' teaching method lectures. The second time around it was easier to head off these complaints by addressing them in the beginning. Combined lectures and tutorials of around 30 students each are not ideal, but are one of the constraints set by the university. The examination, a source of great anxiety as mentioned above, had already been mandated by the accreditation process of the university.

Could this course be described, pejoratively, as a course in mathematical tourism? What are the borders/boundaries between improving disciplinary knowledge in terms of content and process, and enhancing pedagogical content knowledge in terms of offering a 'bigger picture' (Ernest, 1998) of mathematics — in relation to the three aspects of philosophy, interdisciplinarity, and cultural awareness as outlined by Grugnetti and Rogers (2000)? What evidence is there that these students will be more confident and competent as classroom teachers in years to come? The evidence so far, at least, is that new ways of seeing and knowing mathematics have been opened up to at least some of the students. A longer-term research project is needed to answer some of the other questions. As noted in the abstract, this paper has sought to describe a work-in-progress.

REFERENCES

-Australian Education Council, 1990, *A national statement on mathematics for Australian schools*, Melbourne: Curriculum Corporation.

-Bishop, A. J., 1988, *Mathematical enculturation: A cultural perspective on mathematics education*, Dordrecht: Kluwer Academic Publishers.

-Bloom, B. S., (ed.) 1956, *Taxonomy of educational objectives: The classification of educational goals*, New York: David McKay.

-Board of Studies, 2000, *Mathematics: Curriculum and Standards Framework II*, Melbourne: Author.

-Ernest, P., 1998, "Why teach mathematics? — The justification problem in mathematics education", in J. H. Jensen, M. Niss, & T. Wedege (eds.), *Justification and enrolment problems in education involving mathematics or physics*, Roskilde: Roskilde University Press, pp. 33-55.

-FitzSimons, G. E. & Godden, G. L., 2000, "Review of research on adults learning mathematics ", in D. Coben, J. O'Donoghue, & G. E. FitzSimons (eds.), *Perspectives on adults learning mathematics: Research and practice*, Dordrecht: Kluwer Academic Publishers, pp. 13-45.

-Grugnetti, L., & Rogers, L., 2000, "Philosophical, multicultural and interdisciplinary issues", in J. Fauvel & J. van Maanen (eds.), *What engine of wit: The ICMI study on history in mathematics education*, Dordrecht: Kluwer Academic Publishers, pp. 39-62.

-Skemp, R. R., 1978, "Relational understanding and instrumental understanding", *Arithmetic Teacher*, **263**, 9-15.

-Thomas, J., 2000, October, *Mathematical sciences in Australia: Looking for a future*. Federation of Australian Scientific and Technological Societies [FASTS] Occasional Paper Series, No. 3, Canberra: FASTS.