Delivering university mathematics lectures with tablet PCs: Lecturer and student reflections

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Abstract: Tablet PCs are becoming established as powerful technological tools in the university classroom, particularly in the mathematical sciences. In this article we reflect on student and lecturer experiences of the use of a tablet PC in undergraduate mathematics lectures at a South African university. Not only does the tablet PC transform the classroom, it also facilitates the electronic distribution of lecture notes and dynamic lecture screencasts, enriching the lecturer’s and students’ educational resources. Through student surveys we explore student perceptions of the technology, how they use the resources it helps produce and the lecturer’s experience of the changed teaching environment.

Keywords: tablet PC, technology in education, reflective practitioner, student feedback.

1. Introduction
Tablet PCs have developed as a viable consumer technology over the first decade of the current century. Already at the onset of this development the potential applications of tablet PCs within education were evident (Willis & Miertschin, 2004). Indeed, collaboration between computer and software manufacturers and educational institutions has played a crucial role in developing both the technology and its educational implementation (Cicchino & Mirliss, 2004).

By now standard, although still not widespread, use of this technology in the (university) classroom involves projecting the contents of the PC screen through a data projector while the lecturer writes on the tablet. This essentially provides a sophisticated overhead projector on which computer generated material as well as dynamic hand written notes and annotations are displayed. It is this combination of human input and computer generated clarity and precision that lies at the heart of the technology’s appeal.

Moreover, the fact that lectures are transmitted through a single computer allows for easy preparation, recording and archiving of lecture material. Invariably those who teach with a tablet PC distribute “lecture notes”, as saved on the tablet PC, to students after class (Fister & McCarthy, 2008, p. 288). Some go further and use screencasting software to make dynamic recordings of their lectures which are then made available to students (Bonnington, Oates, Parnell, Paterson, & Stratton, 2007).

1 Tablet PCs are essentially laptop computers with the functionality of being able to write with a stylus directly on the computer screen. A convenient overview can be found at [http://en.wikipedia.org/wiki/tablet_pc](http://en.wikipedia.org/wiki/tablet_pc)

Tablet PCs have been particularly popular in teaching in the mathematical sciences and chemistry. This is because the notation used in these disciplines, and the value of developing a problem’s solution in class, lend themselves to dynamic, handwritten lecture delivery.

In recent years a number of authors in the mathematical sciences have documented their experiences of using tablet technology in the university classroom. Surveys are given of their use as “sophisticated overhead projectors” (Loch & Donovan, 2006) and in multiple tablet classrooms (Fister & McCarthy, 2008) as well as experiences and reflection on screencasting (Bonnington, Oates, Parnell, Paterson, & Stratton, 2007). (Budgett, Cumming, & Miller, 2007) and (Loch, 2010). More personal reflections on individual academic’s experiences of using tablet PCs in a variety of settings and applications can be found in (Olivier, 2005), (Biswas, 2007) and (McCann, 2008).

There are also a number of well documented institutional projects involving tablet PCs: Racer Ink (Murray State University, 2007), MathOnline (University of Colorado Colorado Springs) and the groundbreaking software development and tablet use within the Classroom Presenter project (University of Washington), for example.

It is not the purpose of this article to describe in detail the technology and its various applications, however, but rather to reflect through student feedback on its educational impact on undergraduate mathematics classes at Stellenbosch University, South Africa. The references given above as well as the recent survey (Galligan, McDonald, Loch, & Taylor, 2010), and references therein, provide a good insight into the technical details and educational opportunities of tablet PCs in university mathematics teaching.

Our contribution, based on the reflections of an experienced lecturer and about 200 students, aims to add further weight to the body of literature promoting the use of tablet PCs in the university classroom. Our research helps dispel some of the inevitable misgivings regarding the use of the technology and provides further evidence of how students engage therewith.

2. The context
The author (a senior mathematics academic with over 15 years’ university teaching experience) began teaching first-year calculus at Stellenbosch University with a tablet PC in 2007. The current article draws on his students’ experiences of this technology, surveyed over three semesters in 2008 and 2009. The calculus module in question is a fulltime, mainstream mathematics module (five 50 minute lecture sessions per week) taken by residential students. (The University of Stellenbosch only has residential undergraduate students.) Students on the module are divided into a number of classes and those surveyed were in three such classes, ranging in size from 50 to 140 students.

Initially the author was the only member of the lecturing team using a tablet PC. By 2009 there was one other lecturer doing so but her usage was different and her students were not included in this study.

The author’s use of the tablet PC in class was, and remains, as follows. In lectures the tablet PC is connected to a data projector and all presentation to the class is from the PC screen, projected onto the wall. Mostly there are no prepared notes on the PC, all material is written on the screen during the course of the lecture. (In other words at the beginning of the class the PC screen is simply a replacement for a clean blackboard.) Illustrations from an electronic library, supplied with the course text, are sometimes imported while notes are written during class. Regular use is made of the computer algebra system Maple to illustrate concepts, draw graphs and perform calculations. This is done in class. The output from Maple is then copied into the notes “on the fly".
The standard software Windows Journal is used for the writing of notes. BB Flashback screencasting software is used to record the entire lecture. The written notes are saved in PDF format and the screencast is converted to Flash format. These are then put on the course website, usually within two hours of the end of the class.

3. Student surveys

Students were surveyed, anonymously, on their experiences of tablet PC lectures and lecture material over three semesters in 2008 and 2009. There was a degree of overlap between groups surveyed in the first two semesters. (The students surveyed in the first semester were merged into a larger class in the second semester.) The third semester was an entirely different cohort of students.

The first survey was through a paper based questionnaire, issued on one occasion only and completed in class. The results from this survey were used to inform an electronic questionnaire. This was used in the second and third semesters and was posted on the website where lecture material was accessed by students. It was set up so that students could not access the tablet PC produced resources on the website in the last week of classes without first completing the questionnaire.

The principal intention of the questionnaires was to assess how students experienced the technology both in the class and through the resources it generates. They were furthermore designed to gauge whether or not there was an effect on class attendance and student note taking.

The paper and electronic questionnaires both polled the frequency with which students downloaded the tablet PC generated resources. The paper questionnaire then probed why and how the students used these resources and finished with three open questions asking for opinions on why they had or had not enjoyed the tablet PC being used. Responses from the paper questionnaire guided the posing of 10 questions in the electronic questionnaire, answered on a five point Likert scale, about how the students used the tablet PC resources as well as their attitudes to note taking and class attendance. There were a further 10 open questions canvassing students’ opinions on the technology and how they experienced it.

Apart from using the paper based survey to “fine tune” the second questionnaire, the intention was also to see if there was any marked difference between students who were actually present in class and those who accessed the electronic resources but were not necessarily attending lectures.

The sample sizes for the three surveys were n = 71, 136 and 44 respectively (due to the different class sizes). Unless stated otherwise, the figures below summarise responses from the two electronic surveys. These are combined as there was no discernable difference in the response patterns between the two groups.

For the rest of this section we address some of the universal concerns and misgivings about the use of tablet PCs by reflecting on students’ questionnaire responses. We finish with some observations on how the resources are used.

3.1 Students will stop coming to class!

The first response from colleagues when they are told of the posting of lecture notes and lecture screencasts on the web is that students will stop coming to class. This is a valid concern as there is a well established link between student performance and class attendance (Van Schalkwyk, Menkveld, & Ruiters, 2010).
The author’s point of departure is that it is the lecturer’s responsibility to make class attendance worthwhile for students. Class based learning revolves around the relationship between the lecturer and students (Massingham & Herrington, 2006). Lecturing with a tablet PC can in fact increase the sense of identity that students have with the class and their lecturer. There is more intimacy and eye contact between students and lecturer as attention is more focused and the lecturer is always facing the class. (This as opposed to a “traditional” mathematics classroom where the lecturer spends a lot of time with his/her back to the students while writing on a board.) Moreover, the notes and screencasts are very tangibly associated with the lecturer and provide both an extension of and a reproduction of the in-class experience. This all serves to engender a sense of belonging which is crucial for undergraduate learning and encourages class attendance.

In the author’s experience over a number of years of lecturing, there is no discernable difference in class attendance when electronic lecture material is made available or not. Students’ admissions to their class attendance are shown in Figure 1. (Note that these are responses to an online questionnaire so if anything are biased towards those who might follow the course but do not attend class.) This experience is echoed in similar circumstances in (Biswas, 2007) as well as in (Loch, 2010).

Numerous student comments were received about the value of the tablet PC in fostering a classroom atmosphere and a sense of belonging:

- I think the tablet PC in class is so cool, it makes you feel like you belong in that room and what’s GREAT is that he's talking to us.
- The tablet PC allows the lecturer to view the class when he/she is explaining, thus engaging the class more effectively.
- The tablet PC is a very good thing. It makes lectures more personal. It doesn't feel like [the lecturer] only gives the math info, it feels like he is working with us and communicating the whole time.
- It makes class quite enjoyable and you tend to learn more when a class is fun.
- I like it because when you go over it at home it is exactly the same [as in the class].

There were some students with comments such as: [The screencasts] are very handy and provide some kind of back-up which is necessary to have for in case you missed class. They are helpful in many ways and don’t encourage one to miss class, although it makes you feel less guilty to think that you'll go through the lecture later, so it'll be o.k. to miss class and go have coffee.

For the great majority of students posting the electronic resources on the web did not compensate for attending lectures. As is borne out in section 4, the screencasts were mostly used to revisit lecture material and not to replace being in the lecture. There were some
students repeating the course who could not attend classes and they made up the bulk of those who followed the screencasts regularly. And then there was the occasional student who abused the resources: The PDF/Flash video is dangerous for idiots such as myself. I have not been to class in longer than 6 weeks because I believe I can cover up all the missed work by watching the classes and doing the tutorials.

3.2 If students don’t take notes they will disengage from the lecture material
The second immediate concern expressed by those who encounter the modus operandi of teaching with a tablet PC and then distributing the lecture notes is that students will become “lazy” and engage less actively with the course material. This is linked to the concern of them missing class, but extends to the fear that students will pay less attention in class, secure in the knowledge that they can “catch up” later. Furthermore the very activity of note-taking is presumed to be beneficial for making sure that at least some of the work is assimilated and actually passes through the student’s mind during the lecture and note taking is itself a good skill to develop (Makany, Kemp, & Dror, 2009).

Clearly a significant proportion of students choose to take no notes in class. A similar proportion choose to still take comprehensive notes in class while others walk a middle road taking outline notes which are then supplemented by the lecture notes which are available afterwards. Exactly half of the survey respondents agreed with the statement that they “take notes in class and then use the PDF notes to check and supplement these notes”. These findings correlate with the observations of note taking recorded in (Biswas, 2007) and (McCann, 2008).

Opinion was spread across all respondents regarding the statement: “Taking your own notes in class is an important part of learning. To only download the notes and not take your own notes means you understand less and become lazy.” 49% indicated that they (strongly) agreed with the statement while 30% (strongly) disagreed.

Over 80% of the students (strongly) agreed that “Having all the class notes online helps me to organise my own notes more effectively.” Inferring from their open ended comments, this was in part because of the availability of the complete class notes and in part simply because the class notes were posted on the web in an organized fashion – arranged by date with a short descriptive title for each lecture.

One of the points which came
across most strikingly in the initial paper based survey was that students found that the “safety net” of being able to access the class notes after the lecture removed the stress associated with note taking, allowing them to concentrate more fully on the material and explanations during the lecture. As one student put it, “It is structured really well. I know I will have the notes available after class. I do not have to stress about making perfect notes during class.” This was echoed when polled in the online surveys.

The combination of the lecturer facing the class and students being less engrossed in taking notes facilitates more of a dialogue in the classroom. That said the author maintains some ambivalence regarding the lack of note taking by students and regularly exhorts students to take their own notes too. This dilemma is well summed up in one student’s comment: “Personally I agree with the fact that you need to take your own notes in class in order to prevent becoming lazy or not thinking for yourself, however, when I do take notes in class I find that I don’t really take in nearly as much as when I just sit and concentrate on the lecture without taking notes. Rather than to sit and try to scribble everything down as the lecturer goes on, I’d rather just listen and try to understand the work.”

The most common reasons given for appreciating the lecture notes are summarized in Figure 4.

A similarly posed question surveying the negative aspects of the availability of PDF lecture notes returned very little response, although 30% of the students expressed concern that the practice could encourage laziness and the missing of classes.

3.3 My lectures will become static
Another fear expressed by those considering using a tablet PC for teaching is that they will be severely curtailed in their movement in the classroom. In particular those who lecture with the help of a blackboard (as the majority of mathematicians would still do) do not relish losing the aspect of theatre that comes with large gestures and walking around in front of a class. An experienced lecturer can use this to good effect and there is no doubt that some of this is lost when teaching with a tablet PC. Not only are gestures small, they tend to be directed to the tablet itself, but if you are recording the lecture then proximity to the tablet is usually necessary.

A tablet is not as restraining as some may fear, and a good microphone can help in freeing you from its clutches. None-the-less there is certainly less movement and the lecturer does need to be aware of how the class’s attention is held.
What surprised the author most about using a tablet PC, however, was that while the students enjoyed the resources it put at their disposal it was the classroom experience that they valued most. There was universal opinion amongst the students surveyed that classes presented with a tablet PC were more engaging than those presented on the blackboard.

As commented earlier, the simple fact that the lecturer faces the class while teaching goes a long way to strengthen communication and hold attention in the class. As the excerpts below testify, there are a number of aspects (some seemingly trivial) which add to the richness and effectiveness of a tablet delivered lecture.

- Yes, it works well, because he's looking at the class while writing & explaining (not talking to the blackboard & can see when somebody has a question). Use of colours makes everything explained a lot clearer.
- The use of different colours is very helpful. It is easier to read, neater and the lecturer can go back to past notes.
- I like it because it is easy to read off and it allows the lecturer to use colour and plotted graphs which help with the understanding process.
- It is more interactive and different to the usual blackboard. It's easier to see; it's enlarged, and isn't constricted by being on a small area.
- The professor can face the class when writing on the tablet, he can use Maple to draw graphs and it is more structured than most lecturers who scribble all over the blackboard.
- AWESOME!!!! Really good idea - Colours help understand the work - the fact that we can easily go back and look at previous lectures is a big plus... and of course the fact that we can bring maple images into the notes
- I prefer the use of the Tablet. It is clearer to see and there is a greater variety of technology available to demonstrate concepts.
- It is very good, much easier to follow what is going on because the work is written out neater but still looks like lecture notes. It is also great to be able to quickly paste in examples that would be time consuming to draw correctly on the board. The class feels more interactive and is more in line with technology that our generation has grown up with.
- The tablet PC is awesome because the different colours and sketches help a lot and also other details such as graphs being drawn with computer programmes and thus looking more professional. I understand the work better.

In the author’s experience, far from restraining the lecturer a tablet PC opens up a rich array of opportunities to improve the classroom experience and also challenges one to diversify your lectures and your use of teaching resources.

There is a growing array of software packages for tablet PCs available to assist in lecture delivery. A selection of these can be read about in (University of Washington), (Olivier, 2005), (McCann, 2008) and (Bonnington, Oates, Parnell, Paterson, & Stratton, 2007).

3.4 How do students use the electronic resources?

The principal motivation for the author to begin teaching with a tablet PC was the obvious suitability of using a tablet in the mathematics classroom combined with the additional electronic resources that could be generated, hopefully to the students’ benefit. Exactly how do students make use of these resources?
The graph in Figure 5 summarises responses in the online surveys and is thus slightly biased towards students who do indeed download the electronic material. In the paper based survey 23% of students downloaded less than a quarter of the PDF notes. On the other hand in the third semester, as students became familiar with the technology, 67% of the respondents had downloaded more than three quarters of the PDF notes.

Use of the screencasts was more stable across the surveys and clearly less common. As can be seen in Figure 6 there were two patterns amongst those who viewed the lecture screencasts. A smaller group of students made regular use of them while the majority accessed them only if the need to review a lecture or part thereof arose. (This interpretation is based on written comments in the survey.)

Downloading of the class notes is clearly a supplement to or replacement of students’ own class notes. There was more variation in the use of screencasts. The majority of those who regularly watched entire lectures appeared to be repeating students with timetable clashes who were highly motivated to pass the module this time round. More intermittent use was made by those who missed the occasional class or wanted to review a particular section of a day’s lecture. (45% of respondents said that they had watched at least one full length screencast during the semester, but it was considerably more common to watch excerpts.)

- I’m redoing maths. Because of class clashes, it’s not possible to attend most of the classes. This allows me to catch up effectively and quickly rewind if I miss something.
- If I do not understand a certain step in the notes I normally go back to the video and fast forward to that step.
- I use them to understand things I didn't get the first time and if I need to go back to a certain topic that I don’t remember that well, it’s easier to go to it and listen to it. The audio and visual effects help more than a normal textbook.
- If I don’t understand something I can pause and think about it.
- Sometimes it's better to listen to something again and hearing the lecturer say it instead of trying to figuring it out on your own.

There were many students who saw no need to use the screencasts and inevitably those who abused them:

- I do not really use them as the PDF files are sufficient.
- Don't really use the video's much - but I know of people that stay at home during maths and watch the videos instead. They are passing well, so I still think it's a good thing

Some students clearly use the screencasts actively in their learning.

- I find it a very effective learning tool, especially when I don't take notes in class but only print out the PDF files, then when watching the flash movies I add my own notes to the printed PDF files which makes it very useful for studying.
The screencasts and PDF notes are more than just an information source. Because they are an exact replica of the lecture they are not added as another layer of course material but rather provide reinforcement and revision. Having the lecturer “on demand” clearly helped many students revisit and grapple with concepts and explanations that they could not assimilate completely while in the classroom. From the pedagogue’s perspective this use of the screencasts is most rewarding.

With hindsight, as mentioned in the previous section, the impact that the tablet has on the classroom alone is enough justification for its introduction. However it requires minimal effort to produce the PDF copies of lecture notes and Flash movies of the lecture screencasts and they undoubtedly add value to the course being taught.

4. **Is it a worthwhile technological intervention?**

The author’s experience of teaching with a tablet PC has been resoundingly positive. Not only has it been enjoyable, but it has forced him to reexamine his own teaching methods and style. Changing your mode of presentation as well as placing the product of your lectures in the public domain inevitably causes one to reflect more overtly on what you present to students and how this is done.

Students have been overwhelmingly positive in their response to the technology and it clearly adds a significant dimension to their learning. Whether this makes any difference to their actual performance in the mathematics course under discussion is very hard to measure. The number of other variables in an educational environment undergoing such constant change is too great to be able to attribute any change in performance to the tablet PC technology alone.

No single teaching method or technology is appropriate for every personality. Successful teaching with a tablet PC certainly requires a reasonable degree of confidence in working with the technology. It is crucial to be able to “think on your feet” in order to ensure that the technical manipulations remain in the background and do not interfere with the communication of the material being taught.

As has been mentioned elsewhere, the lecturer inevitably becomes more static when teaching behind a tablet PC. This then demands that other skills come to the fore in order to hold the class with you as you teach. A sense of humour, the use of voice, the ability to look the class
in the eye and hold their attention are crucial for any successful classroom interaction but they assume a heightened role when the lecturer is more static.

No technology should be introduced into the classroom simply for technology’s sake. Purely as a means of lecture delivery the tablet PC offers significant advantages. Add to this the resources that it enables you to put at the students’ disposal and it can revolutionise how you teach and the learning with which you enable your students to engage.

Acknowledgement: The author is grateful to the University of Stellenbosch’s Centre for Teaching and Learning for a grant through their Fund for Innovation and Research in Learning and Teaching as well as a two year Teaching Fellowship. These provided the funding and academic space with which to pursue this project.

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