Transforming Mathematical Tastes: a Twist of Lemon – or a Pretzel?

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Abstract

Since the early 1990s, the nature of students enrolling in universities around the world has been changing [(1)]. In New Zealand, the initial government-led focus was "bums on seats" with a drop in prerequisites, open entry and a rise in the average age of students. A subsequent focus, underway now, is "success and retention" – in order to attract the maximum funding, tertiary institutions need to ensure the students achieve. Meanwhile secondary school mathematics has been changing its attention from abstract to more utilitarian content [(2)]. When students arrive at tertiary institutions, many have insufficient mathematics understanding and skills to cope with the demands of such courses as economics and engineering. "Service mathematics" courses have been designed to counteract this lack of mathematical ability. This presentation considers two such courses offered at Bay of Plenty Polytechnic in Tauranga, New Zealand, taught in a manner mostly traditional for secondary but not tertiary level, but with a "twist", in an effort to bring students up to speed. A survey of the students over two years provides evaluations to complement this reflective overview.

Introduction

Bay of Plenty Polytechnic is a small institution, situated in Tauranga in the North Island of New Zealand, with approximately 8000 full and part time students. Tauranga (population 140000) is not a university city but the Polytechnic has degree agreements with several institutions across New Zealand. I am in my 12th year as a mathematics tutor and advisor attached to the Kahurangi Student Services department of the Polytechnic. During this time I have received two peer-nominated sustained teacher excellence awards (2009 and 2005) and one student-nominated exceptional adult-educator award in 2002. I work with students from all programmes where mathematics is involved. The range is broad; from learning multiplication tables and understanding division to calculus and complex numbers and often in context. I have a passion for mathematics; many of the students have a "maths phobia" and I have been particularly interested in analysing how best they learn. In researching this, I became aware of the "mathematics problem" which appears to be world-wide. Students have been arriving at tertiary institutions, enrolled in courses which require a reasonable level of mathematics competency, but without the necessary skills and often with negative attitudes. I have investigated within our Polytechnic with my two classes that I tutor to research how to best teach to alleviate this problem. In my presentation I will discuss my experiences, the papers I teach, and the results of surveys I have administered.

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"I hate maths. I can't do it. I'm only taking this paper because it's compulsory. So long as I get a C, I'll be happy", announced a student (I'll call her Marie) as she entered my management mathematics class for the first time. As I learned later, Marie was an A+ student in all her business, management and accounting subjects. What a tragedy that such an obviously bright person had such an attitude towards mathematics!

This attitude can often be traced back to one particular mathematics teacher at secondary or even primary level. Duncan remembered a teacher in year nine "torturing" him with his sarcasm when he gave a wrong answer; Lauren recalls her teacher telling her at the age of six to "go home and play with your dolls. You will never be good at maths". Yet both of these people now have high qualifications, but certainly not in mathematics. Of course, not all students dislike mathematics. In many cases the students arriving at tertiary institutions "like" mathematics but have either never advanced to any great level for a variety of reasons or they last attended school many years ago and have long since forgotten most of the mathematics they learned. Other students, more recently at secondary school, have become so dependent on graphics calculators (poorly taught and poorly used) that mathematics has become like the "Yellow Pages" – their fingers do the walking but their thinking brain is not involved. When they can no longer reach for their crutch, they topple. Added to this is a unit-based assessment system at secondary level which partitions mathematics and fails to produce a coherent overview. Secondary students can achieve sufficient credits, yet still be inadequately prepared for tertiary demands.

The "Mathematics Problem"

Students are enrolling in programmes such as business and engineering which require mathematics content well above their level of expertise. There have always been some students in this category but over the past 20 years the problem has grown exponentially. This "mathematics problem" is not confined to my institution, or to just New Zealand; it is of global proportions. In the UK in 1995, the Engineering Council [(3)] concluded that "students are now accepted on engineering courses with relatively low mathematics qualifications". In the U.S., also in 1995, a Survey on Remedial Education in Higher Education Institutions [(4)] found that 78% of higher institutions had found the need to offer remedial courses in reading, writing or mathematics. In 2004, also in the US, the Committee on the Undergraduate Programme (CUPM), reporting on four years of findings, discovered that twice as many students were enrolled in "remedial" or "introductory" mathematics courses compared with those in calculus or statistics courses [(5)]. They noted that the remedial courses were particularly challenging to teach because of the diversity of mathematical backgrounds of the students, who also brought with them negative attitudes created by past experiences with mathematics.

From a diversity of countries, e.g. Ireland, Australia and Canada, there is a body of literature that documents the "mathematics problem". Neither is it confined to English speaking countries. At the International Congress on Mathematical Education (ICME-9) held in Japan in 2000, a group which was very broadly international, identified as a serious issue the challenge posed by non-specialist mathematics students requiring service mathematics [(6)]. Here in South Africa, Engelbrecht and Harding in 2008 acknowledged that university lecturers could no longer assume that students have certain mathematics skills [(7)]. Also in South Africa, in 2010, Winnips, Brouwer and Mwambakana confirm there is a "mathematics problem" and have held workshops on using e-learning to improve the situation [(8)].

In New Zealand the problem has become even more pronounced because of a change in government policy. Originally the attitude was "get them off the dole and into education", the so-called "bums-on-seats" policy. The current government has refocused and the policy almost underway is "funding according to success and retention". In fact, the government now requires us to have a "good idea" that students have the capability of succeeding before they can be enrolled. The government has

spent millions of dollars investing in the development of "The Tool" which diagnoses students' literacy and numeracy at an elementary level. The Tool is designed to (a) help prevent students from enrolling in courses for which they have little hope of success; and (b) indicating to both tutors and students the personal specific mathematics skills requiring extra attention.

Institutional Intervention

What steps have we been taking at Bay of Plenty Polytechnic to alleviate this "mathematics problem"?

Unfortunately, due to IT constraints, The Tool is not administered to students until after they are enrolled. However, difficulties and knowledge gaps are highlighted, tutors can become more informed about their students and assistance is offered by our Student Learning Centre (Kahurangi). The drawback of The Tool is that it is limited to an elementary level and assesses whether students have sufficient mathematics to succeed at levels 1 - 3 programmes such as carpentry and electrical level 3. It does not assess whether students have the skills to achieve at higher level Diploma or degree papers.

The current policy within Kahurangi is to focus on providing assistance within the classroom or in workshops specific to an identified problem area. There are fewer one-to-one appointments available due to resource limitations. The main focus is on levels 1 - 3 as per a government directive. This makes the two papers that I teach even more important in helping remedy the mathematics problem at higher levels.

Four years ago, as a mathematics advisor in Kahurangi, I supported students enrolled in a Management Mathematics paper which is taught under an articulation agreement with Waikato University in Hamilton, NZ. It became obvious that some of the students were inadequately prepared to meet the demands of the university paper, which itself was a "service mathematics" paper and had been designed specifically to support those students who needed a higher level of mathematics to cope with their business, economics or management degrees. Subsequently, I wrote a "Mathematics Bridging" paper, tailor-made for the Management Mathematics students, to be taught over three weeks at Summer School. Interestingly, although the paper targeted Management Mathematics students, it has proved to be suitable in content for Engineering students as well. This paper, worth ten credits, is a "short course" for which government has cancelled all funding but I am still able to run it as I am paid to support mathematics and it is classified as "support". It is free for the students and they receive a certificate upon successful completion, although the credits do not count towards any other programme. Ten topics are covered in ten days, and there is a test each day on the previous topic with a chance at a resit in each topic halfway through and at the end. It is an intensive pressure paper and serves as a great refresher for those students who have studied successfully at year 12 level or equivalent somewhere in their past (year 13 is the last year of our secondary schooling).. For those who had never reached that standard, the paper is formidable indeed. With absolute dedication, some students with little background do achieve a pass but it has become obvious the fast pace is not suiting the needs of all the students.

In response to this, I am now also running the Mathematics Bridging paper across a whole semester in the evening and the students have a two-week time span in which to digest the concepts and content of each topic. This mode of delivery will be evaluated at the end of the year. It may be that there is a need for a simpler paper to be provided for those who struggle even at the slower pace.

Over the past three years, while I have been teaching the Management Mathematics, all students who completed the paper passed except for one student who rarely attended lectures and was dependent on his (poorly taught) graphics calculator. The paper is assessed using ten assignments (one per week), two short tests and an examination of three hours. Of the ten assignments, the two lowest are discarded, a feature which the students felt was very fair, allowing for their pressure times or personally difficult topics. (As a Polytechnic, a good proportion of our students are more mature, returning to education to either upskill or begin a new career, but often with family commitments making a demand on their time). Alternatively, the pass mark can rely entirely on the examination, a helpful situation if there has been a crisis in the student's life. The teaching programme was also planned to allow for in-class practice time before tests and the examination. The classes were small (9 to 14 students) and this lent itself to a tutorial style classroom where questions could be raised and answered.

These two papers are a response to the mathematics problem. As well, in a dual project with a colleague, I am helping develop an online diagnostic system specific to each paper that has a mathematical content. Students will be provided with an analysis of their readiness to cope with the mathematics involved in their prospective courses of study. They will then be supported by eMathematics workshops; this should be a successful intervention method for some students. There will still remain a body of students who need an oral explanation and Kahurangi will provide the back-up if the students have enrolled.

The Survey and Key Results

I surveyed the students at the end of the semester using an online survey. Not all students returned the surveys, with non-returns mainly in 2010 when I was delayed from sending out the surveys. In the survey I explored their mathematics background including their feelings towards mathematics at the start of the paper and what changes had occurred by the end of the paper. I investigated their learning needs and styles, their thoughts on the teaching style, whether they used the extra support from Kahurangi, their opinion on the assessment structure and any external factors that had impacted on their progress. The Bay of Plenty Polytechnic also undertakes an evaluation by the students regarding the paper and the teaching. This is completely anonymous and provided not just further data but a check on the reliability of the survey responses.

The mathematics backgrounds of the participants were varied, ranging from being successful at year 12 in secondary school to never being successful in mathematics. Accordingly, feelings towards mathematics ranged from "I love it" to "I am terrified of it". By the end of the paper, everybody had positive feelings towards mathematics and felt confident approaching it. "I feel far more confident in all areas" was a typical comment. Students were quite clear that their learning styles were a mixture of, particularly, visual and aural but often kinesthetic as well. They were happy that all of these had been catered for in the teaching. They particularly liked the build up on the whiteboard of the processes for solving problems, then having the time to practice in class, even discuss it with another student. No one wanted PowerPoint presentations, (and none were given), which is probably a reaction to many hours spent in other lectures where they were subjected to a misuse of PowerPoint. (It can be a great tool when used imaginatively). They were not aware that I analysed every step of the process and identified the basic skills embedded. It takes just a moment to run over something like $\left(\frac{b}{2a}\right)^2 = \frac{b^2}{4a^2}$ before proving the completion of the square to find

maximum/minimum values. If they lose steps like these, they lose the whole proof while they are worrying over basic algebra.

The students really appreciated the relaxed atmosphere in the class, feeling comfortable enough to ask any question. In the first class, I always run an Ice-breaker so everybody knows a little about everyone else. The teaching language used was important and I made a conscious effort to identify new vocabulary, especially in a topic like calculus. Time spent in class on revision was much appreciated; it helped "pull it all together". Students having difficulty grasping concepts were able to book extra time with me through Kahurangi on a one-to-one basis early on before the problem became insurmountable. According to their survey responses, this was essential. The students recognised the sound organisation, the provision of extra resources for practice and the prompt return (by the following lecture) of their assignments. Of course, this last factor was made possible by the size of the class.

Conclusion

Although the classes surveyed were small, extrapolating the findings to larger groups underscores the usefulness of studies such as this. In many ways, the lectures were very similar to the "chalk and talk" often seen in secondary school. The differences are subtle, such as ensuring everyone feels they can achieve despite their backgrounds. The students learn early on that their progress is important to both them and me and are willing to be helped, even if they have a negative attitude towards mathematics itself. The content is thoroughly analysed and considered and taught well. There is time to be assisted, whether in class from peer or tutor, or through Kahurangi.

It is not just one magic factor that has made this class successful, it is a conglomeration of factors interwoven like a pretzel. In my experience, it eventually depends on the attitude of the students. Those who enjoy mathematics and have had success in the past, given that there is "quality teaching", will achieve a good result. For those who arrive with negative backgrounds, learning that their progress is valued and that there is help available can be sufficient for students to overcome their personal barriers – and perhaps that is the dash of lemon that makes the difference. The last words must go to my student, Marie, who passed with her usual A+, not the C she was aiming for. She wrote "I now realise I can do anything I put my mind to". That is a true transformation!

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