Multimedia L*e*arning System on Mathematics

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Abstract

Due to tremendous paradigm shift that technology has brought in the recent years, instruction in mathematics will have to 'catch up' with the new era or otherwise be increasingly irrelevant. Simultaneously with the aid of computer visualization, the horizon of teaching Mathematics is consistently broaden. With the coming of webpage makes it reachable throughout the net.

The growing development of technology-mediated learning systems has lead to 'flexible delivery' and 'virtual learning', which has created a whole new learning environment that enables students to take charge of their own educational experiences. However, there appears to be a concern about sustaining interactivity within a web-based learning system. Animations and interactive computer graphics methods provide new insights into the world of Mathematics.

In an attempt to develop a web-based courseware delivery engine, which incorporates the elements of interactivity, Multimedia University (MMU) developed the Multimedia Learning System (MMLS). It is a web-based teaching and learning tool, with 'virtual teacher within a virtual classroom' environment. To incorporate mathematical subjects into MMLS is another higher challenge altogether.

This paper will then report on the study of the students' perception on the use of Multimedia Learning System (MMLS) for mathematical subjects. This element of interactivity opens a whole new spectrum of communication, which allows for personal and immediate feedback.

Introduction

Designing an appropriate learning environment has been a permanent challenge to university educators. The use of Information and Communication Technology (ICT) in teaching and learning is becoming very crucial. Due to tremendous paradigm shift that technology has brought in the recent years, instruction in mathematics will have to 'catch up' with the new era or otherwise be increasingly irrelevant. Simultaneously with the aid of computer visualization, the horizon of teaching Mathematics is consistently broaden. With the coming of web page makes it reachable throughout the net.

Although there are many examples of web-based courses, it is now clear that much more is involved than just presenting the components of a conventional course via internet [1]. The growing development of technology-mediated learning systems has lead to 'flexible delivery' and 'virtual learning', which has created a whole new learning environment that enables students to take charge of

their own educational experiences. Animations and interactive computer graphics methods provide new insights into the world of Mathematics.

As with any new technology we are often drawn to the technology itself rather than recognizing it as a tool to enhance learning. Thus, the Multimedia University (MMU) has been spearheading the initiative towards a multimedia learning environment by developing a new interactive teaching tool called the Multimedia Learning System (MMLS). This system aims to compliment and supplement the teaching and learning process and materials.

Overview

MMU first started its web-based learning tool in 1997 by having the instructors to create the course content in html file format. There was no standard template and guidelines provided to the instructors in creating the course contents, which resulted in the development of various courses with different templates and designs. The second tool, i.e. LOTUS Notes, was introduced in 1998 to standardize the first tool. The only difference that set it apart from the tool that was firstly introduced was that the templates were provided to the instructors. Subsequently a team of MMU staff was set up to develop a customized web-based learning tool known as On-line Notes (Figure 1).

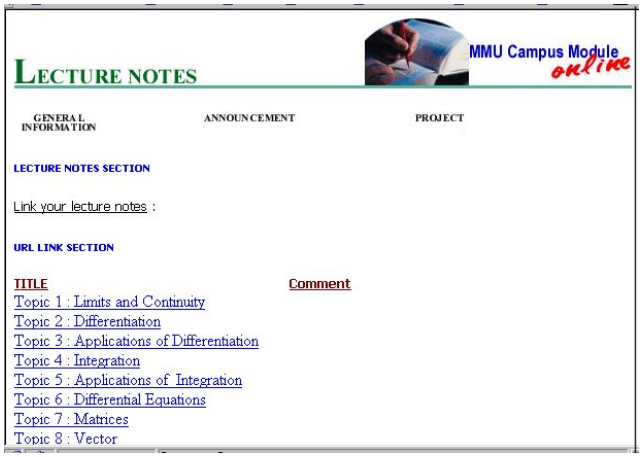


Figure 1 : MMU Online Notes

These three web-based learning tools, which were adopted by MMU were text-based, with limited elements of interactivity including animations and graphics except for the instructors email, and the relative and absolute links. Recognising the limitations of the three web-based learning tools that MMU adopted, the Multimedia Learning System (MMLS) was designed in 1999.

A trial implementation using MMLS was done in the second trimester, session 2000/2001. Seven subjects were selected at the Alpha Level (Foundation Level) for the trial including the Mathematics subject, “Calculus for Engineering” . This on-line learning system suggests self-paced learning among the students. In order to support the self-paced learning, students need to be able to access the on-line resources easily, efficiently, and cost-effective in order to gain maximum benefit in their learning.

Traditional Teaching and Learning

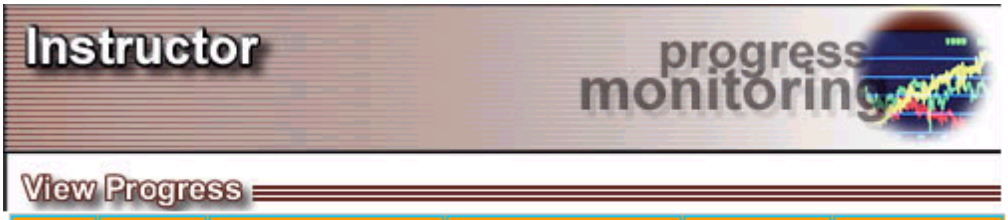
For producing graduates who can adapt their knowledge to changing circumstances, the great emphasis will be on the application of concepts from lectures and reading to solve problem. Therefore, the style of education which called "analytical learning" has been used in teaching and learning process. This style stresses understanding and problem-solving rather than memorisation. Students are given assignments, projects, practical exams and written exams which require their understanding and problem-solving. Furthermore, lecturers' responsibility is to provide experiences from which students can construct an understanding of the subject area. It is students' responsibility to integrate the experiences into their mind, and to use the knowledge gained in different situations.

Figure 2: Multimedia Learning System Webpage

Through the lectures and tutorials, students are given opportunities to involve in both understanding and problem-solving. The lectures will present a summary of the main ideas of the subject, often illustrated with examples. Usually there is a textbook or handout which provides a lot of information on the subject, and lecture can indicate to students which material in the text is important, and also show why these ideas are important. It is important for students to realize that lecture material is not intended for memorising, but rather for understanding. The understanding will be enhanced through the tutorials where the discussion on problems or questions (in which these are given to students in advance) is conducted between students and tutor. Moreover, through this discussion, students are given opportunities to solve the problems. Problem-solving needs the strong foundation of concepts and mastering the skills. Therefore, students are given assignment, projects and etc. either in group or individual to learn how to apply the concepts and skills they gained in the situations of the projects/assignments.

Multimedia Learning System (MMLS)

MMLS is a web-based engine, supported by multimedia tools, which creates a virtual interactive teaching and learning environment (Figure 2). There are three sub systems in MMLS; of the front end system for the user to interact, the main engine which manage the content and interactivity, and lastly the back end systems which stores all data and history of the users.



HTML Page	Frequent	From Time	To Time	Total Time	Last Visited
249	1	2001-11-15-20:14:08	2001-11-15-20:14:17	0:00:09	2001-11-15*
276	1	2001-11-15-20:14:17			2001-11-15*
483	2	2001-11-15-20:14:19	2001-11-15-20:17:57	0:03:38	2001-11-15*
456	1	2001-11-15-20:13:42			2001-11-15*
487	1	2001-11-15-20:28:59	2001-11-15-20:40:46	0:11:47	2001-11-15*
398	3	2001-11-15-20:40:46	2001-11-15-20:47:23	0:06:37	2001-11-15*
471	1	2001-11-15-20:47:23			2001-11-15*

Figure 3: Progress Monitoring Report

The interactive features made available to the instructor are course registration, content uploading, course registration and uploading, and students progress monitoring (Figure 3) which provides details on the students' accessibility and time spent on the materials posted on the MMLS. On the other hand, the interactive features made available to the students in order to enhance interactivity and develop a three-way communication between instructors, students and the system are the chat, newsgroup, email, bulletin board, on-line and short notes.

Multimedia Learning System on Mathematics

The immediate goal of the Multimedia University is to create online Multimedia Learning System (MMLS), which incorporates interactive graphics into a hypertext system for teaching all courses including Calculus. Besides reading the text, students need to merely click on a highlighted word to obtain definition, follow links to related subjects, and interact with a multitude of 3D visualizations, whose parameters can be manipulated to help understand a wide array of concepts. The "interactive book" approach of situating interactive graphics within a written context is an appealing educational paradigm [2].

Information Technology can be potent mathematical tools that engage learners in meta-cognitive reflection. Proponents of computer-aided mathematical visualization argue that visualization can help build the intuition necessary to understand mathematical concept. Computer graphics is a useful tool

for teaching simple topics in mathematics [3]. This technology enables an enriched form of user interaction that can make using and learning to use a computer, easier and more natural [4].

The use of multimedia technology can enhance students' understanding of the Calculus concept. Through the combination of animation and sounds, students are able to visual and learn the approach and concepts better by using MMLS.

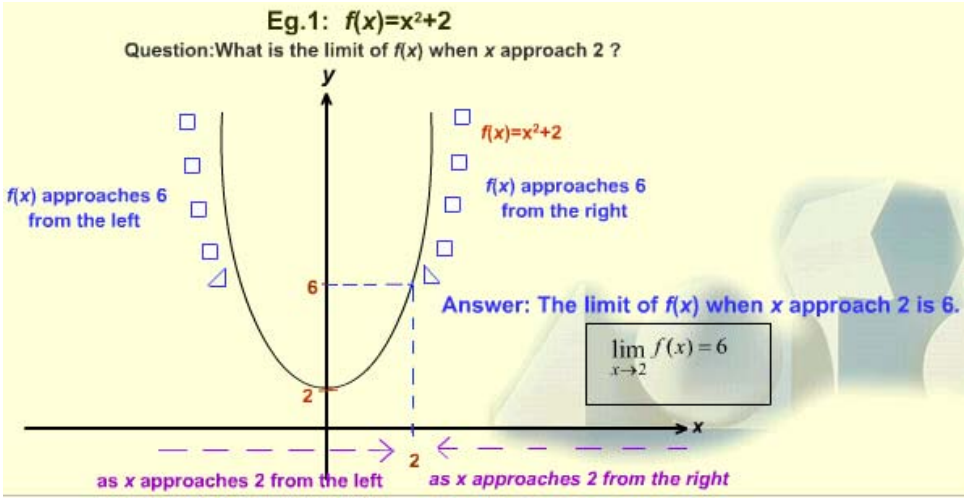


Figure 4 : Limit and continuity

In figure 4, it shows the limit of $f(x) = x^2 + 2$ as x approaches 2 from the left and right, that is,

$$\lim_{x\to 2^-}(x^2+2) = \lim_{x\to 2^+}(x^2+2) = \lim_{x\to 2}(x^2+2) = 6$$

The interactive part of using MMLS is students may require to fill in certain required information into mathematical problem. A sample in figure 5 shows that problem solving question can be done using technology.

Learning activities should incorporate multiple representations of mathematical topics and/or multiple approaches to representing and solving mathematics problems. Furthermore, use of technology allows students to set up and solve problems in diverse ways, involving different mathematical concepts, by removing both computational and time constraints[5].

The prime part of this entire process is the linking of numerical and graphical representation. Such visualization is to be an important fact of cognition:" *Computers can transform symbolic-algebraic situations into spatial-geometric ones"*[6]. It shows that visualization has become an integral part of mathematical concept which do not replace the formal definition, but rather complement it.

The general meaning of maximum and minimum can be illustrated in a much more livelier mode as in figure 6. Students may click on the respective button in order to understand the definition and concepts of absolute maximum and minimum as well as local maximum and minimum of the function. The sound has been utilised where the explanation by instructor can be listened when the button is clicked.

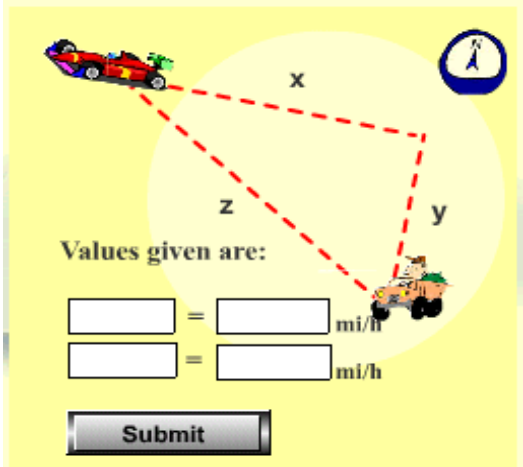


Figure 5: Related Rates Problem

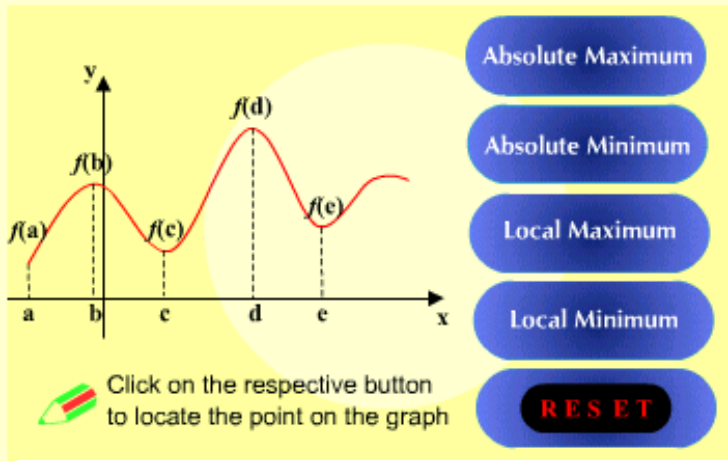


Figure 6: Maximum and Minimum Values

Learning activities should take advantage of the capabilities of technology, in particular, MMLS, and hence should extend beyond or significantly enhance or facilitate what can be done without using it. Using technology to teach the same mathematical topics, in fundamentally the same ways that could be taught without technology does not enhance students' learning of mathematics and rely on the usefulness of technology [7]. Furthermore, using technology to perform tasks that are just as easy or even better carried out without technology may actually be a hindrance to learning.

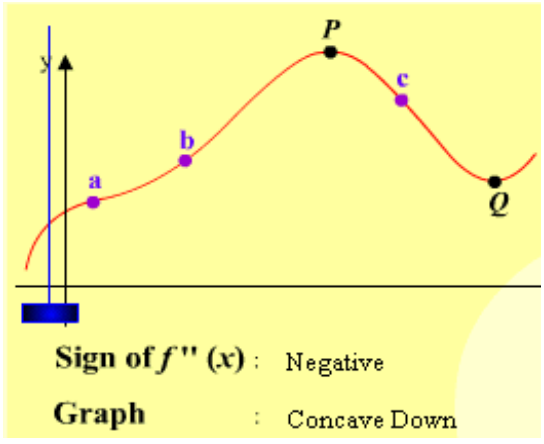


Figure 7: Concavity of a curve

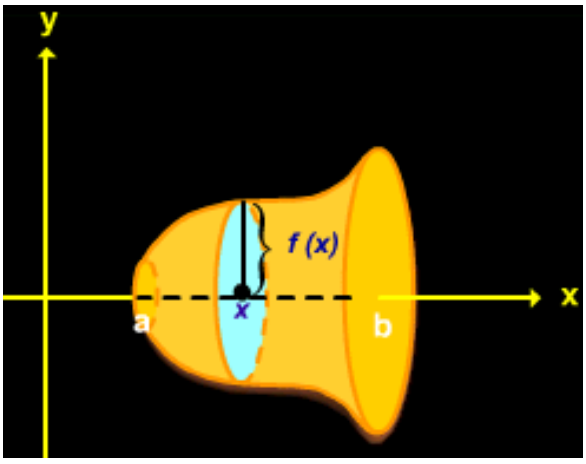


Figure 8: Volume of the Solid of Revolution

In figure 7, it shows the test of concavity/second derivative test. By moving the blue bar with vertical line along the x-axis from left to right across points a, b, and c, the word 'negative' or 'positive' will appear in the line of 'sign of $f''(x)$', and the 'concave up' or 'concave down' will appear in the line of 'Graph'. The explanation in text of the local minimum and maximum appear when student click on the 'tip' button. Therefore, through the interactivity and animation, students are able to enhance their understanding of the concept.

It is much easier to teach 3D images through the MMLS as in Figure 8. The 3D animated images are utilised to elaborate on theoretical concept where students understand how the volume is generated through the integrals. The process in generating the solid by using the washer method/slicing method is visualised through the animation of the graph. In addition more effects had been integrated into this image, whereby colours, lights and cameras are be placed to have the shadow and shading [8]. This has made the images look more realistic and fruitful.

Survey on the Students' Perceptions on MMLS for Calculus Subject

As the students progress, it is essential that they develop an ability to visualize spatial relationship, to estimate numerical answer, interpret data given to them and to reason. A survey was done on the students' perception of the use of MMLS on Calculus subject. The questionnaire consists of A) General background B) Contents C) Perusal of the system and D) students' point of views. It involved 81 pre-university students (Alpha Engineering programme). Two third of them are males and one third are females. They consider themselves above average in terms of English Language use and command as English is a medium of instruction at MMU. 75% of the students own a personal computer with network access at their campus residence.

Overall, two third of the students were accessing the MMLS from their residence while slightly more than half were reported accessing the MMLS from computer labs on campus. Only few students reported accessing the MMLS from cyber café for which they are charged based on hourly basis. While 30% of the students did not access the MMLS every week or just once in a while, a bit more than half reported accessing the MMLS one or two days in a week. The rest of them reported referring to MMLS every other day in a week.

The duration taken by the students to go through the materials presented per access is far shorter than the time it takes for the lecturer to prepare them. 80% of the students reported of spending less than 2 hours on the materials and majority of which just take a glance in less than one hour to browse through.

The content part of the survey basically refers to the suitability of the technical approaches being used. The results are being conveyed via histograms in figure 9. Commons items such as the use of icons, buttons, fonts, and color schemes hardly impressed the students as they are used to browse the net. Any graph that looks heavier to the left and/or skewed to the right implies positive responses from the students. This can be shown clearly on the use of images and voice over the material on MMLS.

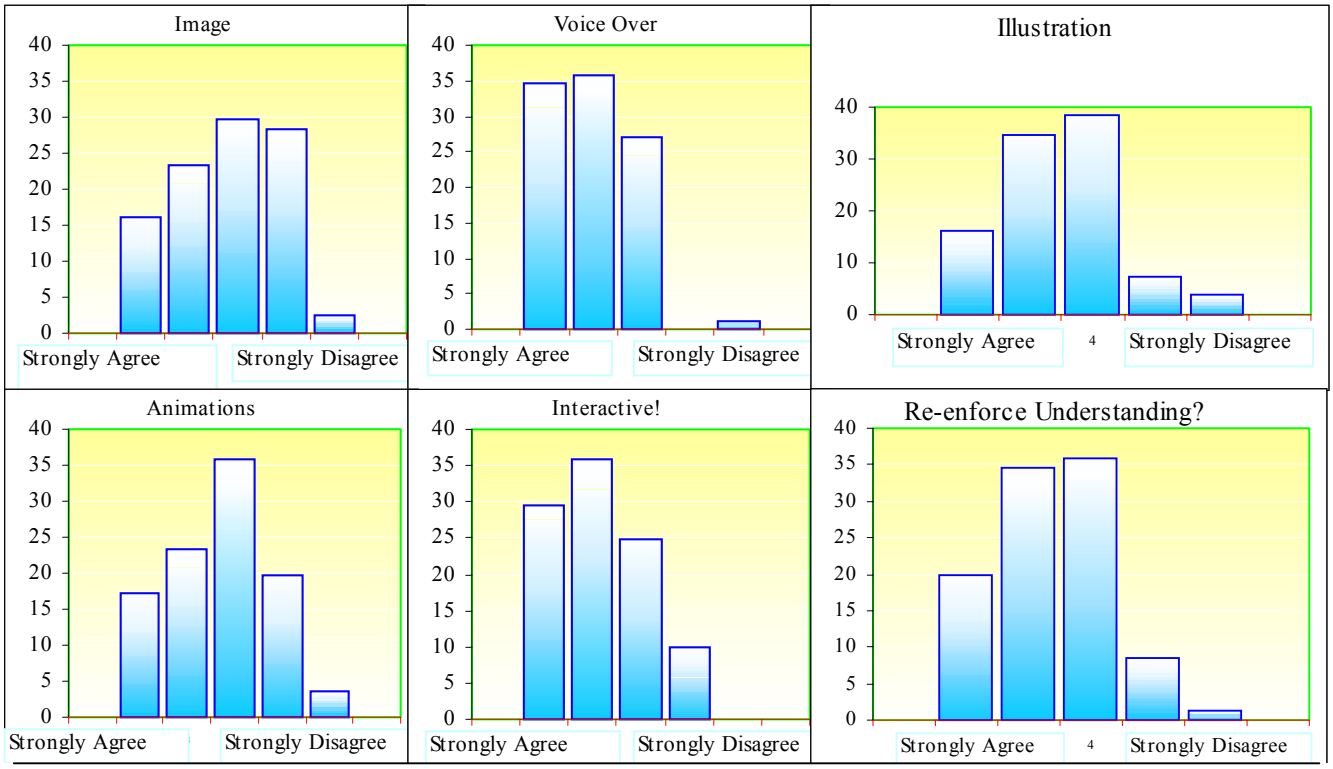


Figure 9 : Graphs that looks heavier to the left and /or skewed to the right implies positive responses from the students on the multimedia features introduced in MMLS.

Students' Comments from the Survey

Some of the comments from the students are presented as follows:

- MMLS should be introduced as an addition, face-to-face lecture still plays the main role.
- Learning online is not really simple.
- Sometimes users have to wait for audio to finish before it starts to play animation.
- MMLS is a good update in the learning world but learning from the textbook and notes are far better.
- The system and everything is good, but I just can't bear going to the lab and it costs me much for an hour.
- Use MMLS just for reference materials.

Future Plan

An Intelligent *e*-Learning System

Future MMLS is a web enable learning management system (LMS) that support multimedia content. This engine has built-in intelligence that can deliver learning objects according to learners ability. The system has excellent learner tracking facility and interactive learning object manager. Future MMLS

provides a course effective yet a powerful solution for organization that wants to deploy an intelligent *e*-learning system quickly.

Virtual Tutor

For future implementation purposes, the Virtual Tutor(VT) will be introduced as shown in figure 10 which will be assisting the students in doing their mathematics works. VT is developed using the Agent Technology. VT is in a form of MMU animated mascot characters, which will definitely attract students to participate in the learning process. These characters can move freely within the computer display, speak aloud (by displaying text on screen) and even listen for spoken voice commands. At the moment, voice over are read out according to the content. The next step is to introduce the audio sound effect within each movie and/or mathematical animated frames. The MMU mascot shall be incorporated in the system.

Figure 10: A mascot from Multimedia Agent Technology project.

Conclusion

With the major concern of incorporating interactivity to diversify and enhance the teaching and learning process, the MMLS provides a multidimensional nature of on-line triangular interaction between instructors, learners and system. Animations and interactive computer graphics methods provide new insights into the world of Mathematics.

The development of the MMLS is ongoing and many more features would be likely to be introduced to further enhance and support interactivity. In practice, it is quite a challenge to construct intuitively useful images. Nevertheless, despite the apparent limitations of visual representations, their utility is far from being completely exploited.

It is time to consider teaching a modern Calculus course that is a lean and lively group of topics from a dynamical system perspective. The teaching mode uses technology to treat most topics graphically, numerically, and analytically. Further research is needed to examine the effectiveness of the interactive elements and its effect on the teaching and learning process.

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