eCULTURE

Volume 2 2009 *Article* 8

Supporting pre-service primary teachers to improve their mathematics content knowledge

Brenda Hamlett*

*Edith Cowan University, b.hamlett@ecu.edu.au

Supporting pre-service primary teachers to improve their mathematics content knowledge

Brenda Hamlett

Abstract

”When someone is told that their performance is not up to a required standard, there can be a tendency to react negatively and to lose confidence. Some deal with this by ignoring or withdrawing from the stressful situation while others face the issue and work to improve. The delivery of the first year unit Becoming Multiliterate as part of the BEd (Primary) and BEd (Early Childhood Studies) courses at Edith Cowan University entailed students completing diagnostic tasks in mathematics, writing and science at the start of the semester to identify their weaknesses. Students were then provided with targeted support to enable them to reach identified benchmarks. This paper reports on how the diagnosis and intervention stages in the mathematics module used approaches designed to develop improved skills without decreasing levels of confidence amongst the students. Given that teacher registration bodies are likely to introduce literacy and numeracy standards for graduating teachers in the near future, the strategies used could be applied to similar courses elsewhere.”

ECULTURE

Supporting pre-service primary teachers to improve their mathematics content knowledge

Brenda Hamlett
School of Education
b.hamlett@ecu.edu.au

Abstract: When someone is told that their performance is not up to a required standard, there can be a tendency to react negatively and to lose confidence. Some deal with this by ignoring or withdrawing from the stressful situation while others face the issue and work to improve. The delivery of the first year unit Becoming Multiliterate as part of the BEd (Primary) and BEd (Early Childhood Studies) courses at Edith Cowan University entailed students completing diagnostic tasks in mathematics, writing and science at the start of the semester to identify their weaknesses. Students were then provided with targeted support to enable them to reach identified benchmarks. This paper reports on how the diagnosis and intervention stages in the mathematics module used approaches designed to develop improved skills without decreasing levels of confidence amongst the students. Given that teacher registration bodies are likely to introduce literacy and numeracy standards for graduating teachers in the near future, the strategies used could be applied to similar courses elsewhere.

Background

It is widely recognised that, in order to teach effectively, teachers need to know and have a deep understanding of the content of the curriculum they are presenting to their students. Unfortunately, in primary teaching it is often the case that mathematical knowledge is superficial and understanding limited. This is a major problem in a world where technology plays an increasing role, and both daily life and the workplace require high levels of mathematical literacy. The BEd (Primary) course at the Mt Lawley campus of Edith Cowan University has been addressing this issue since 2005 through a module within a first year unit entitled *Becoming Multiliterate* and next year will introduce a new unit *Science and Mathematics for Teachers.* One of the key features of the approach has been to ensure that the identification of weaknesses is communicated sensitively and accompanied by individualised support so that students adopt a positive attitude in their efforts to improve their skills. The aim is that, in the terms of this conference, they are engaged and sustained in order to succeed. This paper reports on the success of this approach in terms of improvement in students' mathematical competence, confidence and attitude towards mathematics.

Mathematical competence for primary teachers

Different terms are used to describe mathematical content knowledge including numeracy (used in the Crowther Report and cited by Kemp & Hogan, 2000), quantitative literacy (Latiolais, Collins, Baloch & Loewi, 2003; Steen, 2001) and computational fluency (Flowers, 2003), as well as mathematical literacy. The last is defined by the Program for

International Student Assessment (PISA) as “an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgements and to engage in mathematics in ways that meet the needs of that individual’s current and future life as a constructive, concerned and reflective citizen” (cited in Steen, 2001, p7). For primary teachers this means they need to be proficient in mathematics to at least lower secondary level.

Unfortunately, experience internationally, across Australia and at ECU in particular indicates that it cannot be assumed that pre-service primary teachers entering university will be competent in mathematics. This is not a new phenomenon. In 1949, Glennon reported, “those preparing to teach mathematics in the elementary grades understand approximately 50% of the computational processes taught in grades one to six” (cited in Rech, Hartzell & Stephens, 1993). Hungerford (1994) quotes the Mathematical Association of America: “... the mathematical preparation of elementary school teachers is perhaps the weakest link in our nation’s entire system of mathematics education”. The Australian Academy of Science identified mathematics as a “critical skill for Australia’s future” and recommended that “all mathematics teachers in Australian schools have appropriate training in the disciplines of mathematics and statistics” with “national accreditation standards for teachers of mathematics at all levels of schooling.. and.. appropriate programs to ensure that future teachers meet these standards” (Rubinstein, 2006, p15). The Queensland Government recently supported a recommendation from the Masters Review that teachers be able to meet mathematics competence requirements in order to gain registration and has set timelines for the development and introduction of suitable tests (Queensland Department of Education and Training, 2009). Other states, including Western Australia, are likely to follow a similar path.

CRC – Commend, Recommend, Commend

In response to concerns about literacy levels amongst students entering the BEd Primary and Early Childhood courses, a unit entitled *Becoming Multiliterate* was developed by a large team of staff at ECU to address student needs in mathematical, written, scientific and computer literacy. From the outset there was widespread concern about the impact on students of explicitly identifying areas of weakness. Pre-service primary teachers are already found to have “more negative attitudes towards mathematics than the general college (population)” (Rech, Hartzell & Stephens, 1993). In some cases this can manifest itself as mathematics anxiety (Malinsky, Ross, Pannells & McJunkin, 2006), in others as low levels of self-efficacy as both a mathematician and as a teacher of mathematics (Enochs, Smith & Huinker, 2000). Research in the UK has identified a number of ways in which students can react to an audit of their mathematical skills. Sanders and Morris (2000) classified students into three groups. *Ostriches* either refused to believe they had a problem or avoided doing anything that would provide evidence of their weakness. *Mañañas* acknowledged their difficulties but did little to correct them until they were forced to do so, such as when they had to teach the content. *Nettle graspers* not only acknowledged their problems but also worked to resolve them. ECU needs its students to be nettle graspers.

Despite the concerns, the benefits of administering entry diagnostic tasks could not be denied. Able students who could demonstrate the requisite levels of achievement would be recognised and allowed exemptions from remedial sessions, while those with only a few areas of concern would have targeted support provided. Those who needed more help would be identified and offered more intensive assistance. The agreed approach was based on the CRC model used by Toastmasters International in Australia (2008) when giving feedback to members developing public speaking skills. CRC stands for *Commend, Recommend, Commend* and places a strong emphasis on recognising what has already been achieved,

providing advice and support for further development and recognising subsequent improvement.

Steps taken to ameliorate any potential negative reactions began at Orientation when students were fully informed about the unit, including its structure and the requirements of each module. Lists of the desired skills were available and these were based on Level 4 of the WA Outcomes and Standards Framework - Mathematics (Curriculum Council, 2005) which is the achievement target for year 9 students. Students thus realised that they were not expected to demonstrate tertiary entrance level mathematics. The "test" in week one was called an "entry assessment" and its role as a diagnostic tool was emphasised. Each question in the task was linked to a specific intended outcome of the module so correct answers led to the relevant outcome being "signed off". Multiple-choice questions were not used so that marks could be awarded for answers that were partially correct or where the student had made a simple calculation error. If students scored at least 75% of the available marks for a question, the corresponding outcome was checked off their list. In addition, if they scored a total of 75% on the task as a whole they were deemed to have passed the module even if some outcomes had not been fully addressed. While it would have been desirable for students to achieve 100%, this was seen as unrealistic and 75% was perceived by staff and students as a compromise between perfection and the usual university pass mark of 50%. Students were also told that they would have multiple opportunities to reach the benchmarks.

While the focus of this paper is on the mathematics module, parallel processes were followed in writing and science and this had the added advantage of enabling students who were weak in one area but strong in another to use their partial success to feel more positive.

In the entry task, students were asked to indicate how confident they felt about having answered each question correctly. This enabled tutors to identify students who were particularly lacking in confidence and target them for extra support and provided base data for comparison with levels at the end of the unit. A formatted sample of a question from the task is shown below. The first column indicates the Question Number (7) and the number of marks available (3). The second column indicates the relevant outcome (**M2**: *Convert among units within the metric system eg cm to m, kg to g*). The third column contains the question and includes space for the answer to be written underneath. The final column includes a Likert scale used by the student to rate how confident they felt that they had answered the question correctly:

1. 1 Not at all confident
2. 2 A little confident
3. 3 Reasonably confident
4. 4 Very confident The results of the entry tasks were given to the students in individual interviews. Tutors provided them with a checklist of the skills required in the unit with those linked to correct answers already highlighted as complete. This was the *Commend* stage of the approach.

7 (3)	**M2**	A craft class teacher needs to buy supplies for the students. One week she has to buy ribbon – all the same colour and width – and wants to find out how much she needs to get. She has notes with her students' orders with the following measurements on them: 30 cm, 45 mm, 1.2 m and 1 m 25 cm. how much does she need to buy altogether?	**1 2 3 4**

Over a period of three weeks students attended workshops in a computer laboratory where they were able to work on the outcomes they had not already completed. Tutors suggested a range of strategies appropriate for each student (the *Recommend* stage) including hands on materials based on those used to teach mathematics in primary schools. Worksheets were available for those who preferred pen and paper approaches and care was taken to link

all resources to the specific outcomes so students could focus on what they needed to practise. A mix of whole class teaching, small group work and individual practice was used according to need.

A major component of the intervention stage was the use of the Mathletics website. This had a number of advantages over similar products. In particular, staff were able to select topics from a bank of resources and customise a program to suit the needs of the students both in terms of content and level. There was some concern that students would find the site too childish so staff specifically monitored their reactions. As it transpired, the students felt unthreatened by the activities and engaged with the cartoon characters and various sound effects in much the same way as children in a classroom. The atmosphere in the laboratories was relaxed and even fun – not words usually associated with mathematics.

At the end of the three week module tutors checked with each student that they knew what they had still to complete to meet the unit requirements. In the final part of the third session students sat an exit assessment which exactly paralleled the entry task so there were no surprises. Each paper was individually prepared for the student with the questions they still needed to answer highlighted on the front. While time consuming for staff, students appreciated being treated as individual learners rather than being part of a one size fits all approach. As a further incentive, students knew that if they got a lower score in the exit task for a question they had to repeat, they would retain their previous score for that question, ie they would not go backwards. Results were communicated anonymously via Blackboard and most students reached the 75% benchmark at this stage. Even if they did not pass, their scores improved and the checklist of outcomes still to be addressed was shorter. This is the third stage, *Commend* subsequent achievement. Students then worked individually using the website and other resources until resit opportunities were held at the end of semester one and, if necessary, at the start of semester two.

Unit outcomes

A summary of student performance in the mathematics module of *Becoming Mulitliterate* is provided in Table 1. In 2006 the benchmark was 70% but this was raised to 75% in 2007 and subsequent years after staff raised concerns about student skills in mathematics education units later in the course. Scores improved significantly during the unit although between 5% and 15% of students in a given year did not meet the mathematics requirements. In addition, approximately 20% of the cohort in each year did not complete the exit tasks having either withdrawn from the unit or failed to attend assessment sessions. Exit surveys conducted by the School indicated that many of these students had decided that primary teaching was not

		2007	2008	2009
Number of students enrolled in unit	337	344	371	344
	N %	N %	N %	N %
Met mathematics requirements on entry	38 11%	19 6%	19 5%	19 6%
Met mathematics requirements on exit	250 74%	228 66%	246 66%	262 76%

Table 1: Mathematics task Performance Data from 2006 to 2009

Mean score on entry (out of 100) 51.1 45.7 47.0 36.9 Mean score on exit (out of 100) 78.4 76.9 77.4 71.2

ECULTURE

Data on levels of confidence on exit from the unit was collected at the start of the first mathematics education unit in semester two and compared to the entry confidence data elicited in the first assessment task. Figures are only available for 2006 and 2007 due to course structure changes and staff leave requirements. However, as can be seen in Table 2, the aim of addressing the need to improve competence without negatively impacting on confidence appears to have been successful.

	2006	2007
Mean confidence level on entry	71.5	65.3
Mean confidence level on exit	85.1	79.2

Table 2: Mean confidence scores in mathematics tasks from 2006 and 2007

Additional evidence related to student attitudes was gleaned from the data provided by the university Unit and Teaching Effectiveness Instrument. Selected results for the years 2006 and 2007, chosen on the basis of relevance to this paper, are shown in Table 3 below:

	Year	Percentage agree	Number
The unit enhanced my knowledge and skills in the subject.	2006	87	303
	2007	90	48
The assessments assisted my learning.	2006	84	302
	2007	83	48
The lecturer catered for my individual needs in this unit.	2006	80	156
	2007	82	17
The tutor encouraged and supported my learning.	2006	93	206
	2007	92	49
The tutor provided useful feedback and guidance on my work.	2006	90	206
	2007	94	49
*Overall I was satisfied with the teaching of this tutor	2006	76	95
	2007	73	96
*Faculty – overall satsfaction (tutor)	2006	62	88
	2007	61	87

Table 3: Selected UTEI results from 2006 and 2007

* Tutor overall satisfaction is used as it is based solely on the mathematics module.

The low response rates for 2007 coincide with the introduction of online surveys and it was difficult to accommodate the modular nature of the unit in the new system. However, results are consistent across the two years indicating high levels of student satisfaction which compare well with results across the Faculty.

Students' written comments in the UTEI were also supportive of the approach that was taken in the unit. Over the two years 29% of responses commented positively on the use of the Mathletics site and 29% stated the unit had improved or refreshed skills, knowledge or understanding. The individualised or self paced nature of the unit, the identification and targeting of weaknesses, the easy to access resources and the helpful knowledgeable tutors were all mentioned in at least 10% of the comments. About 35% of written responses referred

to the tutors always being available and willing to help, an acknowledgment of the key role they played in ensuring students maintained positive attitudes towards developing their mathematical skills.

Responses to the question *What changes would you suggest for this unit?* came from fewer students (83 over two years compared to 131 who wrote positive comments) and of these 45% wanted more time for the tests and/or more time to work on improvements. A number of concerns must have been addressed following 2006, as 36% of the responses to this question in 2007 were "Nothing".

The UTEI comments are perhaps best summed up in the following words written by a student in answer to the question, "*What aspect of this tutor's approach to teaching best helped your learning*?"

"Her enthusiasm was awesome, she made me enjoy maths which I usually hate. I liked her availability, no question was too hard or too stupid. She explained why, how etc without making me feel inadequate, which is how I usually feel in mathematics."

Conclusion

While first year pre-service primary teachers at ECU show similar poor skills in mathematics to their counterparts in the rest of Australia and overseas when commencing their course, the mathematics module in *Becoming Multiliterate* has been successful in improving their skills without having a negative impact on their confidence. The approach will be further developed in 2010 with the introduction of *SAM1000 Science and Mathematics for Teachers* which will allow more time for mathematics skills than the three weeks in *Becoming Multiliterate.* By providing effective teaching and learning resources, and through the efforts of tutors who willingly give time and energy to a unit which involves considerable marking and record keeping, students are supported to respond to the results of the diagnostic task positively and purposefully. The CRC approach has meant that, far from ignoring their weaknesses, students are prepared to do what needs to be done to become effective future teachers of mathematics.

References

Curriculum Council. (2005). *Outcomes and standards framework - Mathematics*. Perth: Department of
Education and Training of Western Australia. Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the Mathematics teaching
Efficacy Beliefs Instrument. *School Science and Mathematics, 100*(4), 194-202. Flowers, J., Kline, K., & Rubenstein, R. N. (2003). Developing teachers' computational fluency: examples in
subtraction. *Teaching Children Mathematics, 9*(6), 330.
Hungerford, T. W. (1994). Future elementary teachers: the neglected constituency. *The American Mathematical Monthly, 101*(1), 15-21.
Kemp, M., & Hogan, J. (2006). *Planning for an emphasis on numeracy in the curriculum.* (Retrieved 09/08/2007)
http://www.thenetwork.sa.edu.au/pages/educators/articles_papers_index/
Latiolais, M. P., Collins, A., Baloch, Z., & Loewi, D. (2003). Assessing quantitative literacy needs across the university. *Portland State University Faculty Focus, 14*(1).
Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. (2006). Math anxiety in pre-service elementary school teachers. *Education, 127(2).* 274-279.

Queensland Department of Education and Training. (2009). *Government response to the report of the Queensland Education Performance Review – 'Masters Review'*. Queensland Government. (Retrieved 20/09/2009) http://education.qld.gov.au/mastersreview/pdfs/gov-response-masters-review.pdf).
Rech, J., Hartzell, J., & Stephens, L. (1993). Comparisons of mathematical competencies and attitudes of elementary mathematics majors with established norms of a general college population. *School Science and Mathematics, 93*(3), 141-144.
Rubinstein, H. (2006). *Mathematics and statistics: critical skills for Australia's future. Key findings and recommendations of the National Strategic Review of Mathematical Sciences Research in Australia.* Melbourne: Australian Academy of Science.
Sanders, S. E., & Morris, H. (2000). Exposing student teachers' content knowledge: empowerment or debilitation? *Educational Studies, 26*(4), 397-408.
Steen, L. A. (2001). *Mathematics and democracy: the case for quantitative literacy*: National Council on Education and the Disciplines, Woodrow Wilson National Fellowship Foundation.
Toastmasters International in Australia. (2008). *The CRC*. (Retrieved 14/08/2008) http://toastmastersvq.net/evaluationguide/