Lessons Learned from the First-Time Use of Tablet PCs in the Classroom

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Abstract - **The tablet PC (TPC) is quickly becoming a widely used tool for engineering education. However, as with any new education initiative, care must be taken to introduce this properly. This paper will present the lessons learned from the experiences of two first-time TPC users in the Electrical and Computer Engineering Department at the University of Toronto. The courses were a second-year differential equations & linear algebra course, and a third-year electromagnetic waves course. To evaluate the effectiveness of the TPCs the same survey was given to both classes, with a total of 129 responses. Generally, these students strongly supported the use of the TPC, however, as this paper will show, caution must be exercised when incorporating the TPC into the classroom. This is evident by considering how the popularity of the TPC as a learning tool is correlated with the types of learners present in the class. In most of the literature dealing with TPCs, no such correlation is presented, but as the results of this survey show, it is an important relationship to consider. In this paper we will summarize our approach for using the TPC, present the results of the survey, and discuss some lessons learned.**

Index Terms - Tablet PC, Learning Styles, Engineering Education, Technology in the Classroom.

INTRODUCTION

Over the past few years, the tablet personal computer (TPC) has become a more common tool used in university and college education. This is in part due to the development of the core technology of both the hardware and software aspects of its operation. As well, this type of laptop has become more reasonably priced and is thus available to a broader range of instructors and students.

One of the great advantages of TPCs is that they allow the instructor to combine the advantages of a "PowerPoint-like" presentation with the interactivity of the standard blackboard approach [1]. The teaching of abstract concepts can be easily enhanced through the use of animations, Java applets, and complex graphics. However, the "Death by PowerPoint" problem can be avoided by engaging the students in a way which is not possible with normal laptops [2]. For example, this could be a discussion and subsequent annotation over a detailed figure or graphic, or working through an example problem as a class using the tablet as a traditional blackboard. Indeed, there has been a fair amount of research that has described various teaching techniques that the TPC enables, and the relative advantages and disadvantages of this approach [1],[3]-[9].

In much of the published research on TPCs, there has not been any consideration for how the use of the TPC affects the various types of learners which are present in the class. Most papers are focused on techniques and the general effectiveness of these techniques [3]-[9]. It is the purpose of this paper to present the results of how effective the TPC was as a teaching tool for two first-time TPC users, and correlate these results with the types of learners present in the lectures.

STUDY BACKGROUND

This study is based on the results of student surveys which were taken in two one-semester undergraduate courses in the Electrical and Computer Engineering Department at the University of Toronto. For both instructors it was their first experience with using the TPC, so the study provided some invaluable feedback for how the use of the TPC was received by the students. The course taught by Micah Stickel was a second-year math course in differential equations and linear algebra. Meanwhile, Sean Hum taught a third-year course on electromagnetic fields and waves, which covers transmission-line theory and basic electromagnetic wave theory. In both cases, PowerPoint was used to deliver the lectures, with animations, figures, and videos incorporated into the presentations. In the lectures approximately 50% of the material was annotated over the PowerPoint slides, including almost all of the example problems.

Both courses dealt with a number of abstract concepts which are difficult to teach using classical methods. Therefore, these courses seemed particularly well-suited to the use of the TPC. The main reasons for adopting the TPC as the primary teaching vehicle were to:

- **Incorporate animations and complex graphics into the lectures**: For both of these courses, the discussion of the main ideas can be greatly enhanced through the use of multimedia elements. For example, animations of the fields and voltages along a transmission line, can clearly show how incident and reflected waves interact. As well, it is relatively easy to create and include very detailed pictures of mathematical functions, which can make concepts such as slope fields, stability, and bifurcation a reality for the students.

- **Clearly organize the material for the students**: In both courses, a skeleton version of the PowerPoint lecture notes was provided to the students before each lecture. This enabled the instructors to carefully organize the material and provide a summary of key points for each lecture. At the end of the term, these key points were combined into one file, and given to the students as a study guide for the final exam.

- **Make note taking easier**: The skeleton lecture notes, enabled the students to pay more attention to what the instructor was saying, rather than focus solely on writing down every word. At the same time, the skeleton notes were designed such that the students still had to write down the most important pieces of information and most examples were worked through in the class on the tablet, reinforcing the well-known learning process associated with note taking.

- **Simplify the delivery of large amounts of information**: The use of the tablet also allowed large pieces of information to be included in the skeleton notes, which saved time on having to write these things out on the board. Important figures, tables, theorems, and equations were primarily given to the students in their notes, so this provided more time to discuss these items. As well, the extra time was used to go through more concrete examples which helped to clarify the main ideas.

SURVEY RESULTS

About two-thirds of the way through the term both instructors asked the students in their classes to fill out the same questionnaire, which asked them to assess the effectiveness of the TPC as a teaching tool through their answers to 12 questions. There was a total of 129 responses, with 40 coming from the third-year electromagnetic waves course, and 89 coming from the second-year mathematics course. The results presented below are for the entire group of 129 students. For most of the questions, there was not much variability between the results for each course, hence, only the results for the total group are given in this paper.

I. Learning Style

The first question asked the students to identify their preferred learning style. A brief description of the three main types of learning styles based on modality theory was given, and these were *visual* (learns best through seeing), *auditory* (learns best through hearing), and *kinesthetic* (learns best through doing). This is a simplified form of the Felder-Silverman model, which is commonly used in engineering education studies [10]. Although this is not a rigorous test of the students' learning styles, the authors felt that it was sufficient for the purposes of this quick survey. The students were allowed to select more than one style, if they felt that they learned best through multiple avenues. As is shown in Figure 1, 44% of the students identified themselves as visual learners, 28% of them thought they
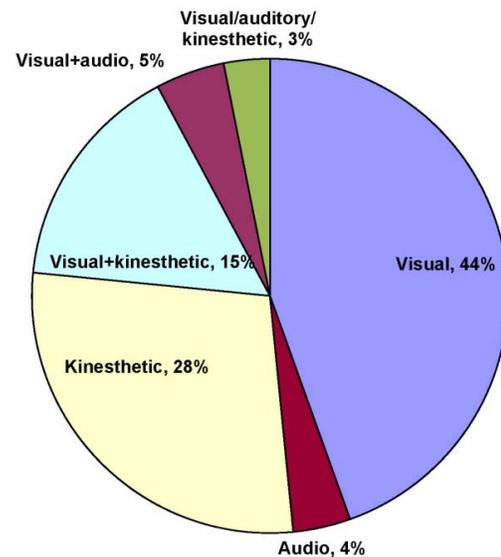

FIGURE 1
LEARNING STYLES OF THE STUDENTS IN THE TWO COURSES

were kinesthetic learners, and 15% considered themselves to learn best through both visual and kinesthetic means. The most important observation is that there is quite a range of learning styles within the classes. This means that in order to teach these students effectively, consideration of their different learning styles is critical.

II. Lecture Experience

The students were also asked a series of questions that dealt with their TPC lecture experience as it related to traditional blackboard-based lectures. The results for these questions are summarized in the first four rows of Table I. For each question they were given a scale of 1 to 5, with a short description of what the numbers meant. These short descriptions are also shown in Table I. The results for the different types of learning styles are given in addition to the results for the entire group. The maximum (bold) and minimum (italic) results for each question are also highlighted. The standard deviations for the entire sample, σ, are also given in the table.

In looking at the total group, the results show that the tablet is generally quite well received by the students. The average of 4.33/5 for whether the lectures were more enjoyable, demonstrates that there is a definite interest in tablet-based lectures. This may be partly due to the novelty of it, but these students have had other classes with tablets, so it is not a completely new experience.

The use of multimedia items within the lectures also had a significant impact on the students (4.5/5), especially for the visual learners (4.63/5). The use of the tablet allows these extra visual aids to be incorporated into a lecture very easily. One can switch between a video or animation and a "blackboard" seamlessly. This enables the instructor to introduce the concepts within the course in a much more engaging manner. For example, a problem can be motivated from a real-world application which can be shown to the students directly. Or, the results of a problem can be

TABLE I
SURVEY RESULTS FOR QUESTIONS DEALING WITH LECTURE EXPERIENCES, LECTURE NOTES, AND THE OVERALL EXPERIENCE

Question	Visual (57 – 44%)	Kinesthetic (36 – 28%)	Visual/Kinesthetic (20 – 15%)	Total (129)
1) Does the use of the tablet make the lectures a more enjoyable experience? (5 – Much more enjoyable) (3 – No difference) (1 – Less enjoyable)	4.35	*4.2*	**4.59**	4.33 ($\sigma = 0.76$)
2) Do the additional visual aids (graphs, movies, animations, pictures, etc.) enable you to understand the material more clearly? (5 – Yes, they are very helpful) (3 – No difference) (1 – They are distracting)	**4.63**	*4.37*	4.53	4.5 ($\sigma = 0.71$)
3) Do you learn more from the lectures? (5 – Learn much more) (3 – No) (1 – Learn much less)	3.98	*3.71*	**4.12**	3.88 ($\sigma = 0.77$)
4) The pace of the tablet-based lectures is: (5 – Too fast) (3 – Just right) (1 – Too slow)	**3.37**	**3.37**	*3.12*	3.37 ($\sigma = 0.71$)
5) Is the balance between what is provided and what you have to write: (5 – Too much writing) (3 – Just right) (1 – Not enough writing)	**3.29**	*3.12*	3.18	3.22 ($\sigma = 0.63$)
6) Compared with notes from a blackboard-based lecture, when I use my tablet-based lecture notes for studying at home, the notes are: (5 – Very helpful) (1 – Not helpful at all)	3.88	*3.82*	**4.29**	3.87 ($\sigma = 0.97$)
7) Overall, my assessment of the tablet as an effective teaching tool is: (5 – Very effective) (1 – Not effective at all)	4.3	*4.19*	**4.41**	4.27 ($\sigma = 0.67$)

analyzed and discussed in a visual way that is not possible with a standard blackboard lecture.

In the first three questions that relate to the lecture experience, it can be seen that the kinesthetic learners have the least positive reaction to the use of the TPC. This trend was observed for the other questions on the survey and, therefore this must be considered when the TPC is used in the classroom.

The last question that relates to the lecture experience deals with the overall pacing of the lectures. Since a lot of the fundamental material can be given to the students before the lectures, there is the opportunity to cover the material in greater detail. This has the potential to overwhelm the students, but as these results show the students felt the pacing was quite reasonable.

III. Lecture Notes

The fifth and sixth rows of Table I summarize the results of the questions that relate to the use of skeleton notes for tablet-based lectures. On the whole, the students felt that there was a good balance between the material that was given to them in the skeleton notes, and what they had to write down during the lectures. As might be expected, the kinesthetic learners seemed to have the greatest appreciation for the required note taking, while the visual learners would have preferred a bit less writing.
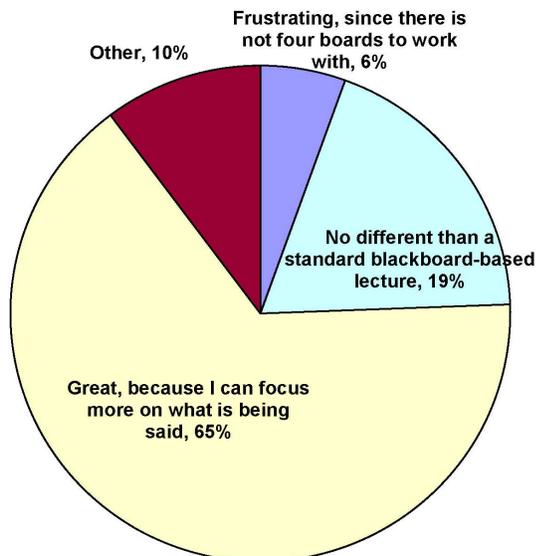
FIGURE 2
HOW THE STUDENTS FELT ABOUT NOTE TAKING IN A
TPC-BASED LECTURE

As aids for the students' work at home, the skeleton-note approach seemed to work well. The students of all learning types rated this type of note taking as being better than their blackboard-based lecture notes for studying at home.

The students were also asked to respond to the following statement, "*Taking notes in a tablet-based lecture with the posted lecture outlines is: …*". They were given four options, and these options and the results are shown in Figure 2. The large majority of the students (65%) appreciated the fact that the reduced amount of note taking allowed them to pay more attention to the instructor. However, there was a significant number (19%) that didn't find this note-taking approach particularly helpful during the lecture. Also, some of the students (6%), were bothered by the fact that with a TPC-based lecture, only one "board" can be seen at a time. In most classrooms, the actual blackboard has at least four panels, which can be referred back to by the students and the instructor if needed. Recently, it has been shown that this board layout can improve the overall retention of the material presented in a lecture [11]. This is because the potentially larger field of view of the blackboard enables the students to re-read the covered material with a glance, which is important to the cognitive processes of how students understand new material. This is one of the significant drawbacks of the use of the tablet in the classroom. However, in some larger classrooms, the field of view of the blackboard is not sufficient, and in those cases the projection of the TPC's workspace can be the preferred means of presentation.

When the results of this question are correlated with the learning styles a couple of interesting observations can be made. First, all the students who found this approach "Frustrating" were visual learners, indicating that they really appreciated being able to see the all the blackboard panels at

once. On the other hand, a higher percentage of the kinesthetic (74%) and visual/kinesthetic (82%) learners both found this approach "great".

Since 10% of the students surveyed selected "Other" for this question, it is important to look at some of their "Other" comments. A representative sample is:
"*I don't use them, I absorb more if I write everything*"
"*Sometimes I forget to bring the lecture outline which can be problematic at times.*"
"*I rarely take notes, I think listening is better than writing things down.*"
"*I don't use the outline…saves paper.*"
"*Sometimes a little fast, because there is a lot to read.*"

IV. Overall Experience

There were three questions that were asked that related to the students' overall perception of the TPC use in the classroom. The first question asked the students to complete the statement, "*For the lectures, I prefer:*". The four possible responses and results are shown in Figure 3. It can be seen that the use of the tablet is supported by the vast majority of the students, but nearly half of them would prefer some use of the blackboard. As well, the majority of kinesthetic learners (57%) would prefer the combined approach, while only 43% of visual learners have this preference. This difference highlights the fact that it is very important to consider that every class has a range of learning styles, and that each style needs to be supported.

The students were also asked to assess the use of the tablet technology, by responding to the statement, "*The technology of the tablet…,*", with Figure 4 showing the results and the possible answers. These results for the entire student group were relatively close to those for the individual learning styles, with the majority stating that the tablet is a great benefit to their learning.
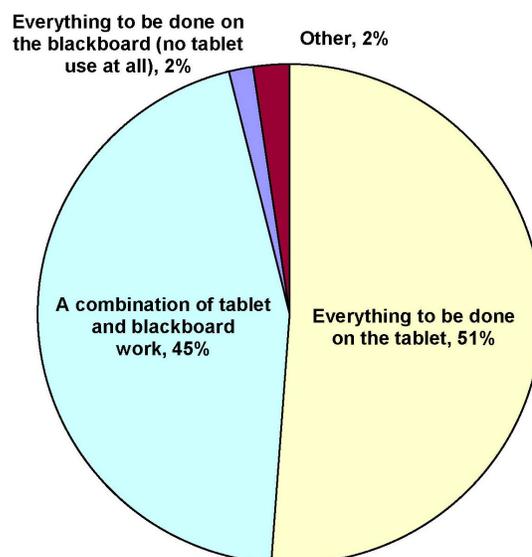

FIGURE 3
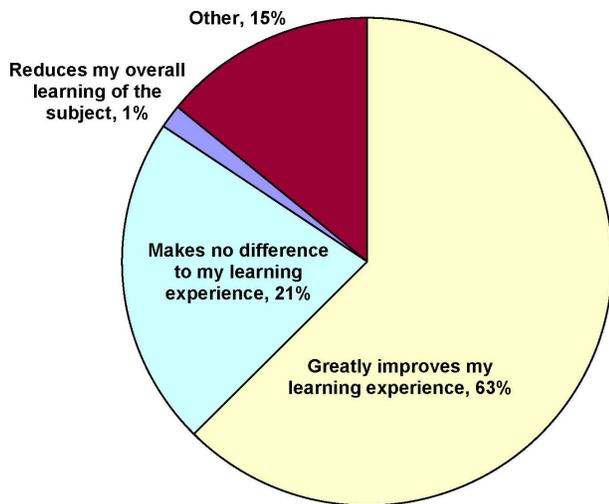THE STUDENTS' PREFERENCE FOR HOW LECTURES SHOULD
BE PRESENTED

FIGURE 4
How the Students Rated the Use of the Tablet Technology

Again, for this question a large percentage of the students (15%), selected "Other", and some of their comments were:

"*It really depends on the professor.*"
"*Moderately improves my learning experience.*"
"*Less frustrating and easy to concentrate.*"
"*Improves my learning experience a little.*"
"*It just makes the lectures 'cleaner and smoother'.*"

The last question on the survey asked the students to give an overall assessment of the tablet as an effective teaching tool. These results of this question are shown in the last row of Table I, and it can be seen that many students found the TPC use quite effective. Again, the kinesthetic learners are slightly less enthusiastic about the use the TPC than the entire group of students in these classes.

STUDENT COMMENTS

As part of the survey, the students were also given the option to provide their own comments about the use of the TPC. Some of the comments that were made by the students in the second-year math course are presented in Table II. Almost all of the comments that were related to the TPC approach are included in this Table. The only comments that are not presented there are ones that essentially repeated the comments shown in this table.

In reviewing these comments, a number of key themes can be observed. First, the students seem to appreciate the ability of the tablet to incorporate added visual aids into the lectures, which aids their understanding of difficult or new concepts. Second, for a large class such as this one (100 students), the projection of the tablet's workspace onto a large screen makes the text more visible than the standard blackboard. However, as was mentioned above and reiterated by a student's comment, the use of only one "blackboard panel" can negatively impact the student's lecture experience. Third, the use of the skeleton notes

allows some students to pay more attention to what the instructor is saying. However, as a few students pointed out, it is important to not assume that all students are using the skeletons. Some students prefer to completely write their own set of notes, which can impact how quickly the notes can be worked through in the lectures. Fourth, some students find that TPC-based lectures can be too information intensive.

TABLE II
STUDENT COMMENTS FROM SECOND YEAR MATH COURSE SURVEY

Comment	Learning Type
"The tablet is awesome."	Visual
"Except for a little bit more writing of obvious material which should be present in the slides, the tablet experience is much better and likeable."	Visual
"With the tablet, I can focus more on what the professor says."	Visual
"As a visual learner, this way will always be better for me compared to other "normal" lectures. I have 5 classes, this one feels the most comfortable to me 'note-wise' and I think the amount of work the professor puts into the slides is why every other class's professor doesn't do it."	Visual
"The tablet is a good visual aid that helps me out visually, but the writing is still too much."	Visual
"I don't think it should be assumed that we print the online notes."	Visual
"This is a very good step taken. The best thing is one can make notes easily and concentrate more."	Visual
"Compared to the blackboard, when slides move on it's hard to pick up what is taught before the slides. Also, its harder to add more info on the slide when self study at home after lecture."	Visual/Kinesthetic
"It's very easy to read written examples in the powerpoint versus the blackboard. Lecture outlines/headings/organization make it easier to know where we are in the course and what material has been learned."	Visual/Kinesthetic
"Sometimes the tablet provides too much information. It would be better if we focused more on key points and examples."	Visual/Kinesthetic
"The tablet really helps me understand the lecture. Anyway, some concepts, abstract ones, if can be done by animations that would be perfect."	Visual/Kinesthetic
"Don't use skeletons, I absorb more if I write everything."	Kinesthetic
"It makes the concepts seem easy."	Kinesthetic
"The use of the system is effective when trying to understand the new or more difficult concepts that are visually clumsily drawn with chalk."	Kinesthetic
"I think the most important thing is that the professor uses the tablet effectively, not the tablet itself."	Kinesthetic
"I would argue the tablet is a very effective teach tool, but has not been optimized yet!"	Kinesthetic
"Is MUCH easier to read than the blackboard, and makes lectures move at a faster pace."	Auditory
"It is a very effective way of learning but access of it will stick us more to the computer rather than our own work."	Visual/Auditory/ Kinesthetic

LESSONS LEARNED

From these survey results and student comments as well as the instructors' experiences, a few important lessons can be gleaned:

- **The Tablet PC must be effectively used, rather than exclusively used.** A surprising result of the survey was that almost half the class (45%) preferred that the lectures involve both tablet and blackboard work. For kinesthetic learners, more than half of that group (57%) had this preference. This indicates that although the tablet has great benefits, it has to be used cautiously to effectively teach all the students within the class. Both authors have found that the tablet is a bit restrictive and therefore tried to incorporate some board work as well. At times, the ability to use four or more panels can provide for a more spontaneous and interactive discussion of the material.

- **The use of skeleton notes can be beneficial, but should be a very brief outline of the lecture material.** For two-thirds of the class (65%), the skeleton notes are quite useful, and allow the students to pay closer attention to what the instructor is saying and participate in the class discussions. However, as a number of comments indicate, they are not used by everybody so this must be considered in the lecture presentations. As well, it has been observed in class that a relatively large portion of students ($\approx$15%) don't take notes at all. They may feel that the skeleton notes are good enough, yet this can be a dangerous trap to fall into. In the end they leave the lecture with very little to study from later on. If skeleton notes are used, they should be a very brief outline of the lecture, and only include the most critical points, any complex graphics, and large pieces of information (formulas, theorems, etc.).

- **It takes a dedicated effort to "tabletize" your lecture material.** The main advantage of the tablet is that it opens up new possibilities in how to teach difficult concepts. The students' interest can be engaged and re-stimulated throughout the lecture by changing the mode of information presentation (text, graphics, animations, web sites, applets, etc.). However, it takes a great deal of time and effort to take existing lecture notes and convert them for use on a TPC. As has been noted by many of the student comments, the effectiveness of the technology of the TPC "depends on the professor".

CONCLUSIONS

Through the authors' first time use of the TPC in the classroom, much has been learned about the advantages and disadvantages of the TPC as an effective teaching tool. The overall response from the students to the use of the TPC was very positive, with 63% of the students saying that it "greatly improved their learning experience". They appreciated the additional visual aids and the larger projected display, which was generally easier to read than the blackboard. The majority of the students also liked the use of the skeleton notes (65%), which allowed them to listen to the instructor more closely. However, when the results are correlated with the learning styles of the students in the classes it can be seen that not all students have the same appreciation for the TPC. The kinesthetic learners, which comprised 28% of the entire student group, had the least positive scores for how they rated the use of the TPC. This shows that in using the TPC in the classroom, it is very important to consider how to use the advantages of the TPC to the benefit of the entire spectrum of learning styles present within the class. The TPC clearly opens up a whole new set of possibilities to teach effectively, nevertheless, one must still devote a lot of time and effort to prepare novel and engaging lectures using this technology.

ACKNOWLEDGMENT

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