Teaching Mathematics: Tablet PC Technology adds a new dimension

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Abstract: In this paper we discuss the use of a recently developed lecture presentation system called *Classroom Presenter* to teach Mathematics. This system, that uses a Tablet PC as a presentation device, was developed at the *University of Washington* in response to the challenge of improving the ability of an instructor to interactively present lecture material from a computer. This system was tested with a group of Mathematics students doing a formal degree programme as well as with a group of students during an informal Mathematics upgrade programme. Some system-specific features will be shown that have contributed to a more spontaneous and interactive Mathematics classroom. These include high quality layered electronic inking, annotations on top of slides, time-efficient use of high quality Mathematics examples and the ease of movement between pre-prepared slides and whiteboards. Some drawbacks and limitations of the system are also discussed with reference to the PowerPoint system for teaching Mathematics.**Keywords** Educational technology, Mathematics teaching, Interactive learning, Presentation tools, Tablet PC.

1. Introduction

Since the introduction of the blackboard as a tool for instruction nearly two centuries ago, presentation technology has had a profound influence on how we teach Mathematics. The blackboard is a very powerful presentation tool that serves as a visual memory for the display of information in a systematic way. The blackboard also serves as a mediating agent between the instructor and the students in providing a basis for understanding and discussion of lectures. In recent times, different technologies supported a variety of instruction styles and provided various mechanisms for engaging an audience. The main presentation technologies in university classrooms today includes blackboards (that may have a white color), overhead projectors, electronic whiteboards, and computers with data projectors.

The benefits of enhanced interactive learning in Mathematics is well known. As classroom technology becomes more prevalent, it is natural to incorporate systems that support more natural interaction between students and the presenter into teaching models.

In this paper, we discuss the presentation of Mathematics lectures via electronic slides in conjunction with high quality electronic inking directly from a Tablet PC. We will show that this approach has a number of advantages over, for example, the use of electronic slides only.

2. Electronic Slides

There are some significant advantages when teaching Mathematics using electronic slides. Slides allow advanced preparation of material, improving organization of the presentation and electronic slides provide a means of showing information-rich content such as complex tables, formulas, graphs and diagrams. Slides also afford instantaneous display, avoiding the inaccuracy and the time of copying material onto an overhead projector or whiteboard. Furthermore, electronic slides offer the advantage of being flexible in term of ease of preparation, sharing, and modification after presentations.

However, teaching from pre-prepared electronic slides comes at the expense of the ability to freely interact with students during a presentation and to adjust the lecture at the request of the audience. Both students and instructors agree that electronic slides tend to script a lecture and do not provide flexible mechanisms to adapt the presentation on demand during a presentation. An important part of lecturing is to have the ability to adjust material in response to student reactions and developing spontaneous examples and explanations to clarify and expand on topics. This is particularly true in a Mathematics classroom where interactive exchanges form the cornerstone of effective learning. The weakness of electronic projection of slides is the absence of a means to alter or augment the displayed material to do this.

The Presentation System

Tablet technology allows for the interaction with audiences during presentations through on-screen annotation with handwritten electronic inking. Combining electronic slides and digital ink using the Tablet PC are also possible. In the teaching model that we will discuss, an instructor loads a presentation composed of a deck of electronic slides onto a tablet computer. The instructor writes on the slides with the tablet's pen and control the presentation by invoking controls that are displayed on

the TabletPC. The TabletPC drives a data projector that synchronously displays the slides and writing to an audience.

Currently, an increasing number of systems combine slides and digital ink using the Tablet PC, including academic systems such as Mylar Slides [1], and commercial applications such as Microsoft PowerPoint and Microsoft Journal. The Microsoft Journal software was developed exclusively as a TabletPC utility programme [2].

2.1 Microsoft Classroom Presenter

The need to freely apply electronic inking while one is projecting electronic slides motivated the Educational Technology group at the University of Washington to develop the Classroom Presenter system [3]. Classroom Presenter, hereafter called CP, is a TabletPC based electronic lecturing system allowing instructors to combine spontaneous inking with static prepared electronic lecture notes. CP also caters for configurations other than the single presenter single audience model that is discussed in this paper. Various inking functionalities of CP that are shown in Figure 1 allows for swift interchanges between natural inking on electronic slides and electronic white boards. This makes CP an attractive option as a TabletPC software tool to teach Mathematics.

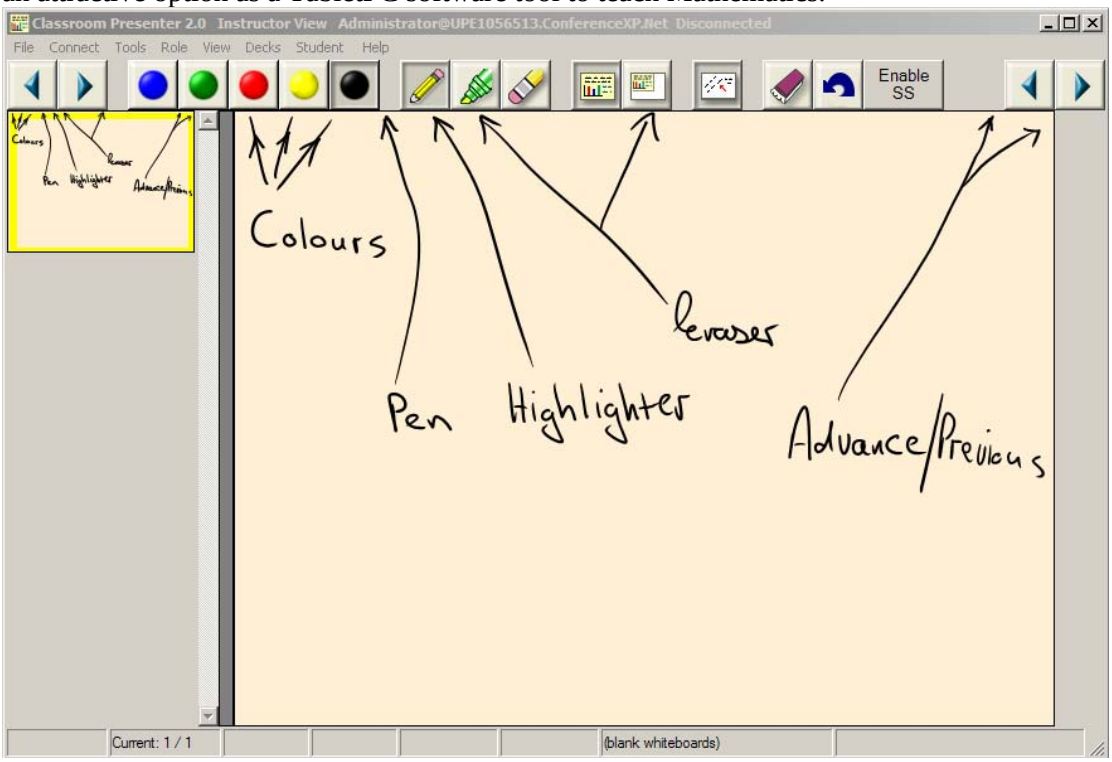

Figure 1: The Classroom Presenter electronic whiteboard with functionalities

2.2 Supporting Software

The quality of the pre-prepared electronic slides is a key factor in the success of the TabletPC-CP presentation system. Before any electronic slide can be displayed by the TabletPC-CP system, it must be prepared as a PowerPoint slide before it is incorporated as CP slide. A number Mathematics ICT software programmes [4] may be used to enhance the quality and the time efficiency of creating electronic slides. The author made extensive use of Autograph 3 [5] and MathType 5 [6] to prepare Powerpoint slides for use in the Tablet-CP system. In particular, a screen-capturing tool was used to capture and paste graphics that were generated using the Autograph programme. Examples of electronic slides that were prepared in this way are shown in the sequel.

3. Classroom Experiences

Various groups of Mathematics students at the Nelson Mandela Metropolitan University were exposed to the TabletPC-CP presentation model during the past year as part of a formal degree programme. We also used the TablePC-CP model to present lectures to a selected group of year-11 Mathematics learners as part of a community enrichment programme. In all of these cases the specialised Mathematics software packages mentioned in the Section 2.2 were used to prepare the CP electronic slides before lectures. Although various aspects of the teaching model were tested during

all of these presentation, the focus was to get a qualitative response from students regarding the value of the TabletPC-CP system as a teaching tool that promotes interaction in the classroom.

3.1 Vector Algebra Case Study

TabletPC-CP presentations were delivered to a group of 130 first year under-graduate students who enrolled for a 15-week introductory vector algebra course at the beginning of 2005. The two- and three-dimensional visual nature of some parts of this course made the use of hand-written annotations on top of quality electronic slides particularly effective. The Tablet-CP teaching experience differed significantly when compared to the experience I had in previous years when I taught the same course using the blackboard as the primary teaching tool. The face-to-face time increased substantially and along with it also the opportunities to judge and respond to student reactions during lectures. I definitely found that this model allows the lecturer to either cover more material in the same time period or to spend more time explaining and discussing the displayed material. This, however, must be seen against the backdrop of a substantial increase in the preparation time that was needed to prepare lectures for a first-time presentation. Electronic hand-written annotations on slides were saved after each lecture and contributed, in many cases, to better informed discussions with students who have asked for assistance between lecture periods. Annotated presentation slides were made available electronically to students after lectures to further assist them with self-study. Figure 2 shows a typical CP electronic slide that were used during the presentation of this course.

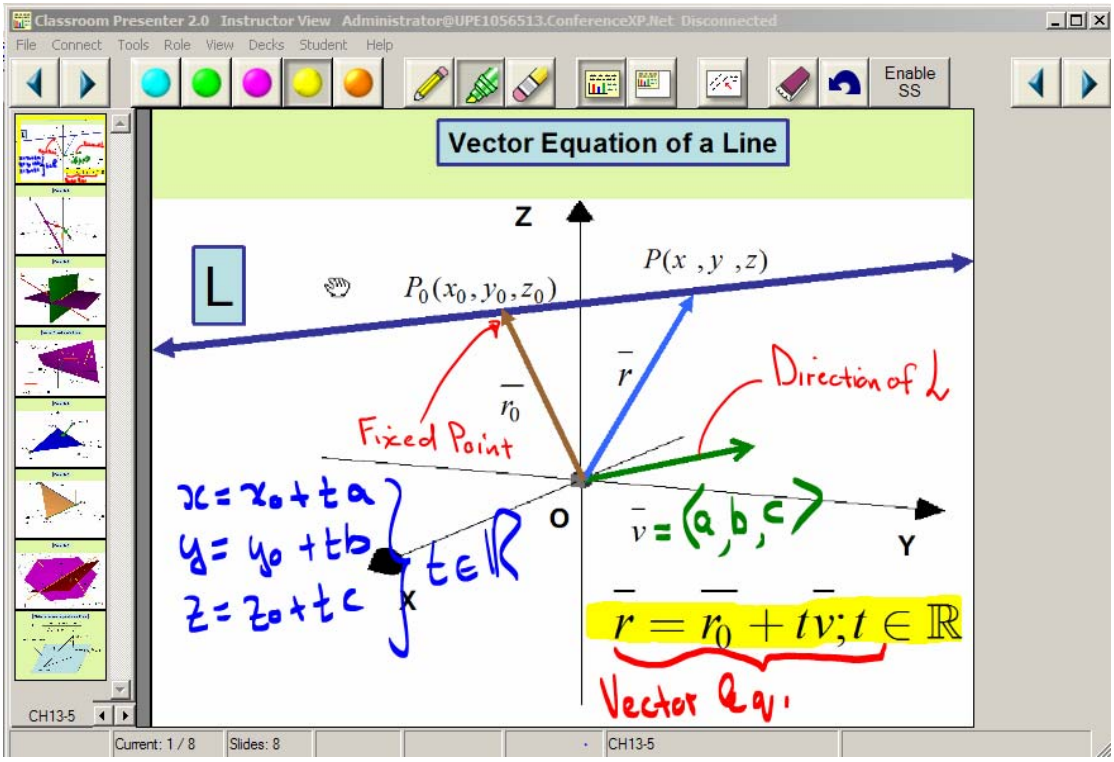

Figure 2: A Classroom Presenter slide with digital inking

3.2 Student Responses

The TabletPC-CP presentation system was received with an overwhelmingly positive attitude by the students. Positive comments regarding the improved visual nature of the lectures were evident from most of the responses that were received from students. The natural use of colourful inking that differentiates and highlights key aspects of a Mathematics problem or solution, for example, also drew many favourable comments. Although the course experiment seems to have been a success, follow-up studies are needed to determine whether the quantitative impact of the teaching model matches the perceived qualitative improvements. The following series of graphs depicts the response from students to some presentation-related questions.

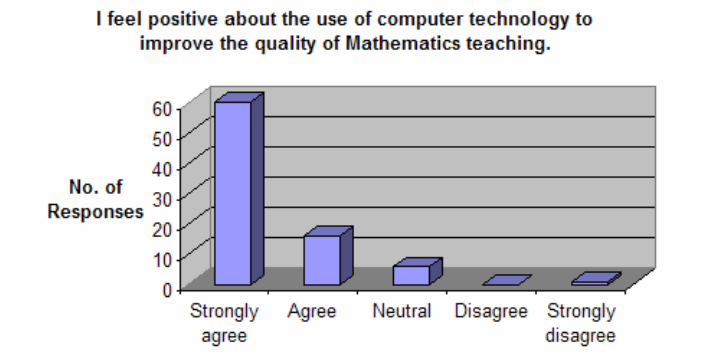

Figure 3: Student response to Computer Technology

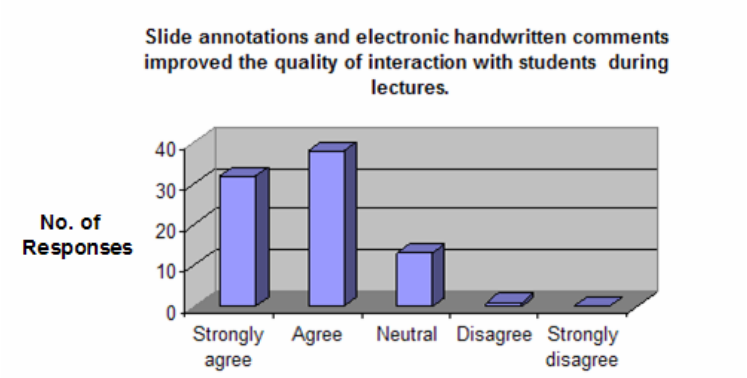

Figure 4: Student Response to inking on top of electronic slides

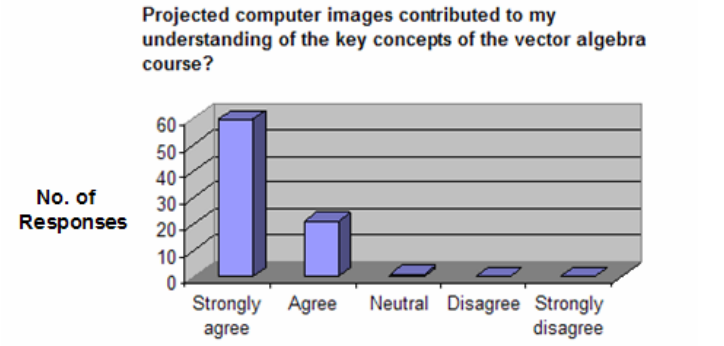

Figure 5: Student Response the value of Projected Computer Images

3.3 Summary of Positives and Negatives

The overall impact of using TabletPC technology to teach Mathematics will certainly not be known for many years to come. Early indications of the positive- and negative aspects are however beginning to emerge. The following table is an attempt to list some of these aspects together with a reference to the recent TabletPC-CP experiences that I have had. A number of these experiences confirm what was reported by some authors to be advantages of teaching with Tablet technology [7], [8], [9].

Some advantages of the TabletPC-CP system

- Eye-contact with the audience over longer periods lead to greater responsiveness from the lecturer which in turn improved the classroom interaction.
- The ability to use Mathematics ICT to prepare CP slides improved the quality of the projected material.

- High quality inking improved the communication. For example, planned gaps in proofs and examples can be interactively restored with hand written annotations after some discussions.
- Multicoloured pen and highlighter functions are effective tools to make proofs and problem solving more visible.
- Work that was done earlier in a lecture can easily be re-visited if requested.
- The retention of inking helps to re-create the context of a topic that was discussed during a lecture. This is particularly useful afterwards when an individual student wants to discuss aspects of a presentation.
- Presentation slides including all or some of the inking can easily be made available to all students as html-files.

Some disadvantages of the TabletPC-CP system

- To prepare quality electronic slides and to set up a series of lectures as a first presentation is time consuming.
- There is a steep technological short-term learning curve before most prospective presenters will be able to make a quality presentation.
- Effective methodology and best practice are not apparent and must be explored over an extended period of time.
- The cost of TabletPC's and Data Projectors are still high and many universities are lacking the resources to switch to a PC-based teaching model.

4. Related Work

A number of leading universities and colleges have launched projects that aim to promote interaction in classrooms through the use TabletPC technology. The following table lists some of the earlier as well as the more recent projects:

Project	**Subject**	**Link**
University of Washington Classroom Presenter Project	Computer Science	http://www.cs.washington.edu/education/dl/presenter
Drexel University Programme Learning Experience, DUPLEX	Mathematical Statistics	http://www.syllabus.com/summer2003/pdf/T11a.pdf
University of Maryland Tablet Mylar Slides Project	Mathematics	http://www.cs.umd.edu/~egolub/TabletMylarSlides
Seton Hall University SHUTAP SHU Tablet PC Project	Computer Science and various other subjects	http://technology.shu.edu/page/SHUTAP+SHU+Tablet+PC+Project!OpenDocument
University of Texas at Austin Microsoft Tablet PC Rapid Adoption Project	Architecture	http://www.utexas.edu/computer/tabletpc-rap2002/
University of Ontario Institute of Technology	Science courses	http://www.uoit.ca/schoolofscience/News&Events/Tablet.htm

5. Possible Future Projects So far I have only tested the TabletPC-CP system with Mathematics students for some introductory courses. The impact of TabletPC based Mathematics teaching at

graduate levels must also be explored. One will also have to test other Tablet based software systems like Mylar Slides, for example. In addition, the quantitative impact of TabletPC based presentation systems in Mathematics teaching still have to be researched. A comparative analysis of the Classroom Presenter System and the Mylar Slides system will also be undertaken in the near-future. In addition, attention should also be given in future to the sequencing and systematic use of electronic inking during lectures. Structured classroom tests should be conducted to determine possible best inking practices for teaching Mathematics using TabletPC.

6. Conclusion

Presenting Mathematics lectures from a Tablet PC using Classroom Presenter adds new degrees of freedom that enhances interactive learning in the classroom. The ease with which various ICT Mathematics software programmes can be integrated in the process of preparing electronic slides paves the way for quality presentations. Both students and lecturers agree that the TabletPC-CP system have managed to address most of the constraints of the traditional PC-PowerPoint type presentations. I believe that it is just a matter of time before Tablet based presentation systems will become commonplace in Mathematics and other classrooms at institutions of higher learning.

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