

# Using a Tablet PC for Classroom Instruction

Carol C. W. Hulls

Dept of Electrical and Computer Engineering, University of Waterloo,  
Waterloo, ON N2L 3G1 Canada chulls@uwaterloo.ca

**Abstract** - An increasing trend for lecture-based courses is for instructors to convert their lecture notes to slides that can be projected electronically. While there are many advantages to electronic projection, a large drawback is the loss of interactivity and spontaneity that can result. The use of a Tablet PC by the instructor promises to overcome this difficulty. The Tablet PC, combined with appropriate software, enables the instructor to “write and draw” using digital ink. This allows the instructor to provide colour attentional marks, annotations and drawings as the lecture progresses. Examples of the use of digitally inked slides for classroom teaching are given. While a basic study of the impact on using the Tablet PC as the primary method of instruction does not show a noticeable difference in effectiveness over using other methods, both instructor and student responses to the use of the Tablet PC were favorable.

**Index Terms** – classroom instruction, presentation software, Tablet PCs, PowerPoint slides

## INTRODUCTION

Electronic projection, or e-projection, usually in the form of Power Point slides that are shown to students while the instructor discusses the material on the slides, is becoming an increasingly common method for instructors to present lecture material. However, this approach can potentially lead to ineffective classroom teaching. In his article on teaching with technology, Young [1] quotes a student who refers to “Power Point abuse”, when an instructor puts complete sentences on a slide and then proceeds to read the slide. The evidence of a backlash against using technology in the classroom can be seen in the increase in articles complaining about the use of electronic projection for teaching, where a typical comment is, “Power Point leads to lazy teachers, lazy students and not much learning” [2]. Felder and Brent give an anecdote in their “Random Thoughts...” column [3] describing a colleague’s frustration with using overhead slides for classroom teaching, and extend this to the use of Power Point slides by instructors. They state that most classes that are simply slide shows appear to be ineffective. In response to this problem, some, like Felder and Brent’s colleague, have decided to primarily use blackboard and chalk for lectures. Others have focused on making their Power Point slides more effective. Antonacci [4] has presented examples of how to develop effective slides for teaching based on Gagné’s [5] instructional theory.

The use of a Tablet PC provides another option for instruction beyond the above approaches. The Tablet PC provides a pen or stylus that can be used to write and draw on

the laptop screen using digital ink. Digital ink is available in a variety of colours, and it can be easily moved or erased. Figure 1 shows how digital ink can be used with a Tablet PC. The ink is shown in black and white for printing in this paper, but in practice a full palette of colours is available. The use of digital ink enables an instructor to overcome many of the disadvantages inherent in teaching with e-projection, while retaining the advantages over more traditional methods of overhead slides or chalk on a blackboard. Ward and Tatsukawa [6] provide an overview of the use of digital ink as part of their discussion on software for taking notes in the classroom. They found that a Tablet PC can be used to provide a natural way to write and draw electronically.

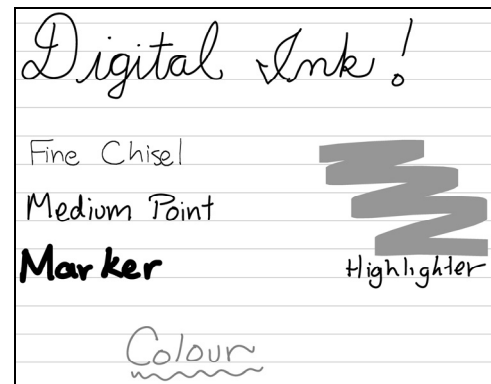


FIGURE 1  
DIGITAL INK DRAWN ON A TABLET PC

This paper presents a discussion on using a Tablet PC in the classroom based on the experience gained while teaching undergraduate courses in electrical and computer engineering at the University of Waterloo. First, a general discussion of some of the advantages and disadvantages of each method of instruction, blackboard and chalk, overhead slides, e-projection of slides, and e-projection combined with digital ink, is presented. Then details of how a Tablet PC and digital ink can be used for teaching in the classroom are given. This includes a discussion of the desired capabilities of digital ink-enabled software when using a Tablet PC in the classroom. Finally, a discussion on the effectiveness of teaching with a Tablet PC is presented.

## METHODS OF INSTRUCTION

### I. Chalk and Blackboard

Chalk and a blackboard have provided an effective means of instruction for millennia. The simplicity of this approach allows for a robust and inexpensive method of presenting

material. Unless the instructor forgets to bring spare chalk on a day when their chalk has “disappeared”, there is little potential for technical difficulties. In addition, the use of chalk can impose a reasonable pacing on the instructor, and learners are able to see the progressive development of the material. It is easy for a learner to see where his or her attention should be focused. The flow of the lecture is flexible and so it is straightforward for the instructor to maintain interactivity with learners in the classroom.

However, there are several disadvantages with chalk, the most notable of which is its limitations in terms of the difficulty inherent in presenting complexity. Felder and Brent [3] agree that for pictures and schematics that are too difficult or complex to draw on the board, the use of slides, whether overhead or e-projected, is a suitable approach. It is challenging and time consuming to generate complex circuit diagrams or to provide syntactically correct code down to the last semicolon using chalk and blackboard. Figure 2 shows a typical slide from a third year course on microprocessor systems and interfacing that is taught to third year computer and mechatronics engineering students at the University of Waterloo. Attempting to correctly draw the relative timing between the three square waves can be quite challenging without the aid of grid lines. There is also a great possibility for error as the student, who may only have a partial understanding of the material at that time and so may not see the importance of some subtle details, must correctly copy the diagram from the board into his or her notes.

instructor using chalk and blackboard is unable to save his or her presentation for review later when setting assignments and exams, and when updating or revising a course for future offerings.

II. Overhead Transparencies

With the above disadvantages, many instructors have preferred to use overhead transparencies. The course material can be attractively and legibly formatted, with students having access to the material either as pre-printed course notes or as files on the course website. While there is an initial time commitment to format the slides, this effort can be shared among instructors and the result used during course offerings in other years. The slide in Figure 2, shown above, was initially drawn for use with overhead transparencies, and has been used for several years.

When using slides however, the instructor must exercise some care. When complete course notes are offered, students can become disengaged with the lecture, after all they already have the information, which can decrease the interactivity in the classroom and provides a temptation to stop attending class. To avoid these two problems, a common approach is to use partially completed notes, and the instructor will “fill in the blanks” during class either by presenting the missing information or calling on students to answer questions. This can involve completion of circuit diagrams, writing code (or pseudocode), or completing derivations. While markers on an overhead transparency provide the advantage of colour over chalk, it can be a nuisance to erase marker in the event of an error. Students could also be asked to work in small groups to complete the notes in order to increase the potential for active learning in the classroom [7]. To focus student attention, some instructors will use the technique of covering part of the transparencies with a paper, revealing the contents as the discussion progresses.

Most overhead transparencies are printed using black and white, and colour is only used sparingly due to cost. If the course material is updated frequently, as is often the case for engineering courses particularly in the electrical and computer engineering areas, new transparencies must be printed every year, which involves a monetary cost and an environmental cost. While there was a pilot project to provide a recycling program for overhead transparencies at the University of Waterloo, the program has not been successful enough to become viable.

III. Electronic Projection

Electronic projection, often in the form of showing Power Point slides, enables an instructor to easily provide interesting graphics, and information can be highlighted in colour. There is a monetary cost saving in terms of not printing slides, but this is offset by the cost of the projection equipment and infrastructure. Flexibility is increased as the instructor can supplement the presentation of slides with video, animations, and demonstrations of some of the tools students will be using in the lab. For example, in a programming course, the instructor can complete a program and then compile and run

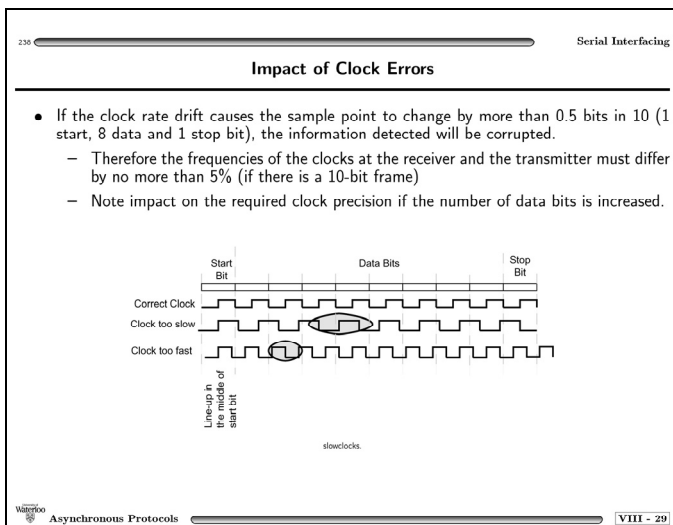


FIGURE 2  
A COMPLEX SLIDE THAT IS DIFFICULT TO DRAW FREEHAND

Other difficulties with chalk include limitations on the use of colour (although this is becoming less of an issue as some schools switch to markers and whiteboards), legibility in large classrooms, and that chalk can be messy to work with. In addition, while the flexibility of the medium to changes in the flow or content of material is advantageous in terms of interactivity, without care it can lead to large differences between material taught to different sections. Finally, while students will have their own copies of class notes, the

the program, demonstrating to the students both the program flow and the use of the programming development environment. It is straightforward to project a large image on the screen, which is necessary when teaching in a classroom with many students.

There are two main disadvantages with the use of e-projection. First, without proper training or experience, an instructor can encounter technical difficulties with the equipment. It is vital that timely support be available for training and to handle any contingencies that can occur [1]. The second disadvantage is a critical problem, which is the loss of interactivity. It is this problem that has prompted a backlash against the use of e-projection, and has resulted in the coining of the phrase “Death by Power Point” [3].

Antonacci [4] has presented examples of how to develop effective slides for teaching based on Gagné’s [5] instructional theory. To enable effective learning, the instructor should provide nine instructional events:

1. Gaining the learners’ attention
2. Presenting the objective
3. Recalling prior material
4. Presenting the stimulus of new material
5. Providing learning guidance
6. Obtaining responses from the learners
7. Providing reinforcement of material
8. Assessing the performance
9. Enhancing retention and transfer

By supporting each of these events, the instructor supports the long term recall and understanding of the course material. Antonacci then describes how these events can be incorporated when using Power Point slides.

Of the above instructional events, some, such as presenting the objective, recalling prior material, providing reinforcement of the material, and enhancing retention and transfer are fairly independent of the medium (blackboard or slides) used to convey the information. For example, to effectively present the objective, the instructor should explicitly state the learning goals for the particularly unit, which is usually presented as a series of point form points that can be written on the board or displayed on a slide. Thus, this paper will explore those events where the use of different media can have an impact.

Initially, gaining the learners’ attention can be achieved through the use of interesting visuals, or the abrupt stimulus change that can be provided by a high contrast slide. Focus can be maintained through the use of “builds” where successive points are revealed one-by-one. A typical sequence showing a “build” is given in Figure 3. Antonacci also uses builds, overlays where additional information is added to a diagram, and highlighting, while presenting new material, and providing guidance to learners as they are presented with new material. Problems are also worked out in this manner to obtain responses from the learners and to enable them to assess their mastery of the material.

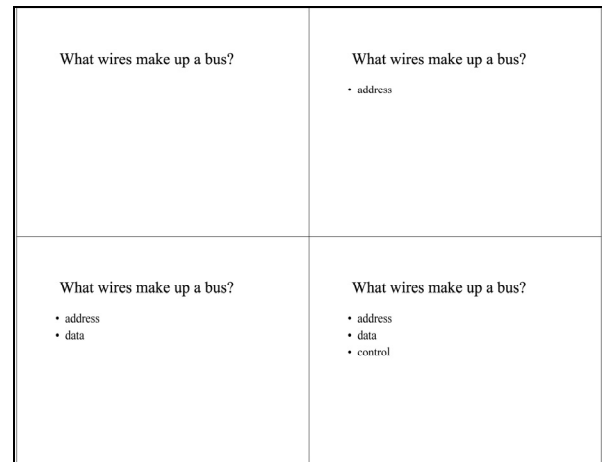


FIGURE 3  
A SEQUENCE OF SLIDES SHOWING “BUILDS”

While this approach can increase the effectiveness of teaching using e-projection, there is still the inherent limitation that the presentation format must be pre-determined before the lecture begins. The approach can also be time consuming as time must be spent on learning the presentation software tools and developing the “animation” required to present the material. Even for a well-crafted lecture, there tends to be a resulting loss of interactivity and spontaneity. The instructor cannot easily take suggestions from the class on ways to attack a problem, and it can be challenging to present clarifications on student questions without an additional blackboard or whiteboard that is visible in addition to the projection screen. While an instructor could attempt annotation of a slide using a mouse, in practice this is difficult to do [6]. Thus, it is difficult to effectively present new material, provide learning guidance, and obtain feedback from the learners, three key instructional events.

*IV. Electronic Projection and Digital Ink*

Use of a Tablet PC can combine the advantages of e-projection while addressing the issue of interaction and spontaneity. The Tablet PC provides a pen that can be used to write and draw on the laptop screen using digital ink. Thus, annotation or “filling in the blanks” of a slide can duplicate the experience of using a marker on an overhead slide. Ward and Tatsukawa [6] provide an overview of the use of digital ink as part of their discussion on software for taking notes in the classroom. They found that a Tablet PC can be used to provide a natural way to write and draw electronically. Thus, the instructor can return to the approach of presenting material by showing the derivation or design, and the provision of learning guidance can be learner driven rather than driven by the pre-determined script. Working out the answers to problems for feedback and assessment can also be handled interactively just as when working on the board. The next section provides examples of how the Tablet PC and digital ink can be used in the classroom.

In addition to the e-projection advantages of being able to integrate video, animations, and the use of software tools into the lecture, providing better visual presentation with colour

and the ability to project a large image, the Tablet PC also provides an excellent way to capture the lecture as it was presented. With most digital ink-enabled presentation software the digital ink can be saved. This provides the instructor an easy method for reviewing their slides. It also enables for an efficient method to transfer this information electronically to students and other course instructors. If the instructor chooses, the inked slides can be made available electronically to students through a website or electronic bulletin board. It is straightforward to print the files to a common file format such as PDF. This can be an advantage for students with disabilities, and can provide students with an opportunity to double-check their course notes as taken in class or have notes for classes missed due to illness. Care would need to be taken so as to not have a negative impact on course attendance however. During a term that the inked notes were made available, the students who downloaded the inked notes as logged by the system were the same students that regularly attended class. The one exception was a student who missed many lectures due to illness. In spite of this one good experience, most instructors would rightfully be cautious about providing the class notes. In addition to providing inked course notes, supplemental material involving diagrams can be quickly prepared and made available in responses to student email or electronic bulletin board questions.

USING THE TABLET PC IN THE CLASSROOM

I. Focusing Student Attention

An instructor can gain students' attention in a number of ways, including gestures, a change of voice, or through an interesting visual. A common gesture when teaching is to underline or circle a key point in order to highlight it. Figure 4 shows an example slide from a lecture where the instructor is easily able to accomplish this with the digital pen.

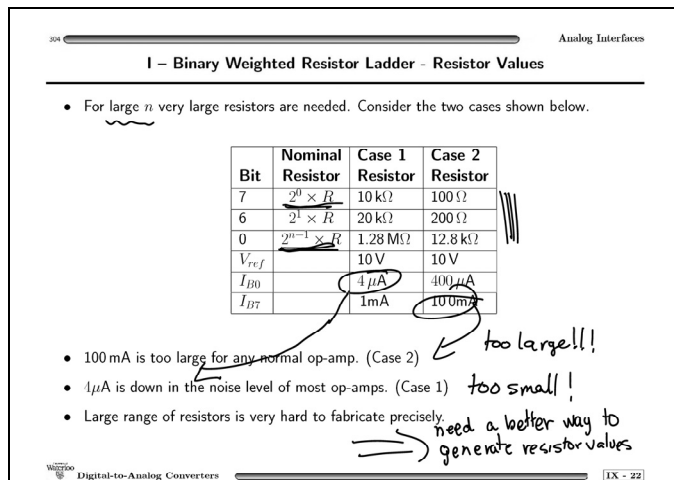


FIGURE 4 USING INK TO DRAW ATTENTION

The figure is shown with black ink for ease of printing this paper, although in practice a wide variety of colours including blue, green, violet and red can be used. Students

had pre-printed copies of the printed text. On this slide, to emphasize the drawback of needing a wide range of resistors, the instructor first drew the attention to the different resistor values by underlining them, and then led students to the implications by drawing the arrows. The point was further emphasized verbally, and by writing “too large!!!” on the slide.

II. Effective Presentation of Material

A common method of presenting material using e-projection is to use “builds”. A very simple example was shown above in Figure 3. However, there are limitations to this approach as the ordering of the information is fixed, and the information itself is pre-determined. The instructor, in effect, controls the presentation of information.

This is contrasted with Figure 5 which shows the result of presenting the material using digital ink. In this case, the instructor can actively engage the students in recalling previous material and developing linkages between it and the current material. The students provide the order of the points, and in response to questions, the instructor can provide review information both verbally and in writing. In this example, a student answer elaborated on the types of control lines, and another student asked about least significant and most significant bits when labeling bus wires. There is a marked difference in classroom interactivity between the two approaches.

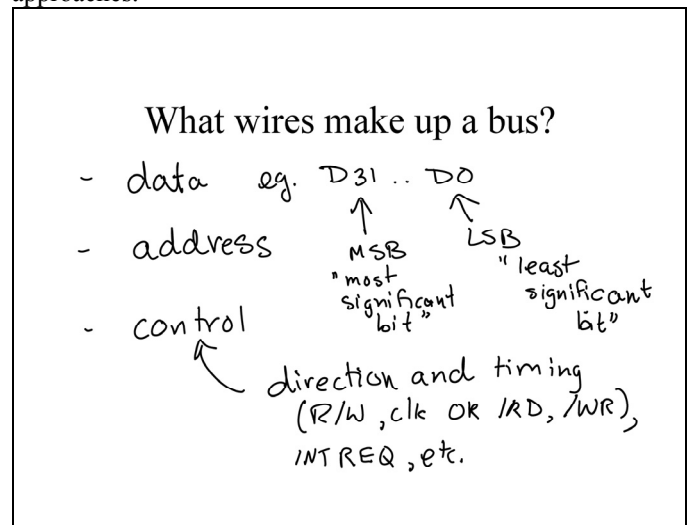


FIGURE 5 THE SAME SLIDE USING DIGITAL INK

Another example is shown in the contrast between Figures 6 and 7. The former figure was used when teaching using e-projection only, while the latter was drawn (originally in colour) during the corresponding lecture when given with a Tablet PC. In the former case, the instructor had to decide whether the effort to animate the generation of each bit in sequence was a worthwhile endeavor. Ultimately, the decision was “no” due to the time and effort required, and so the slide was presented as a static drawing as shown. The drawback is that the students do not see a clear picture of the operation of the ADC as each bit value is determined.

IV. Characteristics of Presentation Software

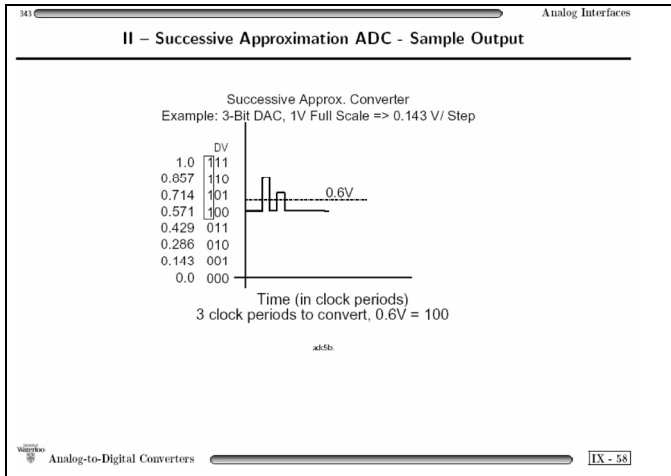


FIGURE 6  
AN E-PROJECTION FIGURE SHOWING ADC OPERATION

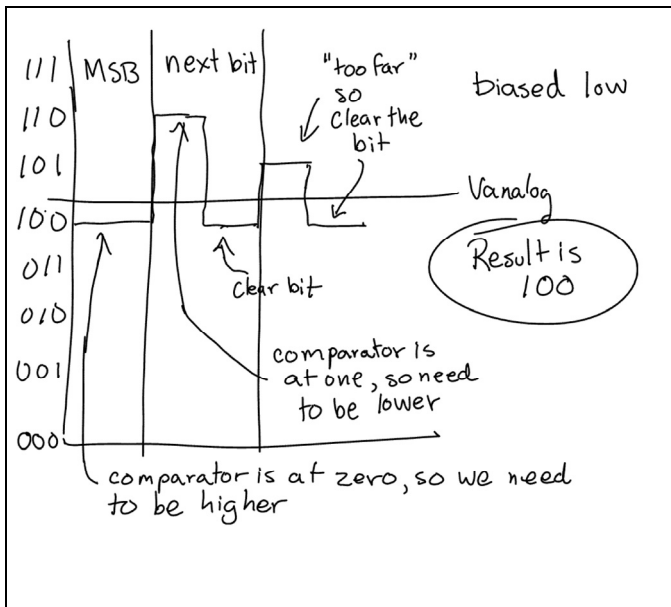


FIGURE 7  
A TABLET FIGURE SHOWING ADC OPERATION

In the latter case, the instructor inserted a blank page into the slide presentation and used the pen to draw the diagram step-by-step on the screen. The students could get a better idea how the circuit generating the signals operated as they drew their own diagrams as this one was presented. The presentation was followed by a second example that illustrated a point of clarification. The only area of concern is that as with overhead slides and chalk, the instructor must make an effort to write legibly. An interesting side effect however, of using digital ink is that some left-handers can write more legibly as they are no longer in danger of smudging the ink or chalk as they write.

Tablet PC software for classroom instruction should be easy to use, allow the easy switching of colours, provide clear digital ink, allow the ink to be easily erased, and provide the ability to save the ink. Other useful functions include the ability to insert blank pages and the provision of instructor previews.

At present, no software package provides all of this functionality. Potential software packages include Power Point, Windows Journal (which is the standard digital ink software provided with the Tablet PC), Adobe Acrobat, and Conference XP. A Tablet version of Acrobat is not available yet, but older versions can be used as the pen can act as a mouse. Conference XP is a Microsoft Research project that provides computer conferencing abilities including the ability to share ink between computers during the presentation. The presentation (and conferencing) software is presently available as a free download. In addition, other software packages for teaching such as Silicon Chalk are expected to become compatible with digital ink in the near future. Table I summarizes the key characteristics for each software package currently available.

TABLE I  
PRESENTATION SOFTWARE CHARACTERISTICS

Presentation Software	Ease of Use	Colour Switching	Clarity of Ink	Erasing	Saving Ink
Power Point	Good	Fair	Good	Poor	Yes
Windows Journal	Very Good	Very Good	Very Good	Very Good	Yes
Adobe Acrobat	Fair	Fair	Fair	Fair	Yes
Conference XP	Very Good	Very Good	Very Good	Good	No

Power Point and Adobe Acrobat are less suitable for classroom teaching primarily due to the extra effort involved in switching pen colours and erasing the ink. All packages except Adobe allow the easy insertion of an extra slide, while only Conference XP can be used to provide small instructor previews for the slides, but the version tested did have the large drawback that the ink could not be saved. Thus, at the present time, Windows Journal appears to be the most suitable presentation software for the presentation of lecture material.

TEACHING EFFECTIVENESS

Microprocessor systems and interfacing is a third year engineering course that is taught to computer engineering and mechatronics students. The course involves many complex diagrams showing circuits and their operation. Thus, the course was quickly converted to the use of overheads and later e-projection as each option became viable. The course sections have been almost exclusively taught by the same

instructors for several years prior to the results presented here, and each has been actively involved in preparing and editing the course notes. Thus, while there are many variables that cannot be controlled for, there is at least a minimal basis for comparison.

Near the end of term, students in each class section complete a survey on the characteristics of the instructor and the course. The method of course presentation has an impact on the following categories:

- Organization and clarity
- Responses to questions
- Visual presentation
- Quality of teaching

Table II shows the average 'mark' assigned out of 100 for each of these categories during the four years of interest for Instructor 1.

TABLE II  
STUDENT SURVEY RESPONSES – INSTRUCTOR 1

Year	Method of Instruction	Clarity	Questions	Visual	Quality
2002	overheads	92	82	81	80
2003	eprojection	90	85	81	80
2004	Tablet PC	98	96	95	94
2005	Tablet PC	96	92	90	83

For Instructor 1, comparing overhead usage to e-projection alone, the numbers show a slight drop in the organization and clarity, and a slight increase in the responses to questions. In the e-projection case, the instructor had to present significantly more material on the board to provide explanations and in response to questions. The visual presentation and quality of teaching was found to be the same. The instructor found the use of e-projection alone to be more challenging due to the loss of interactivity, and decided that e-projection alone was not a suitable teaching tool for this course. There is a noticeable improvement during the first year of using the Tablet PC for Instructor 1, but it is difficult to draw a definitive conclusion as the trend is not as noticeable during the second year of usage. As the 2004 offering was the second course taught using a Tablet PC by the instructor, the initial excitement as using the Tablet can be assumed to have passed even before these results were obtained. Thus the most likely reason for the difference between 2004 and 2005 is due to the innate differences between classes from one year to the next.

For the other instructors who also taught using these three approaches, there is only a marginal difference in the numbers from year to year. And in the overall quality category, both instructors experienced a drop when they introduced the Tablet PC to their classroom. In addition, using the Tablet PC in the classroom does not appear to have a strong influence on the outcomes of students as measured by their course grades. The averages over the past few years are within the normal range of variability for student grades in the course. Other

factors are obviously having a greater impact than the choice of instructional method. Both the instructor and the students in the classroom appear to be able to compensate for the deficiencies, if any, inherent in the primary method of instruction.

However, opinions expressed about using the Tablet PC are quite clear. The instructors found using it as the primary method of instruction to be enjoyable, with a high level of interaction in the classroom. In the written responses to the end of term survey, several students, when asked to elaborate on the quality of teaching in the course, chose to comment on the use of the Tablet. All comments specific to it were favorable. One student stated, "Unlike most profs that I've had, she makes good use of electronic aids (tablet PC)." So, overall, the experience was a positive one.

### CONCLUSIONS

Tablet PCs provide another option for classroom instruction. Through the use of digital ink, they enable the instructor to annotate notes and draw diagrams in a variety of colours using a pen. The pen provides a very natural and easy to use user interface for writing and drawing on the projected screen. The use of a Tablet PC can improve interactivity compared to the use of e-projection alone while maintaining the advantages inherent in the use of e-projection. While student and instructor comments are favorable, it appears that the use of the Tablet PC is not having a significant impact on the course offering.

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