MATHEMATICS CONTENT KNOWLEDGE OF PRE-SERVICE PRIMARY TEACHERS: DEVELOPING CONFIDENCE AND COMPETENCE

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This paper examines the extent to which a group of first year pre-service teachers enrolled in Bachelor of Education courses in primary and early childhood education at a Western Australian university can be considered as mathematically literate when it comes to teaching the content of the WA primary mathematics curriculum, and describes how both confidence and competence have been improved through the introduction of a multiliteracy unit.

BACKGROUND

Nationally and internationally, teacher subject content knowledge is recognised as being of crucial importance (Goulding, Rowland & Barker, 2002). The United Kingdom audits mathematical subject knowledge and the skills needed to interpret assessment information as part of the requirements for Qualified Teacher Status. A report from the Australian House of Representatives Standing Committee on Education and Vocational Training (2007) on their inquiry into initial teacher training placed a strong emphasis on preparation to teach literacy and numeracy and noted widespread concerns about low skill levels in these areas amongst pre-service teachers.

The problem is not new. In 1949 it was reported that "those preparing to teach arithmetic in the elementary grades understood only approximately 50% of the computational processes commonly taught in grades one through six" (Glennon, cited in Rech, Hartzell & Stephens, 1993, p141).

At this university, concerns have been expressed for some time about the standard of pre-service teacher numeracy and literacy, especially on entry to the undergraduate primary education degrees. The introduction of new courses provided an opportunity to include a multiliteracies unit where the specific aim was to determine entry skill levels of students and to put in place intervention strategies to improve these where necessary. While the unit covers information and communications technology, written, scientific and mathematical literacy, the focus is this paper is on the mathematics skills of the students.

Unit outcomes and approach

There was considerable discussion during the development of the unit about the meaning of mathematical literacy and the use of a competency-based approach. Flowers (2003) refers to "computational fluency", the National Council on Education and the Disciplines (Steen, 2001) discusses "quantitative literacy" and various

authors define numeracy as both working with numbers and mathematical competence. In designing the unit, it was agreed amongst the team that the mathematical literacy requirement in this context would be competence in questions based on Level Four of the WA Outcomes and Standards Framework (Curriculum Council, 2005). While this is the benchmark for year nine students, a significant number of primary aged children are demonstrating skills at this level. Higher level content knowledge is addressed during the mathematics education units later in the course and there are plans to introduce an exit audit at the end of the four year degree course, probably based on Level 5 outcomes.

The unit takes a competency-based approach ie it focuses on what students can do, not on their mathematics qualifications. An overall score of 75% (70% in 2006) in the assessment task is sufficient to meet the requirements of the mathematics module as a whole. Students who score 70%/75% in individual outcomes do not need to answer those questions again in the exit task.

Twenty two outcomes are defined for mathematics: six in number, five in space, five in measurement, three in chance and data and three in algebra. The chance and data outcome on reading graphs and tables is covered in the science module and a question on map reading covers both a space and a measurement outcome but otherwise each question in the assessment tasks covers a single outcome.

The entry task identifies strengths and weaknesses for each student and enables individualised intervention strategies to be implemented. A commercial website is available at no cost and students have workbooks identifying specific activities for each outcome they need to address. Worksheets and classroom activities with manipulatives are similarly linked to the checklists. Tutors are available to work with individuals or small groups and provide personal assistance and support.

Confidence and competence

Adults in general, and some teachers in particular, are often ashamed about their lack of mathematical knowledge and this can lead to the adoption of coping strategies such as creating diversions and self denigration (Bibby, 2002). Negative high school experiences in mathematics can be important pre-cursors for mathematics anxiety (Bowd & Brady, 2003) and for some people mathematics anxiety can manifest as an "irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems" (Furner & Berman, 2003).

Intervention strategies therefore need to recognise anxiety issues and, in developing the multiliteracy unit, the advice of a number of researchers was heeded. There is a focus on using concrete approaches till confidence improves and then working on deeper understanding later (Cuff, 1993). Students work individually some of the time to enable them to develop their own methods (Flowers, 2003), but additional group work provides a forum for them to share their ideas and develop new, possibly more efficient, strategies (Bischoff & Golden, 2003). Anthony (2000) identifies a number of student behaviours which lead to success, including motivation, task completion

and seeking help. The unit has therefore been designed to include self paced individual and group work, use of manipulative materials and websites, pen and paper work, practical tasks and access to a skilled tutor. Classes are relatively small (20 students) to allow tutors to cater for the varied learning styles amongst the students and to provide individualised support and encouragement.

Sanders and Morris (2000) note that making pre-service teachers aware of their lack of knowledge can have a negative impact on their confidence, so at all times during the unit care is taken to 'accentuate the positive'. The initial 'test' is referred to as an entry assessment and students are given information at orientation on the format of the task and the outcomes / topics being assessed. Students are asked to indicate the extent to which they feel confident they have answered each question correctly and this enables staff to identify students with particularly low confidence levels who may need extra support. A strong emphasis is placed on the diagnostic role of the tasks and students can then focus on individual areas of weakness. Those who have multiple attempts at the exit assessments can see continuing progress as they "pass" more outcomes each time and this helps to maintain motivation.

Design of the multiliteracy unit

Students attend a three hour workshop in a computer laboratory each week. The semester program includes entry assessment tasks in mathematical, written and scientific literacy in the first week, two weeks working on ICT skill development and then three rotations of three weeks each which focus on mathematics, writing and science in turn. Exit assessments are conducted in the final hour of each rotation.

Students who need more time to reach the required standard can attempt up to two further exit assessment tasks before the start of the following semester. If they are still not successful they are recorded as having failed the unit and have to repeat all components the next time it is offered (in summer school or with the following year's intake). Students who fail the unit three times are excluded from the course.

ENTRY ASSESSMENT SUMMARY

The entry assessment task consists of 20 questions to be answered in 55 minutes. In 2006 only 38 out of 320 students (12%) met the mathematics requirements and the overall mean score was 51.1%. In 2007 performances were worse, with only 5.5% (19 out of 306) students achieving the required score of 75% and the mean score was 45.6%.

In many cases the poor performance can be attributed to having forgotten specialised mathematics knowledge which may not have been used in many years. This is particularly true for the high proportion of mature age students in the cohorts. However, a number of younger students with high scores in TEE mathematics subjects also failed to meet the benchmarks.

During the entry task, students indicated on their paper how confident they felt about their answer to each question. This was on a Likert scale from one (not at all

confident) to four (very confident). Unfortunately, possibly due to time constraints or anxiety levels, students had a strong focus on simply answering the questions and many did not respond to all the confidence rankings. For those who did, the mean confidence score (converted to a percentage) was 71.5 in 2006 and 65.3 in 2007, both significantly higher ($p<0.001$) than the corresponding mean performance scores for those students of 52.5 and 45.9 respectively. This seems to indicate that students had an inflated sense of their own ability. Confidence and competence were strongly correlated for both year groups ($r=0.496$ and $r=0.404$ respectively, $p<0.001$).

EXIT ASSESSMENT SUMMARY

The news is not all bad. After the three week intervention program involving self-paced work on an interactive website, written and practical tasks, and support from a tutor/facilitator in one to one and small group settings, performances improved significantly. As some students had several attempts at parallel exit assessments in their efforts to reach the benchmark, the scores used for analysis were their highest marks regardless of the number of attempts.

Early Childhood Education students:

2006 Mean entry score 47.2% Mean exit score 67.4%

2007 Mean entry score 40.6% Mean exit score 75.8%

Primary Education students

2006 Mean entry score 53.2% Mean exit score 72.2%

2007 Mean entry score 48.7% Mean exit score 76.4%

The differences between Early Childhood and Primary students were significant ($p<0.005$) for the entry task performance in both years and for the exit task in 2006 ($p<0.05$) which might support anecdotal evidence that one reason students choose Early Childhood Studies (ECS) is because of their low ability in mathematics and a (mistaken) perception that they will only need to be able to teach children to count.

At the start of the following semester, when they were enrolled in the first of two mathematics education units, primary education students completed questionnaires on their confidence in their ability to correctly answer each question and to teach the content to primary school children.

2006 Entry confidence 65.8% Exit Confidence 85.1% Teaching confidence 74.2%

2007 Entry confidence 67.5% Exit Confidence 79.2% Teaching confidence 71.4%

In general, confidence improved from the start of semester one (difference significant at $p<0.001$) but students still felt less confident about teaching a skill than they did about their ability to perform the task themselves ($p<0.001$).

Comments in the university evaluation instrument on the best aspects of the unit frequently referred to the use of the interactive website Mathletics (http://www.mathletics.com.au). This was useful feedback as there had been some

concerns that, because the website is designed for primary students, adults would find it childish. In fact the atmosphere in the computer laboratory during workshops was enthusiastic and significant numbers of students reported using the website outside class time and in second semester to improve their skills further. It is my belief – based on student comments on evaluation forms - that this experience was a major factor in the success of the unit. By engaging students in an enjoyable task, not only did competence improve but anxiety and stress were reduced.

It is worth noting that the student comments in the evaluations also placed a strong emphasis on their appreciation of the work of the tutors. Comments about "what best helped student learning" included tutor enthusiasm, availability, approachability, patience, support and advice. The following comments sum up most of the others:

Student A: It was fantastic that the tutor never made you feel stupid, regardless of how basic the question was.

Student B: The tutor allowed us to work at our own pace and get on with the work ourselves but was there if we needed help.

Student C: I believe that the thing that best helped my learning was that the tutor wanted to help.

All tutors had expertise in tertiary teaching in the relevant learning area and this use of specialists was an important aspect of the unit as it gave authority which might have been missing if it had been taught by generalists.

CONCLUSION

Students entering teacher education courses at this university demonstrate low levels of mathematical competence relative to the expectations of Level Four of the Outcomes and Standards Framework Mathematics (the benchmark for year nine students in the state). In addition, they lack confidence in their own ability to answer the questions presented to them.

However, significant improvement in performance and confidence levels can be achieved in a relatively short time and further research will determine whether this continues into the mathematics education units in the two courses. The change in attitude towards mathematics which is achieved by offering a variety of learning materials which are individualised, non-threatening and even fun, demonstrates the value of engaging students in their own learning and giving them responsibility for addressing their individual areas of weakness.

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