OPTIMISING STUDENT LEARNING THROUGH EFFECTIVE USE OF TECHNOLOGY

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Abstract:- Maple is used in most of our undergraduate courses but less so in the first year courses. We introduced a small Maple component into the fundamental calculus type course of first year. Since we teach in relatively small parallel classes, we had two distinct groups: one had a substantial experience with Maple already and the other had no exposure to Maple.

Students participated in a feedback survey designed to investigate student attitude to the Maple component of the course. The survey results showed that students with previous exposure to Maple were more positive about their experience. In this paper, we outline the material used by the two groups of students and present the results of the feedback survey. We then consider whether there were particular features to the material that led to a more positive response for group with more Maple experience or whether it is simply the case that 'more is better'.

Key Words:- Teaching, Learning, Technology, Maple, Survey, Response, Attitude

1 Introduction

Maple modules are incorporated into most Mathematics courses at RMIT. MA910 is a first year, first semester methods course covering functions and their derivatives, integration and its applications, vectors, complex variables and an introduction to Maple. It is closely related to a course taken by engineering students but one of the topics taken by the engineering students at the end of the semester is replaced by the Maple topic.

The Maple component for MA910 ran for three weeks, two hours per week at the end of the first semester, with additional lab time available if needed. We set out with the following aims: to give students an idea of the capabilities of Maple, to enthuse students about using computer packages such as Maple, to enable students to use Maple to solve problems and to consolidate understanding of some of the topics covered in MA910. The weekly sessions were organised so that the first hour was a demonstration lecture and the second hour was a practical hands-on Maple lab session. During the lectures, the key features and commands for the topic area were shown, using a lap-top with screen projector. During the lab sessions, the students worked through demonstration materials themselves, then they used Maple to solve associated problems.

Much of our teaching is organised in relatively small classes which resulted in three classes for MA910. Two of the classes were students studying a multi-major degree in science (with the option of majoring in mathematics), henceforth referred to as 'the science group'. There was one class of students studying our specialist mathematics degree or our Dual Award of our mathematics degree and a diploma in information technology, henceforth referred to as 'the maths group'.

The maths group take the subject MA912 in parallel and in addition to MA910. MA912 is a more specialist course which provides an introduction to iteration methods used in computational mathematics and to phase plane methods used in applied mathematics with applications to population dynamics. The use of Maple is integrated

throughout this subject and animation and programming are introduced. The animations are mostly of parameterised families of curves and details are reported by Blyth [1].

In MA910 therefore, the maths group, because of their MA912 studies, already had substantial experience with Maple so the Maple component for them was more advanced than that for the science group. The topics for the maths group were trapezoidal rule, minimum and maximum application following the Polya "how to solve it" process and further applications of animation to problem solving. These tasks are discussed in detail in "Problem Solving using Maple Animations" by Blyth and Naim [2].

The topics for the science group were an introduction to Maple including basic computations and graph plotting, algebra and calculus commands and using Maple to solve problems involving vectors and complex variables. Since, by necessity, most of the material was elementary, the trapezoidal rule was included with the calculus work to provide a glimpse of a more advanced and useful application. However, since students tend to have low level programming skills, the trapezoidal rule topic for the science group was presented but an assignment was optional (and not taken up).

2 Feedback Survey and Data Collection

In order to ascertain students' responses to the experience of using Maple in their courses, a survey instrument was developed. Similarly surveys have been used in previous studies by Cretchley et al. [3], Galbraith and Haines [4], Coupland [5], Galbraith et al. [6], Cretchley and Harman [7] and Cretchley [8]. Students were asked to indicate their level of computing experience and also the level of mathematics they had previously studied as a broad indicator of mathematical ability. They were then asked to respond to items on a Likert scale and were given space to respond to the general question 'Overall, how did you find the experience of using Maple last semester?' In the analysis of results, scale items that reflected a negative attitude had their scores reversed in polarity. The scale items and a summary of the results are shown in Appendix A.

Out of over 120 students, a total of 60 surveys were completed, 30 from students in the science group and 30 from students in the maths group.

3 Survey Results

3.1 The Science Group

When considering the responses to the individual items, the only item that showed a significant positive response was 'I can see how Maple could be used as a tool in industry', while 'I found that Maple helped my understanding of the Mathematics', 'I tried using Maple to solve other problems not set in the assignments', 'I feel like I am quite capable with using Maple' and 'I was able to enter a method using Maple commands quite easily' all scored negatively.

Items that gave a general impression of students' attitudes towards Maple as a tool overall gave a negative result for these students. On the set of items that gave an indication of students' response to learning to use Maple, the response was more neutral.

In the section where students were asked to write their overall impression of their experience with Maple, many students commented on their frustration resulting from their difficulty using the commands. Some however commented that the experience had been useful and interesting despite the difficulties.

The previously mentioned research by Galbraith and Haines [4], Coupland [5] and Galbraith et al. [6] has shown that the way in which students respond to mathematics tasks involving technology use is more closely linked to their level of confidence as a computer user rather than their mathematical ability. For this group of students, there was little correlation between the response to Maple and the previous level of mathematics studied. However, there was also little correlation with the level of computing experience.

3.2 The Maths Group

The individual items indicating a positive response were 'I found Maple easy to use', 'I would find Maple useful as a checking tool', 'I can see how Maple could be used as a tool in industry' and 'I was able to enter a method using Maple commands quite easily.' Students disagreed with the statements 'I thought the assignments were too difficult', 'I thought the assignments were too long' and 'The time would have been more usefully spent continuing with regular lectures.' However, on the

negative side, students agreed with 'I need more practise with Maple before I feel more confident using it as a tool' and 'I felt that we needed more instruction on how to use Maple.'

In general, this group's attitude to Maple as a tool emerged as being significantly positive. The overall response to the more technical aspects of learning to use the commands was negative however.

When writing their own comments, these students were also more positive, with many stating that Maple had been interesting and useful and that they had found it to be a helpful problem-solving tool. The negative comments again centred on the difficulties with learning the syntax for the Maple commands and getting to grips with the more technical aspects of using the package.

The responses again confirmed little association with the student's previous level of mathematics study but there was some notable correlation this time with the level of computing experience.

3.3 Comparison of Results

Detailed analysis of the survey results has shown that the maths group, with more exposure to Maple, are more positive about their experiences. In terms of the initial objectives of the Maple sessions, these students have agreed that they can see how Maple could be used as a tool in industry, they have come away with a generally positive attitude towards such products and they have had some experience of using Maple to solve problems. As for the objective of consolidating the understanding of topics covered in lectures, about one third of this group agreed or strongly agreed with the statement 'I found using Maple helped my level of understanding of the mathematics.' The science students, with more limited Maple experience, were much less enthusiastic. Although they have an appreciation for the possible uses of tools such as Maple and have had some experience in using Maple as a problem solving tool themselves, it cannot be said that they currently show an enthusiasm for using such products. These students also did not show any positive agreement that using Maple had helped their understanding of the mathematics involved.

4 Discussion

In the light of the results above, it is natural to ask why the two groups of students responded in significantly different ways. The levels of computing experience reported were similar across the two groups so it is not possible to say that this was a determining factor. In terms of previous level of mathematics study, the students in the maths group were twice as likely to have studied specialist than methods whereas for the science students, less than half of the students studied specialist. Although the analysis of results showed that this measure of mathematical ability did not correlate with the responses to individual survey items, we would expect students who had enrolled on the specialist maths degree course to be more mathematically motivated and this may have had an impact on the results. However, our guess is that the difference in the Maple experiences of the two groups is the key factor.

The science students have only spent a brief amount of time working with Maple. When students are first learning to use a new tool, they are engaged in additional cognitive processing which, when taking place alongside mathematical problem solving, can lead to the students being overloaded. This effect has been discussed by Tall [9]. The maths students had been using Maple for longer so had become more accustomed to the commands meaning that they were less likely to be experiencing frustration and cognitive overload. They have therefore reached the stage where they can concentrate on the more rewarding aspects of problem solving.

In terms of the additional content covered, the maths students tackled tasks involving animations and short programs. Although this would initially necessitate the learning of more commands, these elements may give Maple more appeal for the students as they demonstrate more sophisticated features. Some students may have previously carried out some programming activities for mathematical problem solving using graphical calculators but the Maple programs tend to lead to more impressive results. The dynamic nature of animations is visually appealing and the significance of visualisation through the use of technology as an aid to mathematical understanding has been discussed quite extensively. Waits [10] has described how visualisation through graphing technology has been an integral feature of the approach adopted by those involved in the Calculus Reform movement. Kutzler [11] agrees that quick visual representation of functions using graphing technology enables students to develop their competence in changing between different representations. Referring specifically to animations, Bogacki [12] comments

that "Such a medium is particularly appealing in the subject matter of calculus, due to the dynamic nature of the concepts involved therein." Bogacki goes on to recommend that students have involvement in developing their own animations in order to maximise the learning that takes place and this is achieved by students in the maths group.

Another critical difference between the two groups of students discussed here is in the frequency and timing of their Maple work. The maths students had Maple sessions throughout the semester while for the science students the Maple sessions were in the final three weeks. This may mean that the maths students perceive Maple as being more central to their studies. The maths students were perhaps more able to see how using Maple was contributing to their understanding of new mathematical concepts as the semester progressed. Also, the fact that the science students were introduced to Maple towards the end of a busy first semester, as they shift to "Is it on the exam?" mode, may have contributed to their being less enthusiastic about learning to use a new tool.

5 Conclusion

The responses to the survey have indicated first of all that the way students respond to the use of technology in mathematics courses does depend on the way in which the technology is introduced and the type of activities involved.

For the students who had used Maple more extensively, we found some evidence to concur with the results of previous studies that concluded that there is little correlation between response to technology based activities and mathematical ability but that there is some association between response to technology based activities and computing experience.

Our consideration of the two different Maple experiences of students in the courses described has led to the conclusion that: students with increased exposure to Maple become more competent users and hence feel more positive about using the tool; being able to tackle more sophisticated tasks such as animations and short programs also contributes to a more positive response; sessions running throughout a semester will enable students to see more clearly how the Maple work they do can contribute to their understanding of the new mathematical concepts learnt.

The science group taking MA910 only will probably not major in mathematics but it is a possibility. The inclusion of a Maple module for this course will assist generally but for those who decide to major in mathematics, it will help with the higher level courses. Although we believe the science group did benefit from the Maple module, the student feedback shows that we need to do some further development in order for the students to believe that studying Maple is in their interest.

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Appendix A:

MAPLE QUESTIONNAIRE – SCALE ITEMS

The scores listed are the mean for each group of students. A score of zero represents a neutral result while –2 to +2 reflect the negative to positive responses for each item. The items phrased negatively had the polarity reversed for the scores recorded. These items are marked by *.

	Reverse Polarity	Science Group	Maths Group
1. I found Maple easy to use		-0.17	0.42
2. I found Maple frustrating	*	0.17	0.26
3. I would find Maple useful as a checking tool		0	1.00
4. I would like to use Maple more when solving problems		-0.34	0.16
5. I would not use Maple again unless it was part of an assessment	*	0.31	0.29
6. I found it difficult to learn and remember all the commands	*	0.24	0.13
7. I need more practise with Maple before I would feel confident using it as a tool	*	0.45	-0.65
8. I feel like I am quite capable with using Maple		-0.52	0.10
9. I thought the assignments were too difficult	*	-0.10	0.74
10. The time would have been more usefully spent continuing with regular lectures	*	0.28	0.61
11. I can see how Maple could be used as a tool in industry		0.52	0.74
12. Maple was just one more thing to learn	*	0.34	-0.10
13. I found using Maple helped my level of understanding of the mathematics		-0.66	0.13
14. I was able to enter a method using Maple commands quite easily		-0.34	0.42
15. I felt that we needed more instruction on how to use Maple	*	0.31	-0.52
16. I usually had a good idea what output to expect before it appeared		0	-0.13
17. I spent more time figuring out the syntax than actually solving the problems	*	0.28	-0.33
18. I thought the assignments were too long	*	0.14	0.35
19. I tried using Maple to solve other problems not set in the assignments.		-0.48	0.32
20. The assignments were interesting		-0.62	0.32