AC 2007-1683: DEVELOPMENT OF A MULTI-LEVEL ASSESSMENT FOR A CROSS-DISCIPLINARY PROJECT EVALUATING THE SYMBIOSIS OF TABLET PC'S AND COLLABORATION-FACILITATING SOFTWARE IN THE CLASSROOM

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Development of a Multi-level Assessment for a Cross-Disciplinary Project Evaluating the Symbiosis of Tablet PCs and Collaboration-Facilitating Software in the Classroom

Introduction

Pen-based technologies like tablet PCs provide engineering educators the opportunity to increase the visual dimension of many different types of courses. At our institution we have developed curricula that deploy tablet PCs in five courses drawn from different disciplines: Introductory Physics; Technical Communication; Software Requirements and Specifications; Design for Manufacturing (mechanical engineering); and General Chemistry for Engineering Students. While pen-based technologies allow us to enhance the visual dimension of a course (an inherently laudable goal), these technologies are their most powerful when they simultaneously facilitate collaboration—between faculty and students, between students, and between one class and another. For this reason, our project work focuses on the assessment and evaluation of the impact of a symbiosis of hardware (Tablet PCs) and software (DyKnow Vision)[1] on teaching and learning.

Assessment has been developed at two levels for this project. One level of assessment is the development of classroom assessment techniques, or CATs. Basing our project on the work of Angelo and Cross (1993), we have identified CATs appropriate to each course and then adapted them into the tablet PC/DyKnow environment.[2] We have also made use of CATs that are already features within DyKnow, like the participant status and polling features. Each instructor can use CATs to gauge student learning in real time and make pedagogical adjustments as needed. The focus of this paper is, however, the second level of assessment, particularly the summative assessment components.

Summative assessment is used to measure success in implementing pen-based technology in classes in various disciplines, and the data collected are both quantitative and qualitative. Quantitative data are collected through self-report surveys, while qualitative data are collected through focus groups and open-ended items on self-report surveys. During the 2006-07 academic year, we are collecting data in five targeted courses. From these data, we can draw preliminary conclusions regarding the impact of tablet PCs and collaboration-facilitating software on student learning.

Context for the Project

Rose-Hulman Institute of Technology is a private, primarily undergraduate institution of roughly 1850 students offering majors in engineering, mathematics, and science only. Since 1995, students have been required to purchase an institute-specified laptop computer with an installed suite of powerful software (e.g., Microsoft Office, AutoCAD, Maple). The Laptop Computer program has meant that students can use modern computing tools in their classes and for their projects while still maintaining the portability inherent in laptop devices. At present, all classrooms are wired for high-speed network connections, and there are wireless nodes strategically placed around the entire campus. Students use their laptops in classrooms on a daily basis in most first-year courses and in many upper-division courses.

In recent years, however, the emphasis on portability has taken a back seat to power. Each year students have expressed their desire for more and more powerful computers, devices that are capable of hosting memory-hungry applications like games and video, while still maintaining the capability to pick up the computer and take it to class (although the increasing weight of the laptop has become a concern to students who must lug it around with a couple of technical textbooks in overstuffed backpacks).

While we understand and use the power of laptops in education, we also recognize that other computing tools may be better for some student learning experiences. When pen-based computers running tablet PC editions of Microsoft Windows became available several years ago, we quickly recognized their potential for enhancing learning experiences of students and driving curricular change. In 2003 and 2004 we received *Mobile Technology Solutions in Learning Environments* grants from Hewlett Packard Company to purchase HP/Compaq tablet PCs. Our 4½ years of experience with tablet PCs has involved more than half of our departments and about ¼ of our students. Our use of these pen-based devices has allowed new and innovative educational opportunities for our students, as described in recent publications and presentations by our faculty, as well as in presentations at the First Workshop on the Impact of Pen-based Technology on Education (WIPTE) at Purdue University in April 2006.[3-7] In addition to the use of tablet PCs that we have experimented with in the physics studio lab, as well as courses in chemistry, computer science, and mechanical engineering, we have taught over half the sections of our required course in technical communication with tablet PCs.

In our work with tablet PCs, we have come to conclusion that the classroom experience is enhanced when students and faculty make use of collaboration-facilitating software, such as DyKnow Vision. Through DyKnow, faculty can create text and graphics in real time for display in the classroom; faculty and students can take notes that are then saved for later access; and students can collaborate with each other to engage in class activities. While there are other collaboration-facilitating software packages available, we have pursued our work with DyKnow Vision.

Methodology

The quantitative dimension of the project is comprised by two surveys: pre-course and post-course. The pre-course survey serves as a baseline for each course while the post-course survey assesses technology usage and learning following students' usage of tablet PCs and DyKnow. The pre-course survey contains 6 items:

- Previous use of computer devices (a desktop, laptop, and tablet PC (tablet))
- Frequency of use for each of these devices
- Perceived usefulness of each device to complete specified tasks, such as "taking notes" and "preparing for tests"
- Interest in using a tablet PC
- Knowledge of and confidence in a series of course-specific learning objectives
- And tools used to take notes.

During the first iteration of the project, the pre- and post-course surveys were administered during the first and last weeks of the fall quarter in 2006 (August 31, 2006 – November 20,

2006) in 3 courses: Introductory Physics (PH 113), Software Requirements and Specifications (CSSE 371), and Technical Communication (RH 330). A total of 131 students participated in the survey. The breakdown of student demographics can be found in Table 1 below.

Table 1
Student Demographics

	RH330 Students	PH113 Students	CSSE371 Students
Gender			
Male	42	20	55
Female	5	7	6
Year			
Freshman	0	8	2
Sophomore	0	18	9
Junior	37	1	43
Senior	10	0	7
Major			
Applied Biology	1	1	0
Biomedical Engineering	2	2	0
Chemistry	0	3	0
Civil Engineering	1	0	0
Computer Engineering	5	2	2
Computer Science	9	1	33
Electrical Engineering	9	2	0
Engineering Physics	1	1	0
Mathematics	0	3	2
Mechanical Engineering	16	12	1
Optical Engineering	0	0	0
Software Engineering	3	0	23

* RH 330 N = 45; PH 113 N = 27; CSSE 371 N = 59

* Note: The numbers in the table may not add up to the N due to not all students completing a survey.

Pre-course surveys for CSSE 371 and RH 330 contained 2 additional items concerning peer review experience and tools employed for peer review (such as Reviewing Tools in Microsoft Word). These items were added at the request of the instructors.

The post-survey consists of 12 items. Three of the items are identical to the pre-course survey addressing frequency of use of each device, perceived usefulness of each device, and ratings of knowledge of and confidence in learning objectives. Additional items in the post-course survey are as follows:

- Desire to use the current model tablet PC or the latest model tablet PC for future courses (two questions)
- Preference for the tablet PC over a laptop
- Desire to utilize the tablet PC in and out of the classroom (two questions)

Students are also asked what hardware device they used with DyKnow (two questions), satisfaction with their learning experience, and preferred note taking tool (two questions). Post-course surveys for CSSE 371 and RH 330 contained 3 additional items regarding peer review tools and experience.

In addition to the pre- and post-course surveys, a focus group has been implemented. The focus group consists of 9 items focusing on student experiences with the tablet PC and DyKnow combination. A copy of the focus group questions is provided at the end of this paper.

Since this is an two-year project, the surveys will be conducted again during the 2006-07 academic year at the end of the winter quarter for students enrolled in Engineering Chemistry, Design for Manufacturing (mechanical engineering), and Technical Communication. Beginning in summer 2007, a new set of courses will be targeted for the project, although the survey instrument will remain consistent when it is implemented during the 2007-08 academic year.

The student responses from the surveys are analyzed and are presented in several ways. First, frequency of student responses are calculated overall. Second, an ANOVA is conducted to compare each course participating in the assessment to examine the effect of the tablet PC on student learning. Finally, a paired sample T-test is conducted to compare pre- and post-course ratings within courses. The course instructors distribute paper versions of the pre- and post-course surveys to students during the first and last weeks of the quarter for all sections. Copies of the pre- and post-course surveys for PH 113 are located at the end of this paper.

Fall 2006 Pre- and Post-Course Common Item Comparisons

Comparison of the common items on all surveys revealed several interesting results. Students in CSSE 371 rated items on the pre-course survey significantly differently from students in RH 330 and PH 113. Therefore, post-course comparisons were run after computing difference scores for each course. This was done by subtracting students' post-course ratings from their pre-course ratings. An ANOVA to compare courses was then run on the difference scores. This is done so that any differences found better reflect actual differences between courses rather than inflated differences due to the unequal starting point.

When comparing student survey responses across courses, 1 statistically significant difference appeared. Students in CSSE 371 reported a significantly lower increase in tablet PC usage from pre- to post-course than students in RH 330 or PH 113.

There were no significant pre- to post-course changes in student ratings of the usefulness of a desktop for course related tasks. Students in CSSE 371 rated the usefulness of a laptop in communicating with others involved in their project significantly higher on the post-course survey than on the pre-course survey.

There were 12 statistically significant changes in student ratings of the usefulness of a tablet PC for course related tasks.

- Students in RH 330 and PH 113 reported a significant increase in the number of times a day they use a tablet PC.
- Students in CSSE 371 reported a significant decrease in the usefulness of a tablet PC in contributing to their learning.
- Students in RH 330, PH 113, and CSSE 371 reported a significant decrease in the usefulness of a tablet PC in gathering information for a project.
- Students in RH 330 and CSSE 371 reported a significant decrease in the usefulness of a tablet PC in communicating with others involved in their project.
- Students in PH 113 reported a significant decrease in the usefulness of a tablet PC in taking notes.
- Students in CSSE 371 reported a significant decrease in the usefulness of a tablet PC in preparing for tests.
- Students in CSSE 371 reported a significant decrease in the usefulness of a tablet PC for solving problems.
- Students in PH 113 reported a significant decrease in the usefulness of a tablet PC in collecting data for experiments.

There were no significant differences between courses in students' desire to use tablet PCs in the future. Students in PH 113 tended to rate usage items higher than students in RH 330 or CSSE 371. These students also reported using the tablet PC the least of the 3 classes during the quarter. It may be that the tablet PCs are still novel to these students more so than to students in RH 330 and CSSE 371.

One finding of particular importance is the low level of student satisfaction with the tablet PC and DyKnow overall. Even lower are the students' ratings of their desire to use the current tablet PCs in the future. We believe this result stems from the fact that the tablet PCs students use in class are models 1100 and 1000 Compaq Tablet PCs, technology that is quite outdated at this day and time. As much as we can, we are trying to bring out students' perceptions of the tablet PC/DyKnow combination's usefulness to learning without allowing students to be distracted by the age of the device. Our hope is that we can deploy the assessment components with up-to-date devices in the coming year.

Students were asked to report their previous experience using a tablet PC, the type of hardware they utilized with DyKnow, and their preferred tool for peer review and taking notes.

Interestingly, the majority of CSSE 371 indicated previous experience with the tablet PC while the majority of students in RH 330 and PH 113 indicated no previous experience with the device. The tablet PC was the most frequently utilized device for running DyKnow regardless of course. Approximately 1/3 of students preferred pen and paper for peer review while another 1/3 preferred pen-based technology, and the final 1/3 preferred Microsoft Word or did not indicate a preference. The majority of students in all courses prefer using a pen and paper for taking notes.

Fall 2006 Qualitative Data

On the post-course survey, students responded to 3 open ended questions regarding the ways the tablet PC impacted peer review and note taking. In addition to these items, a sample of students enrolled in RH 330, CSSE 371, and PH 113 participated in a focus group. Responses from both assessment measures are summarized below by topic.

Classroom Interaction:

One benefit to using DyKnow with the tablet PCs in class was the ease of allowing the professor to see who was paying attention in class through panel submissions. An additional benefit mentioned by students included a quicker pace to the lecture since the notes were already available and multiple-choice quiz questions could easily be posted and answered.

Students did report paying less attention in class compared to traditional courses not using the tablet PC and DyKnow since the technology made it easy to multi-task and still catch back up with the provided notes. Since students were required to pay attention to the tablet, the instructor was not expecting that the student would be actively taking notes. This made it easier for students to play games or access the internet instead of paying attention in class.

Some students felt they did not need to come to class because they could follow along from home. While students thought there were advantages in being able to multi-task while following along from home, many did not like this idea because it then felt too much like an on-line course which they do not wish to do at our institution.

Class Notes:

Students during the focus group almost unanimously reported a decrease in their note taking with DyKnow throughout the quarter. Some students felt they did not need to take notes for their course while other students preferred the greater flexibility of taking notes with pen and paper. Students did not care for the multitude of pages DyKnow created when taking notes, did not like the constraint DyKnow placed on their note-taking style and organization, and felt they needed to take notes themselves so that they would pay attention in class and not become so easily distracted. Students did report feeling that having the same notes as the professor helped their learning in class because they were easier to refer to later.

On the post-course survey, students were asked to indicate which of 6 tools (pen and paper, highlighting, Microsoft Word, inking, other software, or other tools) they preferred for taking notes and then were asked to explain why they preferred that tool. The vast majority of students preferred to take notes with pen and paper. Their reasons included paying more attention in class and retaining the information better than when using alternative note-taking tools, reliability of pen and paper, greater flexibility in note-taking style, and ease and speed of use.

"[With pen and paper] I'm forced to pay attention and take notes. If the notes are being taken for me there's no motivation to pay attention during class. Also, I will only write down what I understand."
--PH 113 student

"Being dependant on a computer or tablet for notes is hard when technology can crash or become damaged."
--RH 330 student

After pen and paper, the next most frequently preferred note taking tool was inking using a pen-based technology. Reasons for preferring inking included the ease of inking since the professor was already using DyKnow and being able to keep hand-written notes electronically.

"It is very convenient. You don't have to write down anything in class, you only need to listen. Also, the notes can't get lost."
--PH 113 student

"I can take notes on the slides that Dr. Mutchler was talking about and my notes would then include those slides and my notes on those slides."
--CSSE 371 student

Microsoft Word was the third most preferred note taking tool. Students preferring this tool did so because they like electronic notes, can type faster than they write, and prefer the legibility of notes in Microsoft Word.

A handful of students across the 3 courses preferred highlighting the text or prepared notes, One Note, or indicated they did not take notes.

Class Assignments:
Students were split in their opinions of how DyKnow and the tablet PCs changed how they work on class assignments. Some students did not feel the technology made any difference over a regular computer. Other students felt it was a hassle because they could not see the notes and work on the assignment on one machine at the same time. Not being allowed to take the tablet PCs out of the classroom was another issue that contributed to student responses.

Students found working in teams to be more difficult with the tablet PCs and DyKnow. They found it difficult to put content on 1 tablet and had difficulty moving around with the tablet because of the low battery life of the machine and the lack of reliable wireless access. Interaction between students with DyKnow was poor, but the interaction between students and the instructor was nice.

"DyKnow allows interaction between students and the professor, but it doesn't between students."
--Focus Group

Peer Review:
Students in RH 330 and CSSE 371 were asked how the use of the tablet PC impacted their usage of the comments they received on their work compared to other peer review tools. Unfortunately, few students answered this question, but many provided a wide variety of other comments concerning the peer review instead.

Some students preferred the tablet PC to other tools for peer review while other students did not care for the tablet for peer review. Those students who indicated in their comment a preference for the tablet PC did so because they found the comments to be easier to distribute, save, access, and track changes.

> *"It was easier to have an electronic copy. The tablet was useful for writing by hand on the electronic copy. Because I had an easily accessible electronic copy I was more likely to use the peer review."*
> --RH 330 student

> *"I could take notes on the document electronically which made it very easy to keep track of the comment and remember when I fixed them (because I could delete them as I fixed them)."*
> – RH 330 student

Students who liked the tablet PC for peer review did so because everyone in the group could view the same document at the same time and give feedback as a group.

Those students who did not like the tablet for peer review indicated so because as reviewers they felt it took longer to provide feedback. As they reviewed, students felt they received less information in their reviews and received more drawings. It was also more difficult to read the comments due to poor penmanship compared to paper and the small amount of space they had to write comments on. Some students reported using Microsoft Word reviewing tools on the tablet PC rather than the stylus.

> *"On a tablet: [there is] less room for comments, [it's] harder to organize comments, [and it's] harder to read comments."*
> – CSSE 371 student

Some students did not feel the tablet made any difference in their usage of peer review comments.

Students in these two courses were also asked how the use of the tablet PC impacted the comments they provided to other students compared to other peer review tools. Similar to their usage of comments received by others, students were split in their providing of comments to others. Some students did not feel the tablet PC made a difference, others thought it decreased the amount or quality of comments they provided, and others thought it increased the comments they provided to other students.

"I wrote less comments on the tablet peer reviews [because of] less room to write."
– RH 330 student

"I did better because it was like having a red pen to do whatever I wanted, but was erasable, so I was free to make marks while reading, then erase once they became clear."
– CSSE 371 student

General Student Likes and Dislikes:
Students thought the concept of the tablet PC was "awesome" and had a lot of potential to be useful in class. The actual execution of the concept was not seen so favorably however. Specifically, students found the tablet PCs useful for drawing pictures and graphs in physics.

Students did not like the inaccurate stylus and having to recalibrate it each time they used the tablet. They also found the resolution, speed of the machines, and difficulty connecting to their network drives and server undesirable. Some students could not access the VPN on their machine. One of the features students would like in the tablet PC is for it to be thinner so that when they write on it, they feel more like they're writing on paper. One of the most frequently mentioned dislikes was the ease with which students could distract themselves from class content.

Students felt the tablet PCs were "forced" into their classes and the curriculum would have worked just as well without them.

Improving student classroom experiences with the tablet PC and DyKnow can be achieved a number of ways according to students. Using a Wacom tablet with students' current laptops, having touch screen laptops, or using up-to-date tablets were three alternative suggestions to the current tablet implementation. Changing from DyKnow software to Microsoft One-Note software was a second suggestion. Students did not feel adding DyKnow to the tablet PC added to its functionality.

"I have a tablet I bought on my own for class and it affords a lot of functionality of a laptop, but adding DyKnow to it doesn't give any more additional functionality over the tablet itself. Even power point, you can do just about anything you need to do in DyKnow, just not the bells and whistles that waste class-time anyway."
--Focus Group

Creating a digital database of subject specific resources, having the ability to search digital notes, having an index for notes, and creating OCR were all features students would like when using tablets and DyKnow software in the future.

Tablet vs. Traditional Courses:
Most students reported a preference for traditional courses over tablet PC and DyKnow courses. Students felt they were able to focus more in a traditional course and only used technology when

it was needed. They were against the use of technology when it was not needed. Implementing a digital note pad rather than a tablet PC was all students felt was needed in technology-enhanced courses.

Conclusions

At this point, we are finishing the first year of this two-year assessment project, so our conclusions regarding the impact of tablet PCs and collaboration-facilitating software are preliminary. Currently we see some indications from the data regarding the impact of these devices on student learning.

First, students are aware that they are using devices that are outdated and slow. Although they acknowledge this fact, they can also imagine the potential for the technology in its latest form.

Second, students may not adapt their note-taking strategies in class without specific guidance from the instructor. Faculty must also recognize that when students are no longer required to copy extensive formulas and equations from the whiteboard, they will need to be engaged in different activities. Such a transformation of the classroom is something that both students and faculty alike will need to adjust to.

Third, students recognize that adding technology to a course may provide them with additional opportunities to become distracted. While it is possible to limit students' access to the Internet while using tablets and DyKnow, we have opted not to do so with this project. Students at our institution do not have the option to take online courses, but they felt that this combination of technologies could be used in such a manner. They seemed not to be in favor of this option.

Acknowledgements

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PH 113 Course Survey on Computer Technology Usage (Pre)

Name: _____ ID: _____ Section: _____

1. **Please indicate which of the following devices you have previously used for a course.**

   _____ Desktop _____ Laptop _____ Tablet PC

2. **On average, how many times a day do you actively use each of the following devices during the academic year?**

	Desktop	Laptop	Tablet PC
0			
1-2			
3-4			
5 or more			

3. **Using the rating scale below indicate how useful you believe each device is for the tasks listed.**

   1 Not Useful Whatsoever 2 Not Useful 3 Useful 4 Extremely Useful

	Desktop	Laptop	Tablet PC
Contributing to learning			
Gathering information for a project			
Communicating with others involved in your project			
Collecting data for experiments			
Taking notes			
Preparing for tests			
Creating documents			
Solving problems			

4. **For class related tasks, I am interested in using a Tablet PC.**

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

5. **Please rate your level of knowledge of and confidence in your ability for each of the learning objectives below.**

1	2	3	4	5
Very Low	Low	Moderate	High	Very High

	Knowledge	Confidence
Collect simple and accurate scientific measurements in the area of magnetism.		
Collect simple and accurate scientific measurements in the area of optics.		
Apply basic laws of physics to solve problems in the area of magnetism.		
Apply basic laws of physics to solve problems in the area of optics.		
Predict when specific physics principles are demonstrated in real-world situations.		
Integrate the components of the lab process to write a comprehensive and concise report of the experiment.		

6. **Which of the following have you utilized for taking notes in class?**

_____ Pen and Paper
_____ Highlighting textbook or prepared notes
_____ Microsoft Word (Laptop or Tablet PC)
_____ Inking on a pen-based technology (Tablet PC, iPAQ, etc)
_____ Other software, please specify:
_____ Other, please specify:

PH 113 Course Survey on Computer Technology Usage (Post)

Name: _____ ID: _____ Section: _____

1. **On average, how many times <u>a day</u> do you actively use each of the following devices during the academic year?**

	Desktop	Laptop	Tablet PC
0			
1-2			
3-4			
5 or more			

2. **Using the rating scale below indicate how useful you believe each device is for the tasks listed.**

1 Not Useful Whatsoever 2 Not Useful 3 Useful 4 Extremely Useful

	Desktop	Laptop	Tablet PC
Contributing to learning			
Gathering information for a project			
Communicating with others involved in your project			
Collecting data for experiments			
Taking notes			
Preparing for tests			
Creating documents			
Solving problems			

3. **Please rate your level of knowledge of and confidence in your ability for each of the learning objectives below.**

1	2	3	4	5
Very Low	Low	Moderate	High	Very High

	Knowledge	Confidence
Collect simple and accurate scientific measurements in the area of magnetism.		
Collect simple and accurate scientific measurements in the area of optics.		
Apply basic laws of physics to solve problems in the area of magnetism.		
Apply basic laws of physics to solve problems in the area of optics.		
Predict when specific physics principles are demonstrated in real-world situations.		
Integrate the components of the lab process to write a comprehensive and concise report of the experiment.		

4. **For class related tasks, I prefer using the latest model Tablet PC to the latest model Laptop.**

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

5. **I would like to use the Tablet PC regardless of model for other courses in the future.**

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

6. **I would like to use the latest model Tablet PC for other courses in the future.**

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

7. I would like to have the latest model Tablet PC for use outside of the classroom.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

8. Which of the following devices did you use with DyKnow?

_____ Desktop
_____ Laptop
_____ Tablet PC
_____ Did not use DyKnow

9. If you indicated you did not use DyKnow in item 7 above, please explain why you chose not to use it?

10. Which of the following do you prefer for taking notes in class?

_____ Pen and Paper
_____ Highlighting textbook or prepared notes
_____ Microsoft Word (Laptop or Tablet PC)
_____ Inking on a pen-based technology (Tablet PC, iPAQ, etc)
_____ Other software, please specify:

_____ Other, please specify:

11. Why did you choose the particular note taking tool selected above?

12. Overall, I was satisfied with my classroom learning experience using the Tablet PC and DyKnow.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Tablet Focus Group Questions

1. How did the Tablet PC in conjunction with DyKnow change the way you interact in the classroom?

2. How did the Tablet PC in conjunction with DyKnow change the way you worked on class assignments?

3. What did you like most about using the Tablet PC & DyKnow? Least?

4. How could your classroom experience using the Tablet PC & DyKnow be improved?

5. How did DyKnow impact your note taking behaviors (i.e. take more notes, different kinds of notes)?

6. How did the Tablet PC & DyKnow impact the way you work in teams?

7. How did the Tablet PC & DyKnow impact your attention in class?

8. How did the Tablet PC & DyKnow impact your learning in class?

9. How does a course utilizing the Tablet PC & DyKnow compare to a traditional course not utilizing the Tablet PC & DyKnow?