



Tablet PC Use at Northern Lights Public School: An Initial Evaluation

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Executive Summary

The Tablet PC initiative at Northern Lights was evaluated with the goal of determining the impact that Tablet PCs had on teaching practices, student learning, and other teacher and student outcomes. From late March to the end of the school year in June 2004 the researchers observed student usage; surveyed students, teachers, and parents; and interviewed grade 8 teachers, students, and the principal.

Overall, we concluded that the project was as successful as one would have reasonably expected given the short period of time the project was fully operational, the lack of teacher support provided, and the technical difficulties encountered. Teachers in all grades made regular use of the Tablet PCs to perform a variety of functions, including email, lesson planning, student record keeping, communicating with parents, and doing more interactive activities than in the past with students. The grade eight homeroom teacher, whose students had their own personal Tablet, found that the Tablet PC supported his project-oriented pedagogical approach well. The other two teachers also saw the potential of the Tablet PCs to support student work in their subject areas, although they did not make as extensive use of them with their students.

Grade 8 students became more motivated toward their schoolwork as a result of having their own personal Tablet PC, despite occasional technical problems that caused lost work and frozen machines. Teachers and students alike, with a few exceptions, felt that the quality of student work and possibly some grades had improved. Students were able to make sustained formal presentations with PowerPoint; organize and store their work more efficiently; readily develop concept maps; graph data; do Internet research anytime at home or at school; and seamlessly integrate text and handwritten diagrams into documents. However,

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neither most students nor teachers learned about and/or made significant use of some of the more advanced functions of the Tablet PCs such as handwriting recognition.

The project was not without its share of difficulties. Most outstanding was the lack of teacher support for technical, pedagogical, or planning and preparation purposes for using Tablets. Network capacity and reliability caused problems too. The relatively low capacity of the network did not allow for many simultaneous network transactions by students. Frequent down time caused teachers to have to substantially alter their plans. Synchronization of files also appeared to be problematic which resulted in lost student work. Physical deficiencies were noted with the Tablets, which while not serious, need to be addressed. Lastly, wireless Internet access from students' homes was problematic.

We conclude that Tablet PCs offer many advantages over currently available notebook computers and desktop systems for the elementary school; however the above deficiencies need to be remedied before the potential of Tablet PCs can be fully realized. Nine suggestions were offered for action by Microsoft, the school, and school board: that (1) teachers need be given technical training on how to use all features of the Tablet; (2) teachers need to be provided with ongoing pedagogical support for integrating Tablet PCs into their curricula; (3) consideration should be given to mounting a late August voluntary professional development institute for teachers to launch both recommendations 1 and 2; (4) teachers need to be provided with resources to assist them in integrated Tablet PCs into their teaching; (5) the Tablet PC synchronize function needs to be thoroughly tested in actual classroom settings to identify and correct any technical difficulties; (6) increased technical support to Northern Lights should be provided; (7) the strategy of providing wireless home access to students should be reassessed; (8) a teacher should be designated to be the SharePoint Portal Server facilitator in order to foster a stronger teacher learning community; and (9) the formal evaluation of the project should continue next year, employing a year-long research strategy.

Tablet PC Use at Northern Lights Public School: An Initial Evaluation

Background

This report presents the findings of an evaluation conducted by the Institute for Research on Learning Technologies at York University on the Northern Lights Tablet PC pilot project. In this project, Acer TravelMate C110 Tablet PCs loaded with Windows XP Tablet PC Edition and Microsoft Office software were provided to all Northern Lights Public School teaching staff in September 2003 and to every grade eight student in December 2004 for their individual use over the remainder of the school year. The evaluation began in late March 2004 and continued until the school year end in June 2004. The overall goal of the evaluation was to determine the impact that this use had on teaching practices, student learning, and other teacher and student outcomes over that time. Four primary research questions were addressed in the evaluation. These are noted below, together with the methodology used to investigate them. In addition, the evaluation also looked for unanticipated outcomes, perceived advantages of Tablet PC computers over notebooks, and any implementation and technical issues that arose in the pilot.

Research Question 1

What changes in teacher administrative, management, and logistical practice have occurred as a result of using a Tablet PC on daily basis?

To answer this question, all K-7 teachers were asked in June to respond to an online SharePoint Portal Server-based survey. Fifteen of nineteen eligible teachers completed the survey, in which they reported on how they were currently using their Tablet PCs, how the Tablet PCs have helped them in their administrative practices as compared to previous years when they did not have them, how they have facilitated communication with colleagues, parents, and students, and how they have contributed to their professional learning. In addition, end-of year interviews which addressed these questions were conducted with the three grade 8 teachers (the home room teacher; the History, Geography, and Art teacher; and the French teacher). The school principal was interviewed at this time as well to obtain his perspective on this and the other three research questions.

Research Question 2

What is the impact of the Tablet PC on teacher instructional practices?

This question was addressed by means of data collected both from observation of teaching activities in grade eight classes and through teacher and student interviews and surveys. Beginning in April, weekly visits were made by research team members to observe how Tablet PCs were being used. Observations were focused in those classes where they were being made use of on an ongoing basis at the time (Language Arts and Science). Field notes were taken during these visits and later analyzed. Teachers were informally interviewed during these visits about their intended lesson goals, methods, and whether they felt that they were successful in accomplishing the goals. At the end of term, in June, formal interviews were conducted with the three grade 8 teachers that explored in depth how they have used Tablet PCs during the school year and the impact that they have had. The teacher survey completed in June also had several questions designed to assess how the Tablet PCs were employed by the K-7 teachers. In small-group interviews conducted with twelve grade 8 students at the end of the term, students described in detail the various ways in which they had made use of the Tablet PCs in the classroom over the year.

Research Question 3

How do teachers and students collaborate when using Tablet PCs?

For this question we collected data on the collaborative practices of all teachers in the school through the teacher interviews and survey discussed above. We also examined collaboration among the grade 8 students through direct observation as well as through the teachers' experiences as tapped in their interviews and the teacher survey. Students also reported on their collaborative practices in the group interviews.

Research Question 4

What is the impact of Tablet PCs on grade 8 students and their learning?

Here we looked at several dimensions related to student practices and outcomes: (a) when and where students learn, (b) the tools they use, (c) their attitudes toward and engagement in learning, and (d) learning outcomes. The data

sources used include classroom observation, teacher interviews and the teacher survey, and the end of term student interviews. In addition all grade 8 students completed an in-class survey that probed how students were using their Tablets, and what specific capabilities they had developed in exploiting the Tablet's feature set and software. Finally, a short parent questionnaire was sent home at the end of the year that asked parents to indicate what uses they and their child made of the Tablet PC at home.

Evaluation Findings

Prior to Tablet PC use: Teacher background

The three grade eight teachers had each taught for seven years or longer. The homeroom teacher, Donald, had used computers in every year of his teaching and had played a lead role in technology implementation throughout his career, having initially been hired to run a school computer lab. He was experienced in the use of many applications, as well as networking (albeit in a Macintosh environment). The History/Geography/Art teacher, Bill, had extensive prior experience working with digital multimedia tools on both PCs and Macintoshes. Dana, the French teacher, had the least amount of computer experience, describing herself as having a basic background but not being an expert. Although she had taught for 19 years, this was her first year as a core French teacher; as a result she was having to learn several new curricula through the year which limited her time for focusing on technology.

The K-7 teachers, when asked about their prior computer use in the survey, all indicated that they had employed computers for a variety of purposes (see Table 1). Nearly all staff had used technology to research and develop curriculum, do administrative work, and communicate with colleagues and/or parents. Most had their students conducting Internet-based research and using Office software, and a minority had taught using a range of ICT tools, including PowerPoint, spreadsheets, and databases.

Table 1: Teacher prior computer use

Purpose for using	No. of teachers (of 15) using for given purpose
access email	15
seek out curriculum content on the Internet	14
generate lesson plans and/or assignments	10
record assessments	10
have students conduct research via the Internet	10
have students use MS Office	8
communicate with parents	7
have students use other programs (Photoshop, concept mapping software, etc.)	6
make presentations to students	5
teach using spreadsheets or databases	4
have students run tutorial software	3

Teachers' Administrative Uses of the Tablet

The continual availability of the Tablet PCs, their portability, and their wireless network access was much appreciated by teachers, for (among other things) it made it much more convenient for most of them to perform their administrative and managerial functions. Having them at hand led most teachers to make more extensive and frequent use of ICT tools for a range of administrative uses. Administrative applications of the Tablet PCs reported by teachers in the survey are shown in Table 2.

Table 2: Teacher administrative uses

Purpose for using	No. of teachers (of 15) using for given purpose
recording student assessments/records	11
communication with staff	10

creating teaching plans	8
meeting records/notes/minutes	7
email	5
SharePoint Portal Server access	4
internet access	3
report card writing	3
newsletters	2
contacting parents	2
sharing information	2
comparing data	2
creating/updating calendars	2
library budgets and admin/management	1
creating notes for students	1
PowerPoint presentations	1
IEP planning	1
marking tests	1
summarizing data	1
making charts	1

The main uses noted were for record keeping, accessing or storing administrative information, creating teaching plans, and communication. Several teachers noted that having the option to write with the Tablet’s stylus was a significant advantage for them, as it made it possible to record observations and assessments while walking around the classroom with the Tablet.

Like most K-7 staff, all of the grade eight teachers used the Tablet PCs for emailing parents and others, printing documents via the wireless network, and accessing the staff SharePoint Portal Server for updates, peer communication, school calendar information, resource access, and administrative announcements. With the exception of Dana, they also made use of the Tablet’s pen input to record evaluations both during student presentations and at other times. Donald was observed on several occasions to print off a copy of an assessment a few minutes after a student’s presentation ended and then hand it to the student; the students seemed to appreciate the quick response, and Donald liked that he still had the original in his possession for his records. Both Donald and Bill indicated that they were more inclined to use the stylus than the keyboard for notetaking in meetings as it was thought to be more traditional and a better “fit”. Donald indicated that Microsoft had asked him to work with the OneNote beta in the fall rather than Journal but it had crashed too often to be useful. He had no such complaint about

the release version, and had been using it since the Tablet PCs had been imaged with it in the winter.

Dana had tried stylus-based notetaking a few times using Journal but discontinued the practice; her notes were very short, so she found a small piece of paper “easier to carry around”. Unlike her two colleagues Dana did not make use of Microsoft Office applications. She had initially thought she would do her record keeping with them but had not seen anyone else do so and had not had any training on them. She found it faster and easier just to jot down her records in a binder. Bill, by contrast, kept all his records on the Tablet. He did not use the Ontario curriculum planner software for this but a simple Excel spreadsheet he developed. Donald also kept records on his Tablet, and like Bill was comfortable using Office applications. He did feel he needed to know more about using the concept mapping software installed on the Tablet PCs (My Manager). He had also repeatedly requested software for observing his students’ screens remotely as they worked in class (without students knowing that he was observing them), and had been told that it would be made available for trial, but it never showed up.

Both Bill and Donald had tried the writing recognition functionality of the Tablet PC but neither had found it that useful. Bill had used it a few times but it had “not been a great experience” as there were too many recognition errors. Donald thought the concept was “great” but found that it had no real use other than being “a cool thing to show off.” Dana had not tried it at all.

Uses of the Tablet PC in Teaching

K-7 teachers employed their Tablet PCs in a number of ways in their teaching activities. Most of the uses indicated were common to only one or two teachers. The applications most frequently used were (a) employing the Tablet PC as a presentation or interactive medium connected to either a Smartboard or an LCD data projector (8 teachers); (b) accessing the Internet for demonstrations (5 teachers); (c) recording assessments (4 teachers); (d) lesson and unit planning (4 teachers); and (e) research, shared reading, and concept mapping (3 teachers each).² Two teachers used their Tablet PCs for the following three activities—for typing up handouts or worksheets, for creating class booklets, and for modeling writing and art creation for students. Other applications reported by a single staff member included the use of Movie Maker with the class, the digital editing of photos with Photoshop, making PowerPoint presentations, creating spelling

² The numbers for (c) and (d) are artificially low as most teachers chose to report these activities as administrative uses.

assignments, creating activities for students to do on the Smartboard, displaying graphics, creating video lessons, creating a class Web page, generating tests, correcting assignments, practice student reading, and using Journal to take up work and reinforce literacy skills. None of these teachers used the SharePoint Portal Server for hosting student online discussions or assignment posting.

Asked to note changes in their teaching practice that had developed in response to Tablet PC access, teacher responses were highly varied. Only two responses were shared by 2 or more teachers—three staff noted that record keeping was now a more efficient process, and two teachers stated that it was now easier to organize their plans and records (including parental contact records). Other changes cited were as follows:

- doing more interactive activities with students via the Smartboard
- less reinventing of the wheel as templates created on Tablet PC can be reused
- anytime, anywhere evaluation of students now possible
- assessment and tracking was now almost effortless
- greater use of computers with students
- assessment now informing daily teaching better
- instant messaging creating a tighter bond with parents and students
- better communication with parents and staff
- greater use of an LCD projector in lessons
- ability to plan and email in any free time
- preparing work in Word and then exporting it to Journal in order to annotate or highlight with stylus for class
- can now work anywhere

Generally teachers seemed to see changes in three broad areas: enhanced communication, better and easier student tracking and recordkeeping and greater work flexibility. Most of the perceived changes were in the administrative, planning, or assessment domains; few related to shifts in classroom practice, although a few teachers were more inclined to use data projectors for media display, and one mentioned increased use of ICT in class presumably as a result of gaining more confidence and familiarity in using a computer.

As their grade 8 students had Tablet PCs of their own to work with, two of the grade eight teachers were able to make more regular and intensive use of

Tablet PCs in their teaching practices. (The third teacher, Dana, made minimal use of the technology, for reasons discussed later). Bill made extensive use of the Tablet PCs for a major segment of his art curriculum. Students undertook sketching using the stylus. They spent several art classes learning to use Photoshop, downloading images off the Internet and cutting and pasting them into collages, and using the functions of the program to change colours and alter other parameters of the images. They then applied Photoshop to the development of art projects. In his grade eight Health course, Bill had his students develop public service announcements on health issues as their major term project. Here again students made intensive use of their Tablets, editing images for inclusion in their announcements, and then using Movie Maker to create animated presentations that incorporated images, sound, and text.

Towards the end of the year Bill incorporated the use of a multiplayer simulation game, Monopoly Tycoon, into a grade eight Geography unit on city infrastructure and organization. Running the game's client on their Tablets, students competed in planning, developing, and building commercial and residential housing within the context of a city. In a class preparatory to that activity, he had students conduct research using their Tablet PCs to familiarize themselves with planning vocabulary and concepts. They were instructed (via a handout) to conduct a Google search for the official Toronto Web site, to document the results in OneNote, and then do more research to define and give examples of infrastructure. They were then to learn about the elements of Toronto's infrastructure through the Toronto city Web site, and document them in a OneNote table that listed the infrastructure elements in the first column and why they are important to the city in the second column. All the important departments within the city had also to be discovered and listed. The assignment was graded for completeness.

Bill had his grade eight students using OneNote for notetaking on a regular basis. "I incorporated Tablet PCs as much as possible", he stated in an interview. Asked about the overall impact of the Tablet PC introduction on his teaching practice, Bill indicated that he would have done much the same things as he did this year without the Tablets, with the exception of having students engage in the city simulation gaming. He did find that presence of the Tablet PCs made doing what he wanted to do much more convenient.

Donald's most common use of the Tablet PC in teaching was as a medium for presentation—either by himself, or by the students. His (or the student's) Tablet PC was connected to a data projector that was in the classroom, and the image projected to a screen at the front of the room. He would frequently use the Tablet PC as a digital whiteboard, working in Journal or OneNote to take notes or

list points as he talked, creating quick tables or diagrams, or highlighting a document. He would sometimes project visual images to stimulate discussion as part of his oral language curriculum. He would display Web sites of interest on a topic being covered, and have students access sites via their wireless connection to the Internet. For example, for a unit on light in his science curriculum he had students access a site providing a Java based animated interactive tutorial in which students could change the substance light was being refracted through and see how the relationship between angle of incidence and angle of refraction were impacted. Students also made use of a site which allowed them to take a three dimensional “virtual tour” of the inside of a cell. Tablet PCs were used in another project to gather data from the school about school colours and logos; the data was then organized and synthesized by students using Excel, and a PowerPoint report on findings compiled.

Tablet PC use had been an integral part of a robotics unit in Science. Over several periods, students learned how to build and program Lego robots. The actions of the robots’ sensors and motors was programmed via an icon-based procedural flowcharting technique on the Tablets, and the programs downloaded to the robots via a transmitter connected to the Tablet. Several of the grade eight students went on to participate in school teams in the first regional Robotics Challenge. This all-day event was held at the school and teams from a number of schools in the district participated. During the competition the Northern Lights students had the advantage of being able to take the Tablet PCs with them to test areas, correcting programming errors on the spot based on observations of trial runs of their robots. (Other competitors had to return to desktop computers to do this.)

In his Language Arts teaching, Donald sometimes made use of the features of the Tablet PC to promote brainstorming, to foster collaboration, and to get students to record and organize their thinking. In one instance, for example, following a discussion about culture, he had students list in Journal what they thought were the defining features of culture. After several minutes of individual work, he asked them to discuss within their desk-cluster groups in order to come to a consensus about what culture is. They were to highlight those of their own ideas with which the group was in agreement with the Journal’s yellow highlighter; those that turned out to be personal ideas only with a blue highlighter. They were then to rank their individual points by creating a ranking order of them on a new page in Journal. Later he had students come up with more elements that contributed to culture, and he worked through an example of one element – clothing. Students then started inking simple node-link concept maps with “culture” in the centre. Towards the end of the class Donald elicited the

various nodes that students had thought of, drawing them into his own concept map on his Tablet PC in Journal (which was projected on the screen), and getting his students to seek out any links or hierarchical relationships between these elements, which he then diagrammed.

The major Language Arts project assigned to students in the last term, which was worth about 60% of their grade for the term, was the development of a social issues presentation on a topic of the student's choice. The finale for the project consisted of student PowerPoint presentations run off the Tablet PC and using the projector. Project topics varied widely, from global warming to child labour. Presentations lasted from 20 to 40 minutes and as each student had to present individually this took up much of the homeroom class time over the last month of school. Students were graded on three criteria: oral presentation style, visual content of the presentation, and the conceptual content and organization. It was in these presentations that Donald would use his own Tablet PC to write his assessment in OneNote with a stylus and then print off a copy for the student after the presentation had concluded.

Donald had his students use their Tablet PCs in mathematics primarily for spreadsheet and graphics work. Students used Excel to analyze and graph data sets. In one such assignment he presented students with a table of a student's income and expenses over each of four weeks and had them calculate totals and averages using formulas and then graph the average income and expenses over time. Donald indicated that the Tablet PC had had the least impact on his mathematics teaching; he would have done the Excel activities anyway on desktop computers or laptops, but having the Tablet PCs did expedite the process. He indicated that there was a relatively even split between those students who chose to do their normal math assignments and homework using the stylus on the Tablet PC and those who preferred to use pen and paper.

Except for several projects and activities for which Tablet PC use was mandated, Donald left it up to the students as to whether they used the Tablet PC or regular exercise books for day-to-day notetaking. Some chose to do nearly all work on their Tablets, using OneNote, Journal, and/or Word; others used exercise intermittently or most of the time.

Early in the second term, Donald had his students use the SharePoint Portal Server to upload a draft of an essay that they had written dealing with a major turning point in their lives. Students then downloaded their classmates' work, read it, and posted responses providing feedback to the authors. This process was intended to lead to a threaded discussion on the paper. But the SharePoint Portal Server's initial access settings blocked student downloading,

impeding the planned process until permissions were changed by the IT team. Eventually students were able to read drafts and post responses and there was time for “a little bit of threaded discussion” so students were able to get some feedback. Certain students were able to post to the SharePoint Portal Server from home. Donald indicated that he had not done further work with the SharePoint Portal Server later in the year due to a lack of time to find the resources to link into the server (he had two student teachers who needed guidance) and the residue of frustration left with students around the access issue: “Since we don’t have the electronic stuff reliable enough we move a lot back to paper because the kids are going to put up with it [only] so many times.” (See technical issues discussion below.)

The French teacher, Dana, made little use of her own or her students’ Tablet PCs in her teaching. She did have students employ them for one writing assignment in the second term, but found that they would write in English and then use translation Web sites to generate the required French text. The translation would be totally inaccurate but the students would not recognize this and as a result handed in “totally useless work”. She indicated that she could always tell when students tried to use these translation services and she put a stop to it. She did allow them to look up individual words in online dictionaries. She offered students the opportunity to write their stories by hand or on the Tablets, and all chose to do them by hand. In the last weeks of the year they were publishing stories from their Tablets, but she found it hard to get students to use the technology appropriately (see the later discussion of student outcomes).

In one lesson she had her students access a French Web site on the Eiffel tower when this was a topic of study in her curriculum. Students played little games on the site, learned vocabulary, and learned about the tower itself, and greatly enjoyed the activity, she reported. Generally, however, she indicated that she had not altered her curriculum or her teaching practices at all as a result of having the Tablet PCs available. As mentioned earlier, it was her first year teaching core French and she was learning the core curriculum for all grades, so she had little time to focus on learning about and using new technology this year. The principal noted that of the three teachers she was by far the least experienced in working with technology. In her interview she stated that she was unaware of OneNote, but was interested in learning about it.

Student Tablet PC use

Bill and Donald had contrasting perceptions of how much students used the stylus to write with in their respective classes. Bill stated that he had not seen

much stylus writing by students in his classes, but they had used their Tablet PCs extensively in slate mode. This was observed by researchers during student work on the preliminary city infrastructure assignment described above. In that class, most students used the keyboard to enter text on infrastructure or in some instances copied and pasted text into OneNote. Virtually all of them had their Tablet PCs set up for keyboard use. However they would use the stylus for specific things, such as creating the table frame around the text; and some students seemed to prefer to use the stylus rather than the touchpad for mousing functions even when the Tablet PC was set up as a notebook.

Donald, on the other hand, said his students did a great deal of notetaking and drawing of diagrams with the stylus in OneNote or Journal, and some annotation of pages. His lesson on culture described earlier illustrates how students would use the stylus to generate notes and highlight and annotate in Journal or OneNote. He noted that his students were all comfortable and competent enough to do these kinds of operations with little guidance from him, and this was confirmed in our observation. Rarely would a student need to consult with him regarding Tablet PC operation or OneNote functionality unless there was a technical glitch. Students would easily shift from stylus to keyboard modes and back, and often included both typed text and inked elements like table frames or a quick diagram or concept map in the same OneNote document. However no one was observed importing and annotating Web pages or text documents; they tended instead to cut and paste materials from these sources into OneNote, using the automatic citation feature of the program to generate citations for Web pages. In “free” periods in which Donald did not teach but allowed students to work on whatever current assignments or projects they chose to, virtually all students would be working on their Tablets, most in notebook mode, researching on the Web, writing in Word, working in Excel in a few instances, or creating PowerPoint presentations.

As mentioned earlier, during the last month of school the grade eight students presented their social issues projects. They were all able to connect their Tablet PCs to the projector and use PowerPoint on their Tablet PCs to make their presentations (although a few had initial setup issues—see below). In mathematics, about half of Donald’s students would use digital ink to do their math work, with the others choosing notebooks. He had not seen students making any real use of writing recognition however: “Kids type and write with digital ink in the same assignment, but there has not been the need to transfer from one to the other.” Voice recognition for commands and dictations had been used initially by a few students but the noise in the room precluded its effective use. Other applications widely used in Donald’s class included Office programs, My Manager

concept (“mind”) mapping software, Internet Explorer for Web research, Media Player for audio and video clip playback, and Movie Maker to build animated presentations. As mentioned earlier, Bill’s Art class made extensive use of Photoshop, and he had his students working in OneNote and Journal in History and Geography for research notetaking and organizing data in tables, graphs, and diagrams (as in the lesson described earlier).

Student outcomes

Teachers reported that students were initially extremely enthusiastic about receiving their Tablets, and did much of the learning of its functions on their own, over the Christmas holidays (the Tablet PCs were delivered to the students a week or so before the Christmas break). They noted that the motivational impact of the Tablet PCs on work was still present near the end of the year, but that it had faded considerably as the novelty of the technology wore off and the Tablet PCs became part of the everyday experience of school. Donald noted that his students were very well versed in technology; all of the students interviewed had at least one computer at home in addition to the Tablet, and nearly all had high-speed Internet access as well. He suggested that his students will be too advanced for some introductory technology/business courses at high school (and in fact it was reported that three of the grade 8 students had been given placement in the grade 10 business course next year on the basis of their Northern Lights experience).

The ready channel that the Tablet PCs provided to information by means of their wireless connection to the Internet was seen as having a significant impact on student work:

A big point [is] the accessibility of that information in a timely manner. The kids can have a meaningful chunk of information on a topic within minutes rather than having to go down to the library and search through encyclopedias that are often outdated.

Donald noted that he had seen dramatic improvements in the outcomes of several of his students:

We have a number of special needs kids who are excelling because of their attraction to the technology, their ability to get information in different forms and display it....

He also mentioned a few other students “who if I was to look at the willingness that they came in with to delve deeply into topics they’ve certainly improved—they’ve come a long way.”

Donald also found that the greatly increased amount of multimedia use the Tablet PCs made possible had a real impact on student learning by helping to better meet the requirements of individual learning styles. Video clips and other visual aids when embedded in text worked as a hook to help with reading comprehension and motivation. “We do a lot of visual work, finding images related to subject areas for kids who would initially struggle with language.”

Use of the Tablet PCs had made it possible for him to increase the amount of project-based teaching. He prefers this teaching approach, feeling it instills self-management skills and develops student perseverance and initiative—although “a few kids need help with this if they have not had support with this yet”:

I think the access to technology has allowed me to teach more the way I would like to teach. I like to have kids engaged in what they are doing as opposed to me somehow coming down from above saying “thou shalt learn this at this time.” So where I’m able to come in and answer questions because the kids really want to know at that time in that way, it’s different.

Tablets, Donald noted, had also made it possible for

[Students] to be able to use different ways of presenting their learning, [as these] are made much more accessible because of the technology. And you know it kind of weaves together different things like our Instructional Intelligence initiative in the Board. The ability to use My Manager to create graphic organization to demonstrate higher order thinking, and then discuss it—that is a great thing that the technology has made available.

Only two students showed no real benefits from Tablet PC access, and both were students with what Donald termed motivational and intellectual challenges—“they are shut down in any type of work”.

In our observations, it was found that the students’ social issues presentations made in Donald’s class varied in the degree to which their PowerPoint slide layouts were pedagogically effective; some had too much text on many of their slides, consisting either of whole paragraphs or long lists that were hard to read. Other presentations made effective use of bulleted points to draw attention to the central issues of their talk. Nearly all of the presentations demonstrated the students’ ability to develop complex slide layouts incorporating images, wrapped text, slide transitions, and in some cases builds between points and various animations. A few incorporated video clips. Conceptually, most presentations presented a considerable amount of detail on their topic, and had clearly been well researched, with a number of Web sites cited as references. Diagrams, charts, and photographs had been well selected to illustrate and explain key points. The primary area of variance was in the degree of conceptual

coherence of the overall structure of the presentation—some appeared to be loosely amalgamated pieces from various sources that were little more than a pastiche, but the better ones were very well organized, presenting a logical progression through elements of the topic, with the right level of detail at each stage. Oral delivery varied considerably. Some students read the contents of the slides (a common practice when the slides contained too much information). Others read from a talking script as if they were giving a speech. The best presenters consulted notes but did not read verbatim. Presentations had to be followed up with some assessment of the audience’s learning. Some presenters handed out worksheets or quizzes that were completed and then taken up, others asked questions that recapitulated or extended elements of their presentation. Overall the quality of the presentations was strong for students at the grade eight level. Indeed, one of the report co-authors (Owston) compared the quality of the best student work to that of teachers in his graduate education classes! Donald was quite pleased with the outcomes: “It looks like we have done something right because I thought they were pretty well done for grade 8 students”.

Bill noted that he saw the Tablet PCs as giving kids another medium with additional capabilities, which helped certain students “who had trouble getting stuff done on paper”. Dana noticed that in her limited experience the students demonstrated a high level of competence and comfort in using the Tablets; one girl who gave a presentation in French for example was very fluent in the use of PowerPoint. However she pointed out some problematic outcomes of having students bring Tablet PCs to French class: the inappropriate and unauthorized use of translation services on the Web (discussed above), and the unsanctioned playing of games on Tablet PCs during class. Game playing was also an issue for Bill, and had been observed occasionally in Donald’s class although he did not mention it in his interviews. Dana had a policy of taking Tablet PCs away from students caught gaming, but she found it hard to control this activity, as students would quickly shut down their Tablet PCs if she approached, and hid them under their desks. Dana commented that the grade eight students were not where they should be in terms of their French skills, and that they were much less motivated than other classes she had had at other schools. She thought the Tablet PC too powerful and advanced for what her students were capable of in French. She and Bill both noted that from their experience students at this school were not nearly as advanced as those in another, more affluent area of the school board, and that “unbelievable” things would happen if the Tablet PCs were made available to these more advanced students.

Collaboration

The use of the Tablet PCs did not appear to foster major increases in collaboration either amongst teachers or students. Donald had already instituted a focus on collaborative work in his class prior to Tablet PC introduction, and while the use of the Tablet PCs did not impede this orientation, neither did it appear to enhance it significantly. The only activity that went beyond his conventional collaborative pedagogy—the use of the SharePoint Portal Server as a means for encouraging dialog around initial drafts of essays—was only partially successful due to its technical problems and was not tried again. The small group collaborations observed would have happened without the Tablet PCs being present. While less formal collaborations between pairs of Tablet-using students on assignments was very occasionally seen, the lack of a need to share computers meant that students worked independently on their own Tablet PCs the vast majority of the time. As with any traditional seatwork, students would ask each other questions or peer over to see what others were doing. The one area in which collaboration did rise above the norm was in learning about the technology itself. Different students would master different applications and then become a source of support for their peers.

Bill did initiate one project—the use of the Monopoly Tycoon simulation game—which engendered more cooperation than normal activities:

In this game I'm noticing that those who are able to play the multi-player game are actually going back and forth to one another, they are working together to figure out how things work. It is basically self-taught, this program, unless they use tutorials to teach themselves. So there is a lot positive collaboration.

At the teacher level, attempts to build a collaborative community using the SharePoint Portal Server had not proved very effective to date. As the principal pointed out, despite several teachers receiving some SharePoint Portal Server training, “we haven't gotten to the point where now teachers could log in onto the SharePoint Portal Server, and literally have a collaborative environment—sit down in the same room, work on the same unit.”

Even attempts to instigate reflective discussions on pedagogy by the administration had not been productive. No extended discussion threads had developed, and the SharePoint Portal Server never became a nexus for sustained dialog, a deficiency noted by Donald. Some teachers had issues about what work would be expected of them at home in terms of using the SharePoint Portal Server; more were concerned about security and who would have access to the site (e.g., some school board staff could view messages). The principal pointed out

that the teachers need to feel safe if they are to meaningfully participate in discussions.

Student perspectives on Tablet PC use

A usage survey conducted in-class in early May found that some of the capabilities that the Tablet PC and its associated software offered were not being used (and were sometimes unknown) by most students. Only forty percent or less were using their Tablet PCs to transfer paper forms into Journal templates or import files into Journal; add ink to email; use stationery in Journal; set up handwriting recognition; use gestures as editing commands; customize the Input Panel; create quick gestures in Sticky Notes; use Microsoft Reader; or use voice commands or add ink notes in PowerPoint presentations. No use was made by anyone of Outlook and few knew of its capabilities. Most students did know that they could handwrite emails; nor had they used the right-click feature of the stylus; the stylus to annotate document images; Sticky Notes to jot down notes and memos; digital ink in Office applications; ink on slides, notes, or outlines; or used the Tablet's wireless capabilities at home. (See the Appendix for the survey results in detail). It appeared that nearly all students knew most of the basic Tablet PC functions but were not aware of and/or had not tried some of the more advanced capabilities the Tablet PCs had to offer.

This was corroborated both in our observations and in the student and teacher interviews. Students were witnessed using OneNote and Journal to draw, write, and type in text, and Sticky Notes were created, but the use of handwriting recognition was never observed, nor were any of the other advanced features listed above seen in action. In the student interviews, several respondents indicated that they had never used handwriting recognition, a few others had tried it but were not currently using it due to its lack of accuracy or because they type faster than they write. One made use of it intermittently use when in slate mode, and another used it all the time as her typing is too slow. Outlook was never reported as being used although a few students were interested in doing so. However private Hotmail accounts were actively used, sometimes to send each other documents for printing when one or another student could not print from his Tablet PC for technical reasons. Students had been told they would be getting school email accounts but said they never received them.

Nearly all students reported liking using the stylus for some aspects of art work, especially creating comics, but there was a division between the "serious" art students and the rest. The former (with one exception) preferred traditional

media for more serious work. The exception used Photoshop daily at home on her Tablet PC to do anime art, and she found Photoshop ideal for this form of comic art. The more “recreational” art students who were not so good at drawing liked the capabilities Photoshop gave them and preferred to create on their Tablets. They found the stylus as used in Photoshop made it easier to draw. One student used it extensively for her digital photography work. One of the serious artists complained that using the Tablet PC had resulted in her getting lower marks in art – dropping from the 90s into the 70s and 80s. She felt she could not be as creative anymore, and art no longer was fun for her. Several students reported that after several classes of Photoshop use to alter images and draw, art got boring and “everyone hated it” – “everyone started cheering when the teacher brought in paper after using Photoshop a long time”. Nonetheless, two students were currently drawing masks on their Tablet PCs for Art class.

In addition to drawing, students reported making use of digital ink for creating quick diagrams for math and other subjects. A few had used it mark up imported documents or images in OneNote or Journal, but only occasionally. Only one mentioned using highlighting during a PowerPoint presentation. Two students indicated they would ink in homework reminders in Sticky Notes and thought this worked better than the bound agenda the school provided for that purpose.

Students generally preferred to use OneNote over Journal, finding it more powerful. Several students indicated that they had used OneNote more in the earlier part of the year for notetaking in Geography and History, but that now they were not doing so much writing. A few stated that their interest in using the program had dropped and they were more inclined now to write on paper. Two students indicated they much preferred to type in Word. The copying and pasting of outside elements like images and text, or audio from Web pages into OneNote or Journal was more common than the importation of whole files. A few students had used the auto-citation feature when moving in Web content, and found it useful, as it allowed them to easily get back to the source for more information. Students did use inking in OneNote on occasion in History and Geography when it was required, and most reported combining inked input with text a few times. Four of the twelve interviewed stated that they were still using OneNote “a lot” or every day. One offered an interesting perspective on the flexibility OneNote offers:

It’s really interesting having like different ways of doing it so you could say like, say you are using something in OneNote and you are just typing it out and suddenly you have to draw a diagram just quickly switch to Tablet PC

mode and start drawing. And then as soon as you are done with that you could switch back, and it's just handy to have.

A few students noted that editing was challenging in OneNote; it was difficult to select only the items you wanted to move or delete without affecting other elements of the document, and hard to get back to text mode after adding drawing elements. One girl noted that the font always defaulted to Verdana when she reentered text mode, which irritated her.

PowerPoint was used by every student to some degree; it was employed for presentations in Language Arts, French, Science, Health, and Geography. It was found to be easy to use, although one student pointed out that Movie Maker was better for building animated shows. There is little doubt that it proved a valuable aid in both building student confidence with respect to presenting in front of others, and holding other students' interest during the presentation. One student expressed this tellingly:

I found using PowerPoint I could talk for a lot longer and keep the audience's attention because usually school speeches we don't go more than five or six minutes because you lose attention and people stop listening but with the Tablet PC you can have visual aids to help you, I thought that was a cool thing.

Other applications used by nearly all students included Word, Excel (for Mathematics and graphing), and Movie Maker (for Health projects). Several of them had attempted to use the speech recognition feature for voice commands but nearly all felt it did not work well, although one girl was able to use it at home in a quieter environment. SharePoint Portal Server use had been limited to the commenting on each other's essays on life turning points in Language Arts; one student stated that about $\frac{3}{4}$ of the class couldn't access others work initially. Their teacher Donald was reported to have posted assignments and links for science a few times afterwards to the site, "but then nobody did it and he gave it up" – "he went back to the books". A specific question and answer assignment for optics was mentioned as being posted. This was partially supported by another student who said that Donald "always" posted the assignments at first but then stopped doing so. A few students had accessed the SharePoint Portal Server from home to check on homework or post.

Internet access was also a major use reported by students, and observed in classes. Eight of the twelve indicated that they accessed it every day, and they thought it important as a research tool, with a few mentioning that they used it more than the resource room for that purpose.

The playing of music while working in class was mentioned by several students. Teachers generally allowed this practice as long as students were doing individual seatwork and used headphones, and we observed it regularly.

Some students interviewed felt that Tablet PC use had had a significant impact on their course grades. Four reported better grades in one or more subjects and attributed that to some extent to Tablet PC use. One student remarked that with the Tablet PC always available doing homework was more efficient, and this had affected her grades, another noted that the Tablet PC made it easier to do work. Two students specifically cited spellchecking as helping their Language Arts grade. Another stated that her PowerPoint presentations had improved her Language Arts outcome. Four other students, however, saw no change in their performance this year, and another three remarked that their Science or Geography grade had suffered due to lost work as a result of network and Tablet PC reliability problems.

When asked how they had learned to use their Tablets, students recounted that Donald had showed them the basic operations with respect to pen use, and given them a lesson working with the Tablet PC and writing on the screen. Bill had taught them Photoshop basics for Art. Eight students indicated that most of their Tablet PC learnings had developed from experimenting with it, building on their extant computer skills in Windows XP or earlier editions. Two worked with a friend to learn, and others reported getting help from and helping others at times. Three students indicated they wanted to learn about Outlook, and a few others mentioned different applications they wanted to know how to use, including Publisher, Music Café, CD maker, and infrared file transmission.

There were several features and capacities of the Tablet PC that students liked. A number mentioned that it served as a strong tool for organizing and saving their work in one location. A few stated that their typing was much neater or more efficient than their writing, which made Tablet PC use worthwhile. Other aspects cited by one or two students when asked what they like about the Tablet PC included the capacity to both type and write as needed, spell checking, the use of graph paper in OneNote for math, the use of Sticky Notes for homework and other reminders, the use of PowerPoint for presentations, instant access to the Internet, its use for art, and the use of the pen. Three students noted that it made school more fun and interesting, although another indicated that this was no longer the case for her. Other comments included “it was a good experience”, that it was a “privilege” to use it, and that you could do much more with it. Nearly all viewed a Tablet PC as superior to and more desirable than a conventional notebook, valuing the added flexibility provided by the stylus input option. Several students remarked spontaneously that they were going to miss not

having it next year in high school. “I am not looking forward to going back to binders,” a girl noted.

Students were far from entirely happy with the way the Tablet PC project had unfolded, however. Their major complaints centred around the technical problems and unreliability of various aspects of the technology, from clips and latches that broke off too easily and had to be replaced on nearly all Tablets, to networking issues. The process of synchronizing files between the local hard drive of the laptop and the student’s server space was unreliable, not fully understood by students, and often very slow as a whole class of students would attempt to synchronize over a shared 802.11b wireless access point with a maximum total throughput of 4 or 5 megabits per second. This also created havoc when students tried to download large applications or play Monopoly Tycoon with each other (the latter could only be done successfully using Tablet PCs with wired network connections). Further compounding the speed problem was the fact that when the Tablet PC batteries were drained to a certain point the Tablet PC would reduce the strength of the wireless networking signal and slow down or cease any network transmissions—and students were not very consistent in charging up their Tablet PCs and keeping them charged. Even at best a fully charged Tablet PC would be good for only a few hours’ use if networking was regularly being used or music being played. Plans to regularly have students use a docking trolley for recharging never worked out due to student timetabling issues, with students having to take their Tablet PCs to other rooms for rotary classes.

Many students reported problems with lost work files. Some of this happened because students were not storing files in the right locations prior to having their Tablet PCs reimaged—and the whole set of Tablet PCs was reimaged twice, in mid January and over the March break. In addition students reported that nearly everyone’s Tablet PC had to be reimaged at some other point due to hardware or software problems. Other losses had other causes, including waylaid file placements on the server and unreliable synchronizing. If students were working on documents while on the network via wireless in class, these documents were not being saved locally, but on the server, and only synchronized locally on shutdown or logoff. Thus, if the network failed during the class, files and work could be lost or at best be inaccessible until the network was back up. Applications did not work well in response to losing access to remotely located files, according to the head of the IT department that structured and maintained the Tablet PC environment. Students complained of lost work that had to be redone, with teachers sometimes being skeptical of this “excuse” for missing work (which one teacher joked about as being the modern equivalent to “the dog ate my homework” excuse). Other technical glitches would occasionally occur when

students attempted to make presentations using PowerPoint. Connecting to the projector would often require several minutes and teacher help; in one instance a video clip could not be made to play back with sound. At one point due to a virus no student could access their presentations for a few days.

The high level of restrictions IT services had put on user access to Tablet PC system functions like control panels etc. led to some situations that irritated the students. Without access to the task manager, and with no reset button, the only way they could restore functionality if an application locked up on the Tablet PC was to remove the unit's battery. If the stylus got misaligned—which a few students complained about—this could not be corrected by rerunning the alignment routine because access to it too was restricted. Playing music or downloading files caused freezes or screen problems at times. For no obvious reason printing often proved non-functional from certain Tablets, while at the same time working fine on other ones. Only three of the 12 interviewed students reported being relatively problem-free with their Tablets.

Despite the small Tablet PC screen size, only two students mentioned this as an issue for them. A few noted that the touchpad was overly touch sensitive or prone to miscuing cursor positions.

Technical issues plagued some students' home use of Tablet PCs as well. Three students found they could not get their wireless router working at home with the service provided by the project, and a few others noted that it had worked until their Tablet PCs were reimaged. "It doesn't work for me or any of my friends" one remarked. Several students did have success using the router, but some just opted to link up their Tablet PC using a wired connection at home.

Two thirds of the students indicated that they took their Tablet PC home every day, although two of these said they might not use it if they had no homework. Others would take theirs home when they had homework to do. One student said she did everything that was not required to be on paper on her Tablet; two others stated that they prefer to do math homework on paper. Only two students indicated that they left their Tablet PCs at school, one because the Tablet PC did not have Internet access at home so he did his homework on the family computer which had this access for his research. Most students used their Tablet PCs at home to complete homework, but a few boys indicated that they also played games on them. One girl was using it to write a novel, and another to do her anime artwork; a third had tried to make a movie with Movie Maker.

Only three responses were received to an end-of year parental survey about home use of the Tablet. Of the three respondents, two had attempted to set up the home router; it did not work for one, and worked intermittently for the

second. One indicated that their child used the Tablet PC for 6 or more hours per week to do homework; the second, 4 to 5 hours, and the third, one hour or less. Student uses cited by all three respondents were Internet research and creating PowerPoint presentations. Writing or drawing with the stylus was done by two students. Other uses all cited were playing games, listening to music, and emailing. Two parents indicated that had used the Tablet PC to view their child's work but none had used the password provided to log into the student SharePoint Portal Server.

Technical issues

Students were not the only ones aggravated by technical difficulties over the course of the pilot trial. The teachers—especially Donald, who made the most extensive use of the Tablets—also found the system reliability inadequate. File server access and file retrieval had been in his words a “disaster”: “the network was not reliable so even if the documents and work are stored in the correct places on SharePoint [Portal Server] or any of the other storage area they are not always consistently accessible”. Impacted by various virus attacks, the network had gone up and down “like a yo-yo”, and the educational consequences were significant:

You got issues because there are going to be some really great electronic things you want to have the kids access, well they are not there. And we actually had quite a stressful time around as we were getting into the final weeks prior to the second term report cards where assignments were unable to be retrieved, were missing, had been moved to different directories, had not been properly saved by the kids – you know a whole bunch of things. So that caused problems being able to gather data to effectively assess. [Donald]

Donald went on to make that point that “when we are asking the students to access the Internet either to read particular pieces of information or where we really want them synthesizing different media, so we've got kids going out and finding Flash animations, JAVA tutorials or little video clips or whatever, and they embed that link in their presentation, they need to have it [accessible].”

Donald thought that part of the file transfer problems initially resulted from a lack of communication on the part of IT staff to students on how to save their work and shut down before leaving school. As a consequence students would just put their computer to sleep and so would fail to synchronize before leaving the building, and consequently their work would not be downloaded to the local drive.

Long downloading times were an issue for Bill as well. While he thought the equipment generally worked well, the wireless network was inadequate for downloading:

If I want something downloaded [by students] for the afternoon I have to go to them in the morning and say download this package throughout the day just so it gets done. And I mean again, that's where the frustration comes in [that] students don't want to be involved in.

At one point when Donald was preparing his class for a test the network went down for a few days. Because the system was not at that time storing the students' notes on their own Tablets, he was forced to conduct review sessions and share notes, delaying the test for many days. On another occasion a certain amount of student work was lost and a "whole ton" of work relocated on the server in way that it could not easily be retrieved: "essentially when you are dealing with kids it might as well be lost at that point because we can't find it."

Donald noted that reliability had improved somewhat in the last several weeks but that there was still a long way to go; problems had recently prevented his students from making presentations. He commented that these breakdowns not only eat up instructional time but put him in a position where he has to have backup plans for everything as nothing can be relied upon, increasing the preparation burdens on him substantially. (He also indicated that what he called "tourist visits" and media visits had further eroded his teaching time.) Donald stated that what was needed was a ½ time technician solely devoted to servicing the project, because the current IT staff with their board-wide responsibilities had different priorities and could often not respond in a timely manner to technical issues.

As far as the Tablet PCs themselves were concerned, he thought their reliability and robustness needed to be improved, and he felt the screen posed a possible ergonomic danger as he thought it was too small and dim for children to be staring at for hours a day

Implementation issues

The major issues that Donald and to a lesser extent the other two grade eight teachers had with the Tablet PC implementation process were with the lack of training and pedagogical supports such as release time and resources provided in the project. As Donald put it, "I really think that a part that is missing in this whole project is a realization it wasn't [about] simply dropping Tablet PCs in the classroom."

As Donald saw it, training had been repeatedly promised, but never delivered; Donald had only a very brief introductory Tablet PC session with a Board consultant, and learned the system's functions on his own. SharePoint Portal Server training had also been promised but never materialized. On the level of curriculum support, he had, as requested by Microsoft, provided them with his curriculum outlines, including links to the Ontario curriculum, both in mid-January and again in mid-April, but had no followup support despite promises of same. He was never notified that these items had not been not considered specific enough by Microsoft, and when he heard this he stated these outlines were what teachers worked with, and to expect lesson plans to be provided was "unrealistic".

Another area he felt had been discussed a lot but never followed up on was the provision of some release time to allow him to seek out the appropriate curriculum resources, Web sites, and other knowledge needed to push his teaching forward using the new technologies. He saw this as being even more important in light of the school's move away from conventional texts to electronic resources, which left him with less fallback resources when there were problems or no time to plan. He described the constraints he saw himself operating under:

You cannot say to teacher A, well in your class we are going to have Tablet PC PCs therefore, your planning is going to take five times longer than the teacher next door who has got all of their stuff delivered to them in black line masters and can teach from that and go beyond. And, oh by the way not only are we going to do that, where it's going to require five times more planning, but every second day there is going to be a tour group in your classroom wanting to know what you are doing and the press is going to be in there gathering data and Microsoft is just going to be calling you saying what are you doing?... I mean I know here there's a whole lot of teachers who frequently say they are so glad it's not them having to do all this stuff.

He saw a need for curriculum teams to be developing materials for ICT-rich teaching in a manner parallel to that pursued in more conventional curriculum team development work. He had suggested "months ago" that resources need to be made available so that there could be powerful packages created to support teachers in all subject areas who are working with the Tablets.

To some extent Donald felt that he had been left out of the planning process—he had only participated in two of the weekly conference calls on the project—and stated that if he was organizing the project he would ensure fuller participation of the person who would be implementing the initiative in the classroom. He felt there needed to be better communication around issues in the

project, so that people have specific responsibilities, and users know who to contact when problems arise. Speaking more generally, Donald argued that Microsoft “needs to work [more] on appreciating the educational world.” By saying this Donald was implying that Microsoft needs to understand that teachers cannot easily be available for conference calls during the school day, and that they normally do not have daily lesson plans into which Tablet PC activities can be readily inserted—teachers have to work with the curriculum expectations from the Ontario Ministry of Education.

Both Bill and Dana expressed concerns about the lack of training and pedagogical support they had received and Dana particularly felt that she could have been more successful had these been provided.

Moving forward: Ideal applications of the Tablet

When the grade eight teachers were asked what thoughts they had about ideal Tablet PC applications in their subject areas, they put forward a number of interesting possibilities.

Dana saw potential in buying the digital rights to only those sections of the French texts that were actually used, so that the cost of buying full sets of materials when only some would be used could be avoided. She saw the auditory and text-to-speech functions of the Tablet PC as a potentially valuable resource for teaching and testing oral language. Students could hear a question in French and then respond orally. The text to speech function could help students connect the written text to the sound of the spoken word. She also saw advantages in extending the use of Web sites to heighten interest and learning in French.

Bill indicated that he would like to see specific curriculum-oriented software tools and Web links made available in a folder on the server, for example, a folder for Geography. He also thought that a paperless administrative system would be a major advantage, using the server to deliver assignments and communications to parents. He wanted tools that would allow the incorporation of multimedia in assignments. And he wanted to use the Tablet PCs in a way that supported a more project-oriented teaching approach. “Students get more out of learning when they find things themselves – my job [is] to direct that, not spoon feed.” He thought that providing students with experience using technology that they will eventually use in their jobs was ideal.

Donald wanted to see the addition of chat to the SharePoint Portal Server, and a more student-friendly interface (more like that of First Class) to reduce barriers to student use. He also called for a wireless projector that would allow

students to instantly connect with a push of the button, so he could call on any student to display their Tablet-based work for discussion. He wanted to see students doing larger, more applied projects rather than just PowerPoint presentations. He gave some examples for the Science course: collecting field data on stress in bridges, or water quality data, using probes attached to Tablets, and then analyzing it and sharing results with remote schools.

Conclusions and Recommendations

Overall, given that the Northern Lights staff opened a new technically-advanced school last September and received the Tablet PCs with almost no training on their use, and that students used them for about half of the school year, we believe that the project was as successful as one could have reasonably expected. This success was largely due to the commitment and dedication of the teachers, the school's administration, and school board technical and professional staff. Teachers in all grades made regular use of the Tablet PCs to perform a variety of functions, including email, lesson planning, student record keeping, communicating with parents, and doing more interactive activities with students via the Smartboard. They appreciated having their own personal Tablet, its portability, and having access to the school's wireless network whenever they wanted. Donald, the grade 8 homeroom teacher whose students had their own personal Tablet, found that the Tablet PC supported his particular pedagogical approach well—an approach that emphasizes adaptation to individual learning styles, a focus on cross curricular project-based work, student self-management, and student initiative. The other two teachers saw the potential of the Tablet PCs to support student work in their subject areas as well, although they did not make as extensive use of them with their students.

Credit for success must also be give to the grade eight students for their support and enthusiasm for the project. They were enthusiastic and proud to have them. Moreover, they became more motivated toward and engaged in their schoolwork as a result of having their own personal Tablet, and most endured frustrations with aplomb when technical problems caused lost work and frozen machines. Their teachers and students alike, with a few exceptions, felt that the quality of their work had improved: they were able to make sustained formal presentations with PowerPoint; organize and store their work more efficiently; readily develop concept maps; graph data; do Internet research anytime at home or at school; and seamlessly integrate text and handwritten diagrams into documents. As a result, in subjects where Tablet PCs were extensively used such

as Language Arts, there was general consensus that on the whole some student grades improved slightly, although we do not have test data to support this conclusion.

The project was not without its share of difficulties, however. Most outstanding was the lack of teacher support for Tablet PC use. Three areas of support deficiency were noted. First, teachers had only a cursory introduction to the technical operations of the Tablet PCs and were left to their own devices to learn them. This was unfortunate as the Tablet PC has many unique features which, by the end of the school year, teachers never knew existed or had heard about them but did not know how to use them or why they would want to do so. Second, the grade eight teachers did not receive support for integrating Tablet PCs into the curriculum. Teachers had to draw upon their own experiences in using computers, which did not include experience with Tablets. As a result it took considerable time and effort for teachers to both learn about the unique features of the Tablet PC on their own and then devise ways of integrating them into the curriculum. And thirdly, teaching release time was not provided to the eighth grade teachers for planning purposes. This placed a Herculean burden on the homeroom teacher in particular as he had to deal with learning the Tablet PC himself, rethinking his curriculum, devising new teaching strategies and student assignments, and also had to spend time dealing with technical hurdles and coping with media interviews and frequent visitors to his classroom. Given these burdens, it is hardly surprising that neither he nor the other grade eight teachers felt they had been able to fully exploit the potential of the Tablet PCs to support innovative teaching practices and deeper student learning.

The other major area of difficulty for the project was with technical matters. Foremost was network capacity and reliability. The relatively low capacity of the network did not allow for many simultaneous network transactions by students. For example, it is not uncommon for teachers when doing direct instruction to ask all students to perform the same operation (e.g., “Everyone now save your work and close your Tablet”), so the network must be able to withstand this load. The network was also incapable of handling an interactive online simulation that the school board uses. Lack of reliability caused teachers to substantially alter their plans when the network was down. Users can tolerate occasional down time but frequent down time can lead to avoidance of the network and the significant features that it can offer for teaching and learning. Synchronization of files also appeared to be problematic which resulted in lost student work. Physical deficiencies noted with the Tablets, while not serious, need to be addressed. Lastly, while we do not have precise data, all indications

were that the wireless access from students' homes was far from successful as many students/parents reportedly could not get it working.

None of these above issues are insurmountable, however there are resource implications if they are to be remedied. Nor are there any inherent problems with the Tablet PCs that would prevent them from being an effective tool to support teaching and learning. In fact, we believe that Tablet PCs have considerable advantages over currently available notebook computers and desktop systems in the elementary school environment (provided that the cost premium involved is reasonable).

We now offer recommendations that we think will strengthen the current project and have implications for sites contemplating using Tablets.

Recommendation 1. Teachers need to be provided with technical training on how to use all features of the Tablet. This training needs to be provided at regular intervals throughout the school year. A one-shot workshop approach will not be successful as teachers need opportunities to learn features, try them out, and ask questions.

Recommendation 2. Teachers need to be provided with ongoing support for integrating Tablet PCs into their curricula. Again this support needs to go far beyond the occasional workshop. Current research on teacher professional development suggests that for it to be effective, professional development must be long-term, school-based, collaborative, focused on students' learning, and linked to curricula. This implies that teachers need opportunities to experiment with the Tablets, assess student outcomes, reflect on their experiences, and share them with colleagues and professional development facilitators on a regular schedule throughout the school year.

Recommendation 3. Consider mounting a late August voluntary professional development institute for teachers to launch both recommendations 1 and 2. Although teachers cannot be required to attend a professional development activity at that time of year, many schools and districts offer professional learning activities at this time as teachers are not yet involved in typical time-consuming beginning-of-year activities. We believe there is enough good will and commitment from Northern Lights teachers to voluntarily attend such an institute. To the contrary, if assistance is not offered at the beginning of the year, teachers may be less inclined to continue to support the Tablet PC initiative at the school or may never learn its unique features.

Recommendation 4. Provide teachers with resources to assist them in integrating Tablet PCs into their teaching. Admittedly, the Tablet PC is a new technology, nonetheless there is an immediate need for curriculum-related

teaching resources. The resources at the Microsoft.com website focus almost exclusively on the merits of the Tablet PC or on how to use it technically. The website also contains links to other schools/districts where Tablet PCs are in use, but these sites provide only general descriptions of projects. Microsoft could provide an outstanding service to educators if they developed a network (possibly in the SharePoint Portal Server) for teachers to exchange Tablet PC lesson plans and teaching ideas.³

Recommendation 5. Thoroughly test the Tablet PC synchronize function in actual classroom settings to identify and correct any technical difficulties. A technical assessment of the Tablet PCs was beyond the scope of this report. Nevertheless we have enough anecdotal evidence to recommend that Microsoft technical staff should carefully log and study all possible scenarios in an actual classroom of synchronization difficulties. Only by having students perform multiple operations on a live network will the many reported synchronization problems be accurately diagnosed.

Recommendation 6. Provide increased technical support to Northern Lights. The technical support staff, although functioning under heavy workload outside of Northern Lights as well, did their best at supporting the project. Unfortunately, for the startup of a technically advanced network, sufficient support was not available which resulted in undesirable pedagogical consequences. The Tablet PCs themselves require considerable support, both for image updating and recurrent maintenance. Therefore, we recommend that the school board and Microsoft develop a more robust support strategy for the upcoming school year. We would expect that in the following year support could be lessened as issues become resolved and experience is gained.

Recommendation 7. Reassess the strategy of providing wireless home access to students. The notion of wireless access at home for students is a commendable strategy, however unless adequate resources are available to support this mode of access, we suggest that it be discontinued as it is an inefficient use of resources when so many did not operate. Other options are to provide students with a wireless router for their existing Internet service provider, or to ensure equity, provide access only to those parents/guardians requesting access,

Recommendation 8. In order to foster a stronger learning community, designate a teacher to be the SharePoint Portal Server facilitator. All agreed that the SharePoint Portal Server was a valuable resource, but acknowledged that for a

³ The Apple Learning Interchange (www.ali.apple.com) is an example of a widely-used vendor supported teacher resource site.

variety of reasons it was not fully used. Our experience suggests that it is rare for a learning community to flourish without a strong and active facilitator. Therefore, we suggest that the school consider designating a teacher to have this responsibility. In fairness, the teacher would have to be compensated with release from some teaching or other school duties. Very importantly, the teacher should receive training and support from the school board on how to successfully accomplish this task. Additionally, the teacher discussions should not be accessible by school board personnel.

Recommendation 9. Continue with the formal evaluation of the project next year with a year-long research plan. Because of unanticipated delays we did not begin the evaluation of Northern Lights Tablet PC usage until late March. This did not allow for time to implement a full-fledged evaluation that included identifying and enlisting a comparison school to gauge student achievement. Nor was it a sufficient length of time until the end of the school year to expect students to demonstrate measurable learning outcomes resulting from Tablet PC usage. For next year, we recommend identifying a comparison school at the onset and having the students take the same achievement tests at the beginning and end of the school year. Continuous observation over the whole school year to document changes in teaching practice and student learning would be desirable too, as would using the system logging routine Microsoft had intended to have ready for this evaluation. Software that allows teachers to view individual student screens would be helpful for the researchers to see what students are actually doing and would be less intrusive than looking over students' shoulders. Lastly, if teacher and technical support issues above are fully addressed so that teachers can better exploit the potential of Tablet PC technology, we will be in a position to more fully describe and document the unique educational value of Tablet PCs for elementary education.

Appendix A

Student Tablet PC Survey Results (n=27)

Question	% of students responding "yes"
Did you know that you can convert handwriting and speech in multiple languages into typed text by using Tablet PC Recognizer Pack?	48
Have you tried to transfer your paper forms into templates in Microsoft Windows XP Tablet PC Edition Journal?	22
Did you know that you can write e-mails in your own hand on the Tablet PC, or just add a handwritten word or drawing to personalize your typed text e-mails?	63
Did you use this feature?	26
Have you tried to Personalize Journal Notes by Using Stationery?	37
Did you try to set up handwriting recognition on your Tablet PC, switch between language dictionaries?	26
You can work mouse-free thanks to the Tablet PC pen. Have you used right click on your pen?	100
Was it easy to use?	69
Did you use gestures in Tablet PC Input Panel and Windows XP Tablet PC Edition Journal?	11
Like a keyboard shortcut, the start Input Panel gesture lets you use your Tablet PC pen to gain fast access to this often-used Tablet PC utility. Did you know about this?	22
Did you use this feature?	15
Have you tried to customize Input Panel to improve handwriting accuracy and speed, based on how you work?	19
Input panel also can be used to dictate text using speech recognition features. Did you use these features?	74
Did you tried to import documents and other materials in Journal?	37
Did you use your Tablet PC pen to annotate document images	81
Did you know that it works with reports, forms, photos, Web pages?	44
Did you know that you can "promote" any note to an Outlook task? Once you create a task out of a note you have all the functionality of Outlook to manage your task?	4
In OneNote 2003, you can create outlook tasks from items in your notes, and send as email directly from OneNote thanks to Outlook	4

2003. Have you tried that?

Have you used offline files and offline Web pages to keep network files available as you go home with Tablet?	41
Have you used Sticky Notes for:	
Writing notes down?	89
Creating quick gestures?	12
Recording quick memos?	85
Have you used Microsoft Reader?	0
Did you use pen and digital ink in any of the Office applications?	75
Did you know that you can talk to Outlook as a method of entering contents in an e-mail or dialog box field by using the Tablet PC Speech feature?	26
Did you use handwriting on slides, notes, and the outline?	78
Did you work on presentations with voice commands?	11
Did you run a presentation from your Tablet PC?	100
Did you use ink to add notes during a presentation?	22
Did you change the presentation orientation?	78
Did you use Tablet PC's wireless capabilities at home?	59
Did you use ink with Outlook?	4
Did you work in Outlook with voice commands?	7
Did you send Journal Notes to Outlook?	4
