Candy-Coated Mathematics, a more Digestible Approach

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Abstract At the University of South Australia, Macromedia Flash MX has been used in the creation of new online modules for two courses *Mathematics for Computing* and *Differential Equations*. The modules aim to entice students with their eye-catching graphics, whilst embracing learning through interactivity and inbuilt randomised testing. High variations in the mathematical ability and attitudes of the two student cohorts provide an interesting contrast with analysis of their feedback revealing the success of the new learning tools in achieving their goals.

1 Introduction

Advancements in technology have opened new doors for the teaching of mathematics, allowing the development of accessible learning tools that can provide a visual, interactive and self-paced approach to learning.

These modern educational tools aim to facilitate learning by exploiting the power of combining constructivist principles with current technologies in an engaging, student-centred environment. A richer experience has been created for the student, by drawing many features together in a comprehensive format, each with an underlying educational benefit. Graphics and animation have been used to enhance enjoyment and satisfaction as well as presenting a broad visual overview to improve conceptual understanding. Interactivity is encouraged through use of flexible navigation systems, adjustable graphs and animations. Online assessments such as quizzes and worksheets dynamically challenge understanding by using randomised parameters whilst automatic inbuilt marking provides the learner with a higher level of control.

The two courses for which the modules were created provide a notable contrast in their difficulty, content, purpose and target audience. *Differential Equations* is a second year mathematics course offered to students enrolled in a mathematics degrees whereas *Mathematics for Computing* is a first year service course focussing on discrete mathematics with a student cohort consisting largely of computer science students, many of whom have little or no interest in mathematics. Analysis of feedback from the two student cohorts will provide insight into the influence of these variations upon the effectiveness of the modules. Finally this will lead to a discussion of whether the value of these innovative teaching tools is purely aesthetic or is indeed providing a basis for a deeper level of understanding.

2 Online Modules- a Visual Approach

Two unique sets of online modules have been tailored specifically for the pair of different courses. They have been developed using a student-centred, interactive approach that adheres to the fundamental constructivist guidelines [1] in order to create an effective online learning environment. For further details of constructivism as applied to these learning materials, please see [2]. The modules aim to be autonomous, guiding students through information whilst providing flexibility in navigational sequences. This information is presented both visually and verbally, with the aim of accommodating a wider range of perceptual styles of learning [3]. A conceptual overview is presented, with an emphasis on drawing together complex relationships using well-defined tasks. The modules have been created with an interface that is both visually appealing and intuitive. Key features of the modules include:

- **Online Walkthroughs** that introduce new concepts and definitions in a step-by-step format, governed by a clearly labelled navigational structure. Interactive graphs and animated simulations of real-world examples are included to encourage students to actively explore and interact.

- **Online Randomised Quizzes**, with inbuilt randomised parameters and adjustable graphs test conceptual understanding. The quizzes work on the principle that *practise makes perfect*, by retesting incorrect answers with a new randomly selected set of numbers.

- **Online Worksheets**, which also feature randomised parameters, allow students to work through lengthy problems and provide a more open style of assessment, such as testing the creation of a circuit diagram for a given Boolean logic expression.

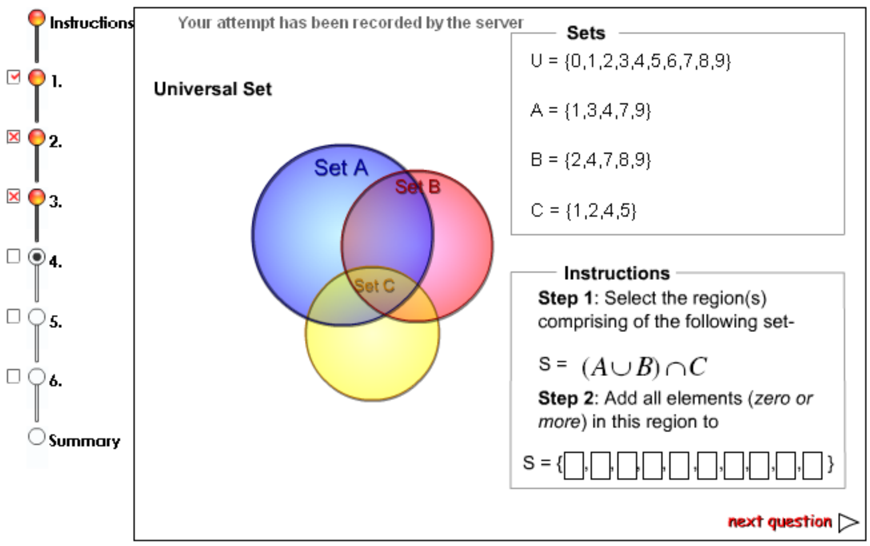

Figure 1: Venn Diagrams Worksheet

3 Research Methodology

Action research has been used as the main framework for this study [4] as it provides an iterative and incremental foundation for improvement. Observations and discussions during practicals, responses to questionnaires and academic performance were some of the key methods of evaluation. This analysis aims to highlight aspects of the modules that would benefit from further refinement and enhancement.

4 Results

Results were collected from questionnaires handed out to all students during the final weeks of semester 1 2005 for *Differential Equations* and semester 2 2005 for Mathematics for Computing. During practical sessions, observations were made by the researcher regarding student performance on the quizzes, opinions voiced about various features of the modules, difficulties experienced working with the modules, questions asked of the researcher/tutor and other students and any interactivity displayed between students.

The questionnaire was divided into four major headings that surveyed opinions on the use of the online modules, a comparison of online assessment and written assignments, a comparison of the online modules and written tutorials and finally a general basis for mathematical preferences, with the aim of addressing the underlying constructivist principles of the modules. 18 questionnaires were returned by students in the *Differential Equations* class and 66 from the *Mathematics for Computing* class.

Analysis of these results has shown that both student groups found the modules to be useful and enjoyable, providing an effective tool for understanding new concepts, however variations in background and reasons for taking the courses have had a strong impact upon the approaches of the two groups to learning and their levels of motivation.

4.1 Using the Online Modules

Both student groups answered positively in the questionnaire to the use of the modules, including the interactive features, visual appeal and ease of navigation. Results from both the questionnaires and observations during practicals showed that analysis of graphs and use of sliders generally helped to provide insight into concepts and behaviour of solutions

> "being able to move graphs around really helps me visualise what's going on"
> "Really helped me to further understand concepts in the course"

4.2 Comparing Online Assessments with Written Assignments

Most students expressed a preference for the online assessments over written assessments, with multiple comments from the *Mathematics for Computing* questionnaires indicated their appreciation for the online assessments and particularly the randomisation

> "I found the modules to be helpful in learning especially the aspect that lets us keep attempting question until understanding it..."
> "We could help each other without giving away the answers for our own work and thinking. Forces students to think about their own work since qu's are randomised (this is good)"

Two comments from the *Mathematics for Computing* students indicated some major differences between the online and written assessments

> "written assessments take longer than online"
> "Using the online tutorials is great because the work is attempted and completed in class. There is no homework, which is great, and can even be attempted at home before taking the in class assessment."

The practicals allow students to get help during class time and complete the practicals to receive full marks. Most *Mathematics for Computing* students were too disorganised to revise their assignments and ask questions during the tutorials the week prior to deadlines, despite encouragement. The *Differential Equations* students verbally expressed their opinions that the first written assignment was long and difficult. These issues were reflected in the high variation of marks for the written assignments. The difference in performance for these two types of assessment is a reflection of their nature, as the online assessments give students an opportunity to continue practising until a correct answer is given as opposed to written assignments which give feedback only after marks had already been assigned.

Initial observations in the *Differential Equations* course have shown that students completed quizzes slowly and carefully, using the walkthrough to help them explore different solutions as well as a pen and paper to calculate numerical solutions. Perhaps they may intuitively guess based on prior knowledge, but often when reattempting a question 'type' after an incorrect guess, the student would reconsider it carefully, further analysing the walkthrough before answering again. This was reflected in their questionnaire responses, as most students did not feel they guessed answers to the quizzes. The randomised nature of assessments encouraged students to work together without directly copying, which they often did by describing their own qualitative understanding or techniques for solving a problem rather than directly telling each other the answers.

Observations in the *Mathematics for Computing* course were a stark contrast, as students came to practicals with a strong desire to finish assessment tasks as quickly as possible. They tended to ask for solutions from each other or the tutor, rather than using resources such as their textbooks or a pen and paper to help calculate solutions. The attempt rate of the multiple choice quizzes was often quite high, and questionnaire responses showed that many students felt they were guessing answers, a few describing their concern

> "Some questions could be easily guessed. This is a temptation to finish quickly so we can leave the prac early and go to lunch (heh)"
> "It would be good if the answers weren't just able to be selected randomly"

These comments are interesting because not only do they point out perceived weaknesses of the multiple choice quizzes but also students perceptions of their own weaknesses. The students admit to guessing as it is faster and easier, but also say that they want to be forced not to. For the practicals with open ended solutions, it was observed that students were more likely to search or ask for help than try to guess answers.

4.3 Comparing Online Modules with Written Tutorials

The autonomy of modules was demonstrated in the two questionnaires by students' response that they did not need much assistance from an instructor with the modules. For *Differential Equations*, this was also observed during the practical sessions, where students asked few or no questions and were able to complete most or all parts of practicals without assistance, which contrasted with *Mathematics for Computing*, where students requested a large amount of assistance from supervisors and peers to complete the assessments.

In both questionnaires, most students responded that they enjoyed using the online modules more than doing the tutorial exercises. Students felt a mix of both types of assessment would be ideal

> "they both have their advantages, they complement each other- practicals make things easier to see but in tutorials the written work gets explained better, which is how we need to know it for the exam"

This is understandable as some components of the course are more suited to explanation using a white board in a tutorial whereas others can be more easily explained through a computer aided visual, graphical approach.

4.4 Mathematical Preferences

Mathematical Preferences		**SA***	**A**	**N**	**D**	**SD**
21. I enjoy mathematics.	M4C†	15%	33%	29%	17%	6%
	DE	35%	53%	12%	0%	0%
22. I enjoyed taking this course.	M4C	12%	27%	36%	20%	5%
	DE	6%	12%	71%	12%	0%
25. I found this course easy.	M4C	5%	14%	32%	38%	12%
	DE	0%	12%	41%	35%	12%

Table 1: Frequency of Responses for Selected Mathematical Preferences Questions

*SA- Strongly Agree, A- Agree, N- Neutral, D-Disagree, SD- Strongly Disagree
†M4C- Mathematics for Computing, DE- Differential Equations

Questionnaire responses for *Differential Equations* indicated a general enjoyment for mathematics (see Table 1), whereas more than half of students from *Mathematics for Computing* felt neutral about or did not enjoy mathematics. The students gave overly neutral responses about their enjoyment for both courses, which could be caused by many factors, but is quite likely to be linked with their perceived difficulty of the courses.

4.5 Conclusion

A lack of motivation or disliking for mathematics may lead to *Mathematics for Computing* students guessing quiz answers, suggesting that perhaps they are only "eating the icing on the cake". To deter students from guessing, multiple answer questions can be re-examined to create more open-ended questions and a higher level of scaffolding can be provided. The largest negative feedback from the modules was the lack of inbuilt help. This problem could be addressed by adding details and more worked examples with more descriptive explanations to walkthroughs as well as providing pop-up windows with assistive explanations of errors. Despite these issues, careful analysis of responses and observations from both groups reveal strong levels of enjoyment and satisfaction with the modules, particularly in assisting students to visualise new concepts. This satisfaction indicates that online modules are not simply educational eye-candy, in fact they have added a richer flavour to the learning experience of the students.

References

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