Teaching Management Mathematics

Shirley Porter[1]
Bay of Plenty Polytechnic
New Zealand

Abstract

Management Mathematics 166 is a paper taught at Bay of Plenty Polytechnic (BoPP) in collaboration with the University of Waikato (UoW) where it is offered to students of both Business and Science disciplines and is a compulsory component of the Bachelor of Business Analysis (Financial). In 2009 a small class of nine students with disparate mathematics backgrounds offered an excellent opportunity to work very closely with students to identify their needs and examine their learning patterns. Although this was a small sample, when the analysis of their results is linked to teaching pedagogy the findings may be applicable to a larger group. While all students passed, some had the potential to perform at a higher level but various factors impinged on their results. In reflecting on my teaching of this paper, I have drawn from over 30 years of teaching mathematics at secondary and tertiary level.

Introduction and background to the study

Management Mathematics 166 is a University of Waikato (UoW) paper taught at Bay of Plenty Polytechnic (BoPP) in the first semester. It is compulsory for the Bachelor of Business (Financial Analysis) and optional for the Bachelor of Management. I taught this paper for the first time in 2009, coming from an extensive mathematics teaching background with some experience at supporting the students in this paper in 2008 and supporting business students for several years in Management Statistics. Although some concepts of economics, business and management were familiar to me in a superficial way, I was often dependent on the students' knowledge to interpret the applications of the mathematical results to the business context.

Traditionally, this Management Mathematics paper has been a difficult one for many students, with success and retention being variable. Students are studying in the mathematics area, which is not their chosen career focus, and they come with disparate mathematical backgrounds. Within the group of 2009, the last level at which the students had been successful in mathematics ranged from below third form level to sixth form level. Some students had external situations which had a major effect on

[1] Porter, S. (2010). Teaching Management Mathematics. In V. van der Ham, L. Sevillano, & L. George (Eds.), *Shifting sands, firm foundations: Proceedings of the 2009 Annual International Conference of the Association of Tertiary Learning Advisors of Aotearoa/New Zealand (ATLAANZ)* (pp. 115-127). Auckland: ATLAANZ.

their progress in the paper. These factors inspired me to reflect on the successful strategies which ensured that every student understood the content and passed.
In this paper I identify a theoretical framework for effective teaching and refer to my study in which data from an online survey, in conjunction with that of an annual student evaluation, highlights strategies for teaching a topic requiring dual discipline expertise. Analysis of the survey data and the evaluations is presented and discussed in relation to the effective teaching framework. I also suggest improvements that could be made and that may be of use and value to colleagues.

Theoretical framework

Effective teaching at tertiary level has all the hallmarks of effective teaching at any level – whether pre-school, primary, secondary or tertiary. There are three factors to being a successful teacher of mathematics. The first is obvious: the teacher needs to know the subject content thoroughly. Without sufficient content knowledge, teachers will not be confident enough to seize the moment and capitalise on situations that arise spontaneously to present good mathematics teaching. According to Anthony and Walshaw (2007), "Low levels of content knowledge and the resulting lack of confidence about mathematics limit teachers' ability to maximise opportunities" (p. 47). Although Anthony and Walshaw are targeting a school teaching audience, I believe their opinions are valid for the tertiary sector as well.

Secondly, the teacher needs to understand the theory behind the mathematics processes. Wood and Harding (2007) cite the list of ten areas of excellence in teaching used by the Department of Mathematics and Applied Mathematics at the University of Pretoria for judging an award for teaching excellence. The first area is "Facilitation of mathematical thinking" with one of the sub-areas being: "Brings insight and understanding of mathematical topics to students of varying backgrounds" (p. 944). Teachers need to understand the hidden scaffolding that underpins the topic in hand; they also need to know where it is leading, the proofs of and reasons for the steps involved. Some students, in my experience, are happy to learn processes and take pleasure out of the 'dance', a term I used to identify that performing algebra moves is like performing dance moves of the mind and thereby enjoyable. Others really need to understand the thinking behind the facts before their brains will absorb the learning.

The teacher also needs to know how to teach. This involves understanding that the group of students is diverse and they have individual backgrounds, environments, needs, learning styles and rates of learning and they bring with them their own attitudes and self-belief regarding mathematics. Miller-Reilly (2007), in discussing teacher effectiveness, notes "the importance of teachers' acknowledgement of students' past experiences and current feelings about mathematics, dealing effectively with students' differing background knowledge of mathematics, as well as the effective use of contexts in non-routine problems" (p. 891). The Tertiary Education Commission (TEC, 2008a) acknowledges that awareness has changed and "Current theories of adult learning reflect the understanding that adults learn in many different ways for many different reasons. Because of this, it is very important that adult-

education programmes are learner-centred" (p. 8). Teachers need to know about learning styles; when to teach, when to hold back and let the students try for themselves; when to step in and offer assistance; and when extra support is needed. Ideally, the teacher will connect with each student and understand their knowledge base and the steps required to lead them to the level of their course. This is difficult for a teacher with a large class but, at the very least, the range of learning styles can be catered for within a lecture; tutorials provide closer encounters and students can be directed to a learning support centre where their individual needs can be met. Some students need more time to absorb the concepts and it is vital that mathematics support is available. A succinct summary of the characteristics of the effective teacher is given by Anthony and Walshaw (2007) who note that mathematics teaching for diverse learners:

- demands an ethic of care
- creates a space for the individual and the collective
- demands explicit instruction
- involves respectful exchange of ideas
- demands teacher content knowledge, knowledge of mathematics pedagogy and reflecting-in-action. (p. iv)

The teaching skills required at school level are still necessary at tertiary level. Halcon (2008) advises that business calculus should be taught in "the most elementary manner"(p. 13), including the use of lesson plans. In my opinion, the language used must be carefully considered and any new words clearly defined, remembering that 'new' means new to the student, not the teacher. Many students suffer from mathematics anxiety and they need to develop confidence that together (teacher and student) their goal of passing is achievable. I have observed that for those who are struggling, this goal can change from 'mere passing' to 'passing well' as their confidence grows. When teaching mathematics to management and economics students, it is essential that the teacher has the mathematics skill base. It is also imperative that the teacher has some understanding of the applications to economics and business. The students can supply some of the links to their other papers and together it can be an enjoyable learning journey for both students and teacher.

Method

The research study described in this paper examined the students' perceptions of effective teaching and learning in this particular mathematics course which involved applications to economics and management. I taught this paper to a small class of nine students, a diverse group, with different needs and backgrounds. Since I also worked in the student learning support area, I was able to offer extra tutorials to those who needed them. In addition, I offered extra revision tutorials in the study weeks prior to examinations.

The paper was directed from the UoW with the text being a booklet produced by them. In discussions it was agreed that I would write the assessments and an examination

which would be moderated by the UoW. The course was a mixture of pure mathematics with applications to the business and science disciplines and contained algebra, coordinate geometry, trigonometry, graphs, matrices and calculus. There were ten assignments or quizzes to be delivered weekly, the best eight results of which formed part of the internal mark of 50%, along with the results of two tests. The remaining 50% was the examination. A second option was available in which the total mark rested solely on the examination result. The idea of quizzes was abandoned after the first week as the students were not ready to be tested after such a short time. Subsequently, ten assignments were completed. All nine students passed the paper with grades ranging from C to A^+.

BoPP has a standardised student evaluation form which is presented to the students in the last two weeks of their paper before examinations are held. All teachers are evaluated at least once, but not all classes are evaluated. The teacher concerned receives a complete copy of the evaluations.

In the following semester, after the paper was finished and grades had been published, I sent an electronic questionnaire regarding the paper to the students. The questionnaire had seven sections with 26 questions overall. The seven sections were:

- mathematics background: last study level, feelings about mathematics
- learning needs and styles
- teaching style, possible improvements
- understanding and passing
- extra support
- assessment
- external factors.

Seven out of the nine students returned the questionnaires. The majority of the students (88%) were aged 20 or above, so most had some experience of life outside of school. One obvious limitation to this study was the small sample size, although the response rate was high at 78%. Interaction with the small class allowed for closer personal observation of the students. There could have been some response bias with such a small group as the students may have been wary of giving adverse comments in their online responses which clearly identified them. This was minimised by analysing the student evaluations which gave complete anonyminity. The same opinions and messages were evident in both the evaluations and the surveys. There was no concern about adverse comments rebounding on marking as all assessment results had been delivered to the students before they were surveyed. It cannot be assumed that the findings would apply directly to a much larger class size, but this study does provide a baseline against which further studies can be measured. This is planned to be an on-going study and the classes for 2010 and 2011 will be surveyed so that results can be collated and compared with those reported here.

Findings and discussion

This section of the paper contains analysis of the evaluations and the questionnaire, with links to the theoretical framework described earlier.

Organisation

Sound organisation and preparation was noted. The students knew what was to be taught in a session and appreciated that this was signalled. Student 3 commented: "Lessons were extremely well structured. You knew what would be covered in a lecture and it was." Student 7 said: "This is the most organised and prepared class I have taken in my three years here. I know exactly what I need to do to pass and [she] gets the information across very clearly".

Mathematical background

Five students reported that they were successful at the same level at which they last studied but in two cases, the levels varied (see Table 1).

Table 1. *Mathematical background of students prior to this paper (n = 7)*

Student	Level at which you felt successful	Last study level	Highest qualification level
1	at work, spreadsheets	Dip Sport Science (UK)	10 credits sport science numerical applications
2	NCEA level 2	NCEA level 2	NCEA level 2 geometry, algebra etc
3	basic, 3rd or 4th form if that	School Certificate	School Certificate
4	6th form maths	7th form	University Entrance
5	5th form maths	5th form (1995)	School Certificate
6	level 2 NCEA and basics	NCEA level 2	there was just one paper - mathematics
7	GCSE mathematics	NCEA level1	NCEA level 1

The students had a wide range of feelings about mathematics. All seven students had enjoyed mathematics at primary school but only four of them enjoyed secondary school mathematics. When they reached the workforce, three were still enjoying mathematics. Two students loved all arithmetic topics (see Table 2). All students felt at least "okay" with basic addition and multiplication but five out of seven students were anxious about fractions, an important piece of information as some of the mathematics required an ability with algebraic fractions, which is underpinned by competency with arithmetical fractions.

Table 2. *Students' feelings regarding topics without a calculator, before taking the Management Mathematics 1 = 'yes, I love it'; 2 = 'I'm okay with it'; 3 = 'I'm a bit anxious'; 4 = 'I'm terrified'*

Student	Addition	Subtraction	Multipli-cation	Division	Fractions	Decimals	Percen-tages	Word problems	Multipli-cation tables
1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	3	2	3	3	3
3	2	3	2	3	4	4	2	4	3
4	1	1	1	1	1	1	1	1	1
5	2	2	2	2	3	3	2	2	2
6	1	1	1	1	2 – 3	2 - 3	2	2	2
7	2	2	2	3	3	2	2	2	2

No one felt confident with all six higher level skills: only Student 6 was confident with algebra which was the basis of the whole paper even though five other students had studied at 5th form (NCEA level 1) or above. Student 4 was confident with just measurement skills although she had been 'successful' at 6th form level; no one felt confident with powers which were also a vital part of the paper (see Table 3).

Table 3. *Students' feelings regarding higher level topics before taking the Management Mathematics. 1 = 'yes, I love it'; 2 = 'I'm okay with it'; 3 = 'I'm a bit anxious'; 4 = 'I'm terrified'*

Student	Algebra	Geometry	Statistics	Trigonometry	Measurement	Powers
1	3	3	3	3	2	3
2	3	3	4	3	2	3
3	4	4	4	4	4	4
4	3	3	3	3	2	3
5	3	2	3	2	2	4
6	1 – 2	2	3	1 – 2	2	3
7	3	2	2	1	2	3

It was essential that the teaching took into account students' feelings regarding basic mathematics skills. As Klinger (2007) states, "mathematics self-efficacy beliefs and early maths learning experiences are clearly related in their influence on the subjects' maths learning characteristics" (p. 203).

Students indicated in their evaluations that they realised there were different abilities within the class, that these were catered for, and that a clear understanding of the mathematics was communicated to them in a "simplified manner". This approach is supported by Andy Begg (2006), who, in his list of 'Rich learning tasks/activities' stated that the activities should: "approach the unknown through what is known to the

students - be accessible to all students at the start" (p. 8, modified from Ahmed, 1987 and Cox, 1998).

Extra support

Five of the seven students made extra appointments through our support services, some for just a few sessions and some regularly. All five students stated that it was essential for them to have the extra tuition. Student 3 noted that she "Would not have passed without it. Increased knowledge and confidence [sic]." Gill and O'Donoghue (2007) also found that "a more individualized structure was essential to reach those who were, perhaps, lost in large group situations" (p. 157). Another student had illness in her family and was unable to attend most classes so she used the tutorial appointment system when it was possible for her. Student 4 appreciated the ability to use email contact when working on a problem between classes. The help may not have been immediate but it was a quicker response for the student than waiting until the next class. This idea directly links with Gill and O'Donoghue's (2007) proposal of having online help provided by student support.

Basics

Students appreciated that the lessons were delivered in understandable language. It was important to analyse the vocabulary and skills utilised within problem-solving processes and remind students of these first. This was not a new idea. Shulman (1986) wrote, "Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult" (p. 9). As Student 3 wrote, "A better knowledge of basic maths would have been a huge help."

I observed that once these skills were revisited prior to travelling through the process of solving a problem, the students could concentrate on the flow of the steps and not become sidetracked. Recognising and embedding basic numeracy skills in courses has been identified as important to success: "Analysing problems… will help you to decide the nature and amount of scaffolding (guided support) you will need to provide for the learners" (TEC, 2008b, p. 6). The principle is the same with higher level mathematics; sometimes the underlying skills required are at a higher level but basic numeracy skills are also a cornerstone of a correct solution. A calculus problem requiring a whole page of processing can (and did) result in a wrong answer by using the calculator incorrectly in the final step.

Processes

Students identified as effective teaching the slow build up in front of them of a complete solution with full explanations followed by plenty of practice with different examples. They liked moving at a pace that suited them rather than being confronted with a completed worked example. Felder (2002) comments on this 'traditional' deductive style of teaching, starting with the basics and processes and only then moving on to applications. He acknowledges that "many or most students would say that they prefer deductive presentation" (preface to p. 674). Student 1 wrote about how her learning needs were addressed with: "clear accurate examples, slow logical

progression which allows for some reflection, not too much information overload." Student 6 appreciated "lots of examples shown step by step."

Learning styles

Only student 4 had a preference for a single learning style (visual). All the rest acknowledged they used a mixture of learning styles – visual, aural and kinesthetic. Because of this preference for a mixture, the content needed to be presented using all styles. Felder and Silverman (1988), when explaining how to teach both visual and auditory learners, comment, "Process flow charts…and logic or information flow charts should be used to illustrate complex processes" (p. 677). Kinesthetic styles can be catered for by giving students time to work on problems in class and in groups. Felder and Silverman (1988) agree with this as a good way to address this learning style.

PowerPoint

PowerPoint was not a favoured method of learning mathematics. Some students had experienced PowerPoint presentations in other classes and, as Voss (2004) states, the teacher "tends to focus on the technology and ignore the audience" and "Power point should not be used simply to demonstrate that an instructor is using technology in his or her classroom" (p. 155). Students' learning capacity was expanded by observing the physical process, with the understanding that they could stop the flow to ask for further clarification.

Class climate

The atmosphere in the class was also considered important for students to absorb the learning. They particularly appreciated that the classroom climate was relaxed and they had the opportunity to ask questions. Student 2 commented that "it was pretty relaxed, anyone could ask questions in class without feeling embarrassed, was fun at times, nice small class size was good for learning." Student 1 also felt "relaxed and not cause anxiety [sic]." Another student wrote, "….easy to approach and really understands when students are confused and how to clear any confusion."

With consistent opportunities for questioning, the teaching became student-centred and discussion would often follow about applications to the business world. As a result of shared learning it became clear that the students felt that their contribution and how they delivered and achieved it was valued. This result supports Gill and O'Donoghue's (2007) finding in their study in Limerick, that "students value personal interaction most highly" (p. 164).

Assessment

Students were very pleased to see assignments take the place of the quiz. Student 1wrote that "The quiz given after one week caused anxiety and prevented clear understanding of topic [sic]."

All students found the assignments were most useful in helping them gain understanding. Because of the small size of the class, the assignments were marked and returned to the students in the next class while the content was still fresh in their minds. This made for effective feedback and formative as well as summative assessment and helped address any difficulties in understanding before students moved too far on in the course. As Flinders University (2004) state in their notes on feedback, effective feedback should be "Timely – so that students can use it for subsequent learning and work to be submitted."

Opinions were divided as to which was the most fair way of assessing understanding. Some students favoured the tests and exam, some the assignments and some a mixture of all three. None of them mentioned the quiz as part of the fair assessment. Even though there were different preferences regarding the assessment types, all students liked the system of choosing the best eight out of ten assignment marks. Student 5 stated "I think it's a good and fair system considering the length of the course and the possibility that there may be external things that may affect the marks of a couple of assignments (such as time commitments etc.)." Student 1 supported the system, commenting "I think it motivated me to make sure I completed the assignment as best I could. This then provided feedback for the exam, tests. It worked." Student 2 also thought it was "great because you may not be as good on a few topics as others."

The volume of assessment, at one assignment per week, was a demanding workload but all students thought it was fair, useful and manageable. Only one suggestion was offered for a different type of assessment: to have a group problem to solve. This could be a formative exercise and will be inserted into the paper next year.

All students liked having the option of 50:50 or 0:100 with internal and examination assessment credit respectively. Student 1 wrote "I think it was fair. It allowed students with different performance strengths to be measured accurately." Certainly for the student unable to attend many classes, it provided the opportunity to demonstrate her ability in the subject although she had missed many of the assignments.

Revision

For passing (and often well), students valued the revision classes run in the two study weeks before the examination. These classes had been planned when the schedule was prepared for the semester. Every topic of the paper was revised and this gave the students an overview of the content. Begg (2006) supports revision as a necessary part of effective teaching, advising teachers to "provide opportunities for constant review" (modified from Ahmed, 1987 and Cox, 1998). From my observation, parts that had been unfamiliar to students in the first instance were now taken for granted, previously new vocabulary was immediately understood and they could concentrate on the more difficult steps or sections. There was time for them to grasp the whole topic. Student 7 supported this, commenting that "The feature that helped me do well in passing was the time taken to ensure you had the understanding needed for the subject."

External Factors

Students, especially mature age students, often have many external factors to mesh into their study framework. These can take their toll on progress and level of achievement. Workload/work commitments, family illnesses and personal illness were challenges to overcome. Students mentioned good time management, working hard and keeping on top of their assignments as strategies for lessening the effect of external factors. Having the backup system of one-to-one tutorials was vital in these circumstances as students were not left to catch up as best they could. The one student who did not take advantage of these tutorials did realise, upon reflection, that it would have lessened the impact of her illness if she had made an appointment. Student 7 reflected that "I tried to attend every class and if I wasn't able to attend I tried my hardest to catch up on material. I could have gone to extra tutorials to make catching up easier."

Improvements

Most students had no suggestions for improvements, but one student suggested that using computer graphics could have helped them understand graphs better. Using appropriate technology is an avenue to consider, but with caution, bearing in mind that the students did not want PowerPoints slides.

There were some negative comments relating to the booklet provided for the course. The booklet was written more from a pure mathematics point of view, involving proofs of formulae, rather than from a business context. The language used was in some cases too sophisticated and obscured meaning for the students. Student 3 wrote that it "Would have been helpful to have a book that was simple to understand. Waikato txt [sic] seemed poorly written and difficult to follow." In the evaluations, one student wrote, "The tutor is required to use the Waikato Math 166 Book which at times can be too theoretical and abstract for what we are learning. Booklet needs more management examples exercises [sic]." The booklet contained applications to science, medical and business disciplines and the students had difficulty with the applications outside their discipline because the context was not familiar.

Shifting sands

A key reason for the success of this paper was that the teacher was an effective mathematics teacher[2] with a little business knowledge, rather than an effective business teacher with a little mathematical knowledge. It must be remembered that the focus of this paper was to provide sufficient skills in mathematics for the students to be able to cope with any business applications they encountered in their other papers. The emphasis shifted in each topic within the course from pure mathematics to applied mathematics. In one assignment in particular, the problems were written completely in context. The students had to adapt and some found this difficult because they had to

[2] Evidenced by the receipt of two peer-nominated sustained teacher excellence awards (2009 and 2005), one student-nominated exceptional adult educator award (2002) and consistently high ratings in annual student evaluations.

recognise the mathematical procedures required to solve the problem. Experience with this type of problem increased their ability to solve problems of this kind .

All students needed to be reached at their individual levels of mathematical expertise. This did not involve re-teaching the basic skills as topics but rather being aware of when they were embedded in the current topic and addressing them at the start of the class. As misunderstandings arose, these could be addressed and the foundations firmed. In one case, individual tuition was needed to address a problem area. By the end of the paper, all students were feeling much more confident. Student 3 felt: "more confident that if I'm shown how to solve a maths problem I can grasp it and apply it to other problems." This student also stated that she had learnt she could tackle anything and, with diligence, could achieve. This was a revelation and a great mind-shift for her. Student 2 also commented: "I feel a lot better about them now, feel more confident, and refreshed heaps of basic things I had completely forgotten from school."

Changing personal circumstances also required students to cope differently. It was fortunate that an alternative system of assessment - 100% on the examination - was available for the student who had on-going family illness to contend with. The system of eliminating the worst two assignments was also to the advantage of two students whose external circumstances impacted on their progress.

Summary

Good organisation and preparation, along with the use of simple language, coverage of basic skills and a slow build-up of processes all contributed to effective teaching. Students came from diverse backgrounds which necessitated an awareness of the gaps in their knowledge and attention to those at appropriate times throughout the paper. Extra support was essential for the majority of students and readily used. Feelings towards mathematics also varied but by the end of the paper all students felt motivated and confident they could succeed.

A mixture of learning styles was favoured by most students and this was provided for by maintaining student-centred learning and responding to their expressed needs. Power Point was not required and students strongly rejected the suggestion of using it. A relaxed atmosphere within the classroom was recognised as important. The mix of assignments, tests and examination was well received, especially with the different options for grading.

Understanding was gained through effective teaching but passing required a good revision programme. There were many and varied external factors and these were able to be negotiated around within the flexible framework of the course. There is a need for a booklet with less abstract examples and simpler language.

Some business knowledge, linked with a sound knowledge of mathematical content, along with a deeper understanding of the concepts plus a teaching pedagogy developed from approximately 30 years of reflective teaching experience enabled this paper to be delivered effectively. Small classes allowed personal as well as group tuition. Following this study, it was recommended that the booklet be revised with less emphasis on abstract mathematics, simpler language and more relevant problems. It was also suggested that a computer programme be used in the graphical section. These new amendments to the paper will be trialled in 2010, and the ongoing evaluation project will compare new students' experiences with those reported here.

References

Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/pangarau*. Wellington, New Zealand: Ministry of Education.

Begg, A. (2006). *Becoming a tertiary educator*. Retrieved from http://www.aut.ac.nz/resources/ schools/education/mini-conf_begg_abs.pdf

Felder, R. (2002). Learning and teaching styles in engineering education. Author's Preface. Retrieved from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/L5-1988.pdf

Felder, R., & Silverman, L. (1988). Learning and teaching styles in engineering education. *Engineering Education*, *78*(7), 674-681.

Flinders University. (2004). *Teaching for learning:Feedback*. Retrieved October 1, 2004, from http://www.flinders.edu.au/teach/assess/feedback.htm

Gill, O., & O'Donoghue, J. (2007). Mathematics support for adult learners. In T. Maguire, N. Colleran, O. Gill & J. O'Donoughue (Eds.), *ALM 14 The Changing Face of Adults Mathematics Education: Learning from the Past, Planning for the Future. Proceedings of the 2007 14th International Conference of Adult Learning Mathematics (ALM) in co-operation with The National Adult Literacy Agency (NALA), Ireland* (pp. 154-164). Dublin, Ireland: Adults Learning Mathematics (ALM) – A Research Forum.

Halcon, F. (2008). Teaching business calculus: Methodologies, techniques, issues, and prospects. *DLSU Business & Economics Review*, *17*(1), 13-22.

Klinger, C. (2007). Experience the difference: Maths attitudes and beliefs in commencing undergraduate students and pre-tertiary adult learners. In T. Maguire, N. Colleran, O. Gill & J. O'Donoughue (Eds.), *ALM 14 The Changing Face of Adults Mathematics Education: Learning from the Past, Planning for the Future: Proceedings of the 2007 14th International Conference of Adult Learning Mathematics (ALM) in co-operation with The National Adult Literacy*

Agency (NALA), Ireland (pp. 197-206). Dublin: Adults Learning Mathematics (ALM) – A Research Forum.

Miller-Reilly, B. (2007). Three different teaching approaches in pre-calculus bridging mathematics. *International Journal of Mathematical Education in Science & Technology*, *38*(7), 891-905.

Schulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Tertiary Education Commission. (2008a). *Learning progressions for adult literacy and numeracy: Background information.* Wellington, New Zealand: Author.

Tertiary Education Commission. (2008b). *Teaching adults to make sense of numbers to solve problems: Using the Learning Progressions.* Wellington, New Zealand: Author.

Voss, D. (2004). Power point in the classroom: Is it really necessary? *Cell Biology Education*, *3*(3), 155-161.

Wood, L., & Harding, A. (2007). Can you show you are a good lecturer? *International Journal of Mathematical Education in Science & Technology*, *38*(7), 939-947.