HARVESTING FRAGMENTS OF TIME

Mobile Learning Pilot Project

EVALUATION TEAM REPORT

Judy Roberts, B.A. (Hons), M.A.
Naomi Beke, B.A., M.Sc.
Katharine Janzen, B.Sc.N., Ed.D.
Dawn Mercer, Ph.D.
Elaine Soetaert, M.Ed.

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Dear Educator,

As Co-chair and Chair of the Mobile Learning Consortium, David Cho and I are extremely pleased to present this research report on the outcomes of the Mobile Learning Pilot Project.

This project was initiated by a simple question asked by Henry Hirschberg, Group President for Higher Education at McGraw-Hill Companies, Inc, and John Dill, CEO of McGraw-Hill Ryerson Ltd. The question was: What, if anything, can "anytime, anywhere" access to learning material contribute to the education experience?

In June 2001, and with the generous support of Cap Gemini Ernst & Young (CGEY), McGraw-Hill Ryerson invited over 50 people from across the industry to a concept meeting to discuss how to address this important question. Attendees included educators as well as hardware, software, and telecommunications leaders. After all, wireless campuses and wireless enabled devices were (and still are) proliferating. Some even say wireless is the "next big thing."

The outcome of this initial meeting was a plan to develop a pilot project in the accounting discipline that would test the value of integrating wireless-enabled PDAs into the learning process. Dr. Sam Shaw, President of Northern Alberta Institute of Technology and Cindy Hazell, Vice President-Academic of Seneca College bravely committed their institutions to become hosts for this project. Other industry leaders, including Hewlett-Packard, Avaya, Bell Mobility, and Blackboard joined the consortium and devoted a tremendous amount of resources to the project.

In January 2002, the MOU was signed and the pilot project was launched.

This research paper summarizes the results of our research. It reflects the efforts of over 35 people from consortium member organizations over two years and represents the enormous commitment of all key organizations to the advancement of post secondary education in Canada. It also represents a success story as a public-private collaboration that we believe can serve as a model for other institutions and commercial organizations looking to collaborate on large scale projects.

David and I would like to thank all those involved in this landmark project. In particular, I would like to thank the evaluation team for pulling together a report that has integrity and provides terrific insight into the opportunities—and limitations—for wireless enabled education in the near future.

Sincerely,

Petra Cooper
President, Higher Education Division
McGraw-Hill Ryerson

EXECUTIVE SUMMARY

The key finding within which the other results should be understood is that students and instructors recommended that the colleges continue to explore the potential of wireless networks and devices for teaching and learning, and providing college services. The largely subjective results from this project are thus a pilot for this larger vision and are suggestive of possibilities that need to be confirmed in future.

More precisely, the project's objective was to assess the effectiveness and efficiency of handheld wireless technology in a first-year college accounting course as a value-added classroom tool that could:

- enhance student success and achievement of intended learning outcomes,
- increase student access to college services, and
- enlarge the teaching and learning strategies available to faculty.

All stakeholders committed to a comparative design involving students with a wireless Hewlett-Packard iPAQ (PDA) and Control cohorts with the level of technology each college considered as its "standard" for all students; one college also had a laptop group of students, half of whom had a wireless network card. A variety of student and instructor self-report perceptions and quantitative, "third party" data were collected and analyzed using SPSS; tests of significance were conducted where appropriate. Approximately 300 students participated in the study: roughly 100 in the PDA groups, 50 in the laptop group and 150 in the Control groups. Four faculty were involved in content development and teaching.

Based on end-of-semester survey results, all student groups, including the Control groups, thought that the digital content helped them to learn accounting. PDA students reported that Interactive Exercises were most useful to their learning in a significantly higher proportion as compared to the Control group. When PDA student self-report Activity Logs were analyzed, the results showed that the content students thought most helped their learning was also the content that they used the most, i.e., Interactive Exercises, Quizzes (taken as a group) and Chapter Summaries, in that order. Students indicated that faculty used the PDA in class, assigned it for use out of class, and were very comfortable using it themselves.

In their final survey, faculty reported that the digital content helped them to teach accounting, and that Interactive Exercises were particularly useful, but that the PDA device as such did not make accounting more interesting to teach. On the other hand, they were moderately satisfied with the wireless PDA as a learning tool, although they did not think that it contributed much to student learning and believed that students were dissatisfied with the PDA as a learning tool. They thought that the most important new teaching strategy was more student interactivity with content. Instructors reported that they used the PDA in class and assigned it out of class and that they were comfortable using the PDA with the students. They also noted that use of the PDA enabled them to encourage independent student learning because they could adopt a coaching role.

When final grades were examined, the results were inconsistent. At NAIT, the average grade of the PDA students was statistically significantly higher than the average grade of Control students. At Seneca, on the other hand, there was no statistically significant difference between the average grades of students in the PDA and Control groups. The pattern of the Seneca results, contrary to that at NAIT, could be interpreted to mean that the PDA had an adverse effect on average student grades. This is an intriguing finding given that the small iPAQ class sizes (14 and 15) could have led to improved grades due to extra instructor attention. However, these results should be interpreted with caution, especially since learning is a multi-faceted process that mitigates attribution of a result such as this to only one factor such as the effect of technology.

Five key lessons emerge from this pilot that could be useful to anyone contemplating similar work in future. First, the technology has to work reliably. While small screen size and the lack of a keyboard were noted as PDA limitations, they did not generate the level of dissatisfaction that the poor wireless WAN network functionality did. Second, a multi-factor approach to assessment is required. The teaching/learning process is a complex one that needs to be reflected in the assessment of learning. As has been noted in the literature about other technology interventions, it is very difficult to isolate reliably specific cause and effect relationships. Technology also has many dimensions, as demonstrated by the varied levels of satisfaction with the PDA, the wireless networks and "the course overall." Third, both student self-report and server data clearly indicate that the learning activities with a high level of learner-content interactivity were the most used and were perceived as most helpful to learning. Fourth, the Consortium's collective commitment to innovation, accountability, and

credibility was important common ground between the public and private sector stakeholders. Fifth, project management is an effective approach at both the consortium and institutional levels. Leadership alignment and resource allocation both among external agencies and within each stakeholder is critical to success.

Four recommendations are offered to guide future experimentation with wireless networks and devices:

- First, replicate accounting content with different wireless devices. Both faculty and students perceived the content to enhance learning; Interactive Exercises were particularly well received by both groups. However, the PDA device was seen as too small for accounting content and the PDA is not a tool commonly used in the accounting workplace except as an organizer.
- Second, re-examine affordability issues. There are issues to be addressed regarding student accountability for, and ability to absorb, project costs, especially wireless WAN usage.
- Third, explore a range of content. The exploration of content delivery by PDA in only one subject in a student's timetable is not an adequate basis for long-term decisions. Students seemed to indicate that they would integrate wireless devices and networks into their college life more fully if such technology were used in more than one course.
- Finally, offer a diverse suite of college services. To learn anything useful, a range of services, formatted to the wireless device, has to be offered so that the wireless environment becomes a way of life for students.

This project was undertaken by a consortium of public and private stakeholders, who agreed in the fall 2001 to collaborate in a project exploring how ubiquitous student connectivity could add value to teaching, learning, and service provision to college level students. Stakeholders included McGraw-Hill Companies, Inc. and McGraw-Hill Ryerson Ltd.; Bell Mobility; Blackboard; Hewlett-Packard, Avaya; Cap Gemini Ernst & Young; Northern Alberta Institute of Technology (NAIT), and Seneca College of Applied Arts and Technology in Ontario.

1. Project Description

While wireless technology is new and emergent, its application to teaching and learning in college classrooms has the potential to offer significant advantages. For example,

- Students would have more flexibility and choice in where and when they learn outside of the wired (or un-wired) classroom.
- Students would be using technology in their college study that would enhance their readiness for tomorrow's workplace where employers want graduates who know how to use technology for learning and working.
- Given the trend to lifelong learning, many "students" are working adults with full- or part-time jobs. Mobility offers them an opportunity to maximize learning while commuting or during what might otherwise have been "down time."

However, important questions such as the following need to be researched or documented:

- What value-added learning will result?
- How much will students actually take advantage of the potential flexibility offered by the technology?
- What content works best to support learning on a wireless device?
- Are there administrative services that a college could offer (e.g., course registration) and that students could create (e.g., organizing their homework schedule) that lend themselves ideally to wireless technology?
- How will wireless/mobility change traditional analog (i.e., books and documents) and wired web-enabled learning and teaching?

Consequently, a consortium of public and private stakeholders agreed to collaborate in a project exploring **how ubiquitous student connectivity could add value to teaching, learning, and service provision to college level students**. Stakeholders included the McGraw-Hill Companies Inc., and McGraw-Hill Ryerson Ltd.; Bell Mobility; Blackboard; Hewlett-Packard, Avaya; Cap Gemini Ernst & Young; Northern Alberta Institute of Technology (NAIT) and Seneca College of Applied Arts and Technology.

1.1 Goal

More precisely, the project's objective was to assess the effectiveness and efficiency of handheld wireless technology in a first-year college accounting course as a value-added classroom[1] tool that could:

- enhance student success and achievement of intended learning outcomes,
- increase student access to college services, and
- enlarge the teaching and learning strategies available to faculty.

Within this broad goal, specific objectives were developed for each of the three stages of the project: alpha, beta, and full pilot phases.

The **alpha** stage (March 2002) was a **proof-of-concept** phase designed to:

- Test the usability of content and services in terms of the technical repurposing to wireless technology.
- Ensure technology functionality on and off campus wherever content and/or services are to be used by students.

The **beta** phase (May to August 2002) involved **user testing** with the objective of:

[1] Classroom student means a student who physically attends the course in a classroom, not in a distance education mode.

- Testing all content, evaluation, technologies, support capabilities, etc. to be used in the fall 2002 pilot project.

The **full pilot** phase (September to December 2002) was designed to test the efficiency and effectiveness of mobile learning in a conventional college semester, using the evaluation design, instruments, and methods validated in the beta phase. All stakeholders committed to a comparative design involving three groups of students: those with a wireless HP iPAQ (PDA); those with a wireless laptop; and Control cohorts with the level of technology each college considered as "standard" for its students.

1.2 Course Content and Design Principles

"Wireless technology and mobile computing devices are changing so rapidly we need to design curriculum that is scaleable and reusable no matter where the technology takes us... it is truly designing for a "moving target."

– Sandi Barber, NAIT Project Manager

Three types of content were used in the pilot: learning activities, student services, and other applications. Each is briefly described below.

1.2.1 Learning activities

Both colleges used content based on a textbook authored by Larson, Jensen, and Carroll (2002) published by McGraw-Hill Ryerson; at NAIT, the course is Business 106, at Seneca Accounting 106. Decisions on content development were based on several factors including the ability to use existing resources from the textbook such as quizzes, glossary, and Chapter Summaries, the ability to redesign or convert current content to the wireless PDA environment (screen size and bandwidth being key factors), and the ability to design some new content to exploit the potential of the technology.

Once faculty release time was available in January 2002, each college participated actively in designing the wireless course and associated learning activities. Faculty drew upon activities that were already available in the Larson textbook, its printed supplements and Blackboard/WebCT cartridges, and a Seneca online accounting course, to create or customize the types of activities shown in Table 1 for delivery using a PDA.

Table 1: Learning Activities

1.	Learning Objectives
2.	Full Chapter Reviews
3.	Streaming Video Clips
4.	Key Terms/Glossary
5.	Multiple Choice Quiz
6.	True/False Quiz
7.	Fill-in-blank quiz
8.	Glossary Match Quiz
9.	Interactive Exercises
10	Concept Demonstrations
11	MS-Reader Summaries
12	Tetraccounting Game

Some customization of materials was required to conform to the terminology and practice at each college:

- Learning Objectives were referred to as Learning Outcomes at Seneca and were embedded in modules called Learning Outcome Guides at NAIT.
- Course content design met MERLIN requirements, NAIT's digital content repository.
- Interactive Exercises were labelled Journal Entry and Trial Balance activities at Seneca.

NAIT and Seneca also investigated McGraw-Hill Ryerson's GradeSummit (an online diagnostic self-assessment and exam preparation tool for students); it was accessible only by PC.

All students were provided with access to the same learning materials whether they were in the PDA, laptop or Control groups.

General high-level principles governing the learning design and content development included grounding in learning outcomes and experiential learning theory.

1.2.2 Student services

Service applications were adapted for PDA access at each college. Student chatter was real-time instant messaging that sends handwritten as well as text messages; it was developed by NAIT specifically for this project and was made available to students at both colleges from the NAIT server. Seneca's services included online course registration and timetable applications from SIRIS (Student Internet Registration and Information System).

1.2.3 Other applications

The evaluation also captured "unintended" applications that capitalized on the software pre-loaded in the PDA, e.g., the use of the PDA as a personal organizer for key dates, phone numbers, etc. (see Table 2).

Table 2: Other Applications

1. E-mail
2. Calendar
3. Contacts
4. Tasks
5. MS Word
6. Excel
7. MS Reader
8. Personal, e.g., games, music

1.3 Technology Configuration

"The challenges faced on the technical side were not insurmountable. With careful planning and investigation into what is possible with today's technology, we achieved success in using wireless technology to deliver curriculum to the handheld device."

– Kieron Quigley, NAIT
Applications Environmental Specialist

1.3.1 PDA and laptop groups

1.3.1.1 Networks

Students had access to two types of wireless networks during the fall 2002 semester, the city-wide Bell Mobility Wide Area Network (WAN) or each college's wireless Local Area Network (LAN) using Avaya wireless cards.

- *On-campus college wireless LAN*: Both colleges had wireless LAN service available in a limited number of buildings. At Seneca, the service was available in the Information Commons (library), Computer Commons, accounting classroom building, cafeteria, and Administration boardroom; at NAIT, the service was available in the Business Centre (8th Floor, Tower Lounge and 5th Floor, East Wing). The LANs function in theory at 10-11 mbps, practically at 6 mbps; streamed video and high bandwidth graphics were slow depending on the level of network traffic.
- *Off-campus Bell Mobility WAN*: A new 1X network service was available anywhere in Edmonton or Toronto. It functioned like a 56 kbps modem (slower than the campus wireless LAN). Bell Mobility contributed to the project, at no charge to students, a set usage of approximately 10 MB/month/student (i.e., 250 e-mails/month/student). Bell Mobility's normal basic monthly rate is $50 + taxes for 10 MB, and $6 for each additional MB. (**Note**: The WAN card also had cell phone capacity, but this feature was not activated during the project.] Streamed video and animated content plays back at an unacceptable rate on this type of network interface.

1.3.1.2 Course management software

Although all stakeholders envisage content being made available long term for both the WebCT and Blackboard platforms, Blackboard Unplugged was used in the project because of incompatibilities between the availability of the wireless version of WebCT and this project's timelines. A watching brief was maintained regarding developments with wireless WebCT. NAIT used its digital curriculum delivery system to dynamically deliver curriculum to the PDA.

Blackboard Unplugged was developed at Seneca College using Blackboard Building Block functionality, as an adaptation to "Blackboard to Go." It is an alternative interface to Blackboard specifically for a PDA or other reduced screen device. Blackboard Unplugged formats the output in a more compact fashion and allows for off-line access, if required. Thus content within Blackboard can be accessed using a PC or a PDA because the output is device specific.

1.3.1.3 Wireless device

Windows CE Pocket PC was the designated project standard. After a due diligence process, Hewlett Packard's Compaq H3850 iPAQ was selected as the PDA testbed for this project, on the understanding that content would be compatible with any other Windows CE device. At Seneca, in the rooms in which iPAQ classes were scheduled, software and hardware were configured to project the iPAQ screen so the students could follow demonstrations of a variety of functions; Control group classrooms had digital projection with Internet access. At NAIT, projection equipment was available in the iPAQ classes for the entire term but in the Control sections, it was only available in the last few classes at the end of the semester.

1.3.2 Control groups

Control classes at both colleges used the Larson textbook and materials similar to the PDA group except they were configured for full screen size. They had a variety of technologies in their classrooms.

1.4 Student Recruitment

"I am very excited about this PDA project; it will be a great experience for my career."

– NAIT student
Baseline evaluation

First-year **students** in a general accounting course were the primary target group. They were chosen for reasons such as: (1) large numbers, particularly when colleges across Canada are considered, (2) differing levels of commitment and interest in the subject of accounting (e.g., specialized accounting and general business students), and (3) diversity of learning styles. A continuing focus on student success guided all stages of the project. Each college agreed to try to recruit 100 to125 students to participate in the pilot project.

Students volunteered to be in the iPAQ or laptop groups and students were randomly assigned to Control groups. The chronological sequence of the recruitment is as follows:

- In March 2002, all prospective Business Administration students at NAIT were sent a letter that outlined the details of the voluntary **laptop** computer option, which has been offered since 1995. The letter indicated how the technology is incorporated into the classroom as well as the type of laptop that students should purchase. The **wireless option** was mentioned in the first week of classes. At that time, the price of that option was disclosed to the students. Students who agreed to participate in this project paid a $100 technology fee for one wireless WAN card with 10MB/month wireless connectivity for the fall semester.
- In the summer of 2002, a letter was sent to all students eligible to enrol in each college's version of the course informing them of the **PDA option**, its opportunities and costs and, in Seneca's case, inviting them to attend an information session. The goal was to recruit two PDA classes of 30 students each at Seneca and two classes of 40 students each at NAIT (class sizes at each college are different).
- In July 2002, Seneca held an information session about the **PDA option** to be offered for September. At the end of the session, students who wished to participate agreed in writing to purchase an iPAQ for the subsidized price of $450. For that price, they received a wireless LAN card and a wireless WAN card with 10 MB/month of wireless connectivity. Twenty-nine students agreed to purchase this iPAQ package; because two

faculty members had already been seconded to the Program, the 29 students were divided into two cohorts of 15 and 14.

- By the first week of the semester, all the 80 available **PDA positions** at NAIT were filled. Participating students agreed to pay a $150/semester technology fee for the fall semester, inclusive of a wireless LAN card and a wireless WAN card with 10MB/month of wireless connectivity. They were given several options to extend their contract over an additional three semesters or to purchase at a reduced cost at the end of the project. Students were divided into two cohorts of 40 each.
- All students in the iPAQ and laptop classes signed consent forms at the start of the semester confirming their willingness to participate in the research project (i.e., complete surveys, attend focus groups as necessary, allow the research team to track their network access), and to permit the college to take and display their photos. Later, it became clear that to access the students' Bell Mobility data, an addendum to the Seneca consent form was required; it was signed in mid-October.
- Students were randomly assigned to the two classes designated to be the **Control** group. During the first or second class, the project was briefly described and the expectations of the participants in the Control group were outlined. Students who agreed to participate were asked to sign the Declaration of Consent. Of the 82 students in the two Control classes at Seneca, 34 students in one class and 26 in the other signed the consent form for a total of 60. NAIT Control students volunteered to complete the surveys without a formal consent process.

Additional information about students recruited to the three groups is contained in Section 3, **Results and Discussion**.

1.5 Faculty Participation

"The team approach to developing the content was a great learning experience I am so used to doing it all myself; it was great to be a member of a team."

– Seneca Faculty Member

Four instructors were involved in the project, two from each college. At both colleges, each instructor was assigned one iPAQ section and one Control Group section; at NAIT, one instructor also taught the laptop group. All instructors had previously taught the course, and were involved in all phases of the project: i.e., in addition to their teaching duties in the beta and pilot phases, they were actively involved in developing and designing interactive learning materials. Instructors were given release time for the term when they developed the learning materials and were allocated a reduced teaching load for the term when they taught the course.

1.6 Orientation and Technical Support

Colleges provided students with a number of sources of technical support. The start-up process common to both colleges was:

- To expedite student use of the device, all software that was required for the project had been installed and configured ready for student use once they signed the purchase (Seneca) or rental (NAIT) and consent forms.
- In-class training was delivered in the first week or so of the semester by appropriate college staff. Covered topics included the features of the iPAQ, both network cards, the installed software, access to the Internet, the course learning materials using Blackboard Unplugged, how to set up their iPAQ with their desktop, and how to synchronize.
- At that same training, students were informed of technical support resources, including the colleges' online iPAQ Website, and their Help Desks. A printed student orientation

guide was distributed and students were informed about a series of streaming video training modules about the iPAQ that had to be accessed with a PC. [2]

Each college also provided other services, including (1) in-class demonstrations by instructors on specific components and features of the iPAQ as needed, (2) a Help Desk support staff member available via e-mail and phone, and (3) drop-in assistance by technical staff during class time if possible. At NAIT, a volunteer student who was technically knowledgeable assisted students and drop-in sessions were scheduled outside of class time. HP and NAIT collaborated to plan a "cool factor" session, but it was late in the semester and no student chose to attend.

Help Desk staff who had provided instruction for the students as well as other appropriate IT staff also offered support to the faculty. A printed guide was planned for faculty but was not available during the pilot. However, faculty were interviewed regularly by the Content Development Team to provide input to a guide that was developed throughout the semester for future use.

1.7 Level of Effort and Resources

This project was self-funded by its public and private sector partners; partners estimate that they contributed in cash and in kind, at a minimum, in the order of Cdn $1 million. A strategic description of their respective contributions is as follows:

- McGraw-Hill Companies, Inc., and McGraw-Hill Ryerson Ltd.: Steering Committee leadership, project management, content development and adaptation, leadership of the evaluation process, international marketing, and distribution structures.
- Bell Mobility: wireless expertise and service to students.
- Blackboard: web course management system and content cartridge adaptation to wireless format.
- Hewlett-Packard: highly discounted handheld iPAQs and wireless expertise.
- Avaya: highly discounted wireless WAN cards.
- Cap Gemini Ernst & Young: project management, business planning, and solutions integration.
- Northern Alberta Institute of Technology (NAIT) and Seneca College of Applied Arts and Technology: equipment, staff and expertise, such as release time of two instructors (for each of three semesters) for content development and teaching, internal project management, college wireless LAN, technical support, two members each for the evaluation team, instructional design, graphics design, editing and programming for content development, corporate communications, and marketing.

All stakeholders, except the colleges, were collectively known as the Consortium. The Consortium signed a Memorandum of Commitment in November 2001 and a Definitive Agreement in February 2002 with each college. Each partner assigned at least one person to a senior level Steering Committee that met monthly; one meeting each quarter was conducted in person, with others being held by conference call. McGraw-Hill Ryerson engaged two consultants to the project: Bodec Co. was engaged to assist with content development and Judy Roberts & Associates/Associés Inc. to assist with evaluation. Both also contributed in various ways to project management and were ex officio members of the Steering Committee.

[2] MicroVideo Learning Systems, a Calgary-based company, contributed access to the PDA portion of its MVLS Trainer, "a training application that utilizes the latest video compression technologies to provide students with an 'in class experience' to learn on their time." Hosted by Joan Bogden, MicroVideo's most experienced on-screen instructor, the series consisted of 19 modules.

2. Methods

This applied research was designed to meet diverse needs of public and private stakeholders, including the needs of the corporate partners to address future commercialization plans. This process generated initial data that need to be validated with more students in future studies. The evaluation design balanced client needs, research integrity, and instructor/student fatigue.

2.1 Approach and Context

A comparative approach was adopted; one key variable was the type of device used (PDA, laptop, or PC) and another was wireless access. Except where otherwise noted, the college data were pooled because of small student numbers at one college to permit analysis that reflected these factors. Self-reported data were verified wherever possible with quantitative measures such as Bell Mobility usage data and server access data. Final student grades were retrieved and analyzed. All data collection instruments were tested and revised in the beta phase of the study. A summary of the approach is contained in Table 3.

Table 3: Summary of Evaluation Methods[3]

Evaluation Category	Timing & Method		
	Pre/Start Semester	*During Semester*	*End/After Semester*
Recruitment	Letter + Consent form		
Learner characteristics	Self-report questionnaire		
Student success	Self-report expectations	Students assess content value + self-report of content usage (x 2) + faculty perception	Self-report of success + grades + faculty perception + server access data + WAN data from Bell Mobility
College services		Students assess services + self-report of usage	Final student assessment + self-report of usage
Teaching & learning strategies		Faculty self-report	Faculty survey + interviews
Technology functionality: PDA and networks			Help Desk records Faculty & student assessment
Tech training & support			Faculty & student assessment

2.2 Student Profiles

A survey was administered to students at the beginning of the semester that collected data such as,

- computer expertise, previous experience with online course materials, existing computer hardware, and connectivity, and
- demographic information such as age and household income.

2.3 Student Success and Achievement of Learning Outcomes

2.3.1 Student self-report

Survey instruments were administered at the beginning, middle, and end points of the semester to gather student self-report data.

Typically, a member of the research team administered the survey during class time. Data from each administration of the survey were entered into an Access database by staff at each college. NAIT

[3] Requests for copies of the forms should be e-mailed to mlearning@mcgrawhill.ca

Institutional Research conducted frequency analyses on all college data using the SPSS software package. Tests of significance were conducted where appropriate. [4]

2.3.2 Grades

Final grades were collected at the end of the semester, converted to a common 100 point scale and a test of significance applied.

2.3.3 Faculty perceptions

Faculty were profiled at the beginning of the beta phase and then consulted about their perception of student learning at the middle and end of the semester:

- Start: Evaluation Team members developed faculty profiles based on personal knowledge and the baseline forms administered in the beta phase.
- Mid-semester: Faculty were asked to share their views on the benefits to students' learning, technical support, and other related matters.
- End: Faculty again shared their views in writing via a survey form and were interviewed individually.

Faculty responses for each college were verified then combined to ensure confidentiality because of the small number (n=4) even when both colleges' data are combined.

2.3.4 Content

Self-report and server data were used to assess the role that content such as the learning activities played in facilitating student learning and success. Some content changed slightly during the evaluation period, but before students covered that part of the course: for example, new Flash elements in Interactive Exercises and Concept Demonstrations were added in September and Tetraccounting content was added later in the semester.

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[4] Two tests of significance were conducted. The first test uses the general form of the standard normal statistic to evaluate if the **mean** of sample one is significantly greater than the mean of sample two. The test statistic:

$$z = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

is a one-tailed test where the null hypothesis—*the mean of sample one is equal to or less than the mean of sample two* —is rejected with 90% confidence if Z>1.29 and 95% confidence if Z>1.64. If the null is rejected, the alternative is assumed, i.e., that the mean of sample one is significantly greater than the mean of sample two.

The second test uses the general form of the standard normal statistic to evaluate if the **proportion** of sample one, p_1, is significantly greater than the proportion of sample two, p_2. The test statistic:

$$z = \frac{p_1 - p_2}{\sqrt{\left[\frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}\right]\left[1 - \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}\right]\left[\frac{1}{n_1} + \frac{1}{n_2}\right]}}$$

is a one-tailed test where the null hypothesis—*the proportion of sample one is equal to or less than the proportion of sample two*—is rejected with 90% confidence if Z>1.29 and 95% confidence if Z>1.64. If the null is rejected, the alternative is assumed, i.e., the proportion of sample one is significantly greater than the proportion of sample two.

2.3.4.1 Self-report

Two tools were used at the beginning, middle, and end points of the semester: survey instruments and Activity Logs. Surveys were administered in class at the start, mid-point, and end of the semester:

- Start: The baseline survey asked students to indicate their general expectations regarding the use of the PDA to access curriculum materials.
- Mid-point: The survey asked students to rate the usefulness of several parts of the course to their learning, e.g., class lectures, digital content, etc. It went on to ask them very specifically about how often they used and enjoyed each type of learning activity (e.g., True/False Quiz, Learning Objectives, Interactive Exercises, etc.) and how much they thought each contributed to their learning. The survey also verified their perceptions that instructors used the activities in class and/or assigned them as homework, that they themselves were comfortable using the PDA, and whether they thought that they were learning valuable IT skills by participating in the pilot project. Students were also asked the same questions regarding access to college service and use of other applications software in the PDA.
- End: The survey asked students to summarize how useful the content was to their learning, their views on technical support, delivery of college services on the PDA, and their recommendations for the future.

An Activity Log summarizing PDA use for the previous seven days was also completed three times during the semester. Irregularities in administration and format of the first form, used the first week of October, led to a decision to discard those results.
The logs were completed in mid-November and again at the end of the month. In each case, the same process was followed to gather the data:

- Advance notice was given by e-mail or as an Announcement in Blackboard.
- An evaluation team member attended each class in person on an appropriate date and asked students to report on their use, in minutes, of listed activities in the seven previous calendar days (including weekends).
- Students could complete a Web form or paper version of the log. At NAIT, virtually all laptop students had their device in class and completed the online version while most PDA students did not have their device in class and used the paper version. At Seneca, most PDA students completed the Web form version on their PDAs.
- One follow-up e-mail was sent to encourage a high response rate from anyone who had not completed the log in class.

The raw data were entered into an Excel Spread Sheet. Frequency distributions were calculated.

2.3.4.2 Server data

Both colleges had software that tracked hits to the server; NAIT used WebTrends and Seneca used Webalizer. Both programs showed the hits to each content area by type of device (PDA vs. PC); considerable work was involved at the end of the semester to map the content URLs. To ensure consistent reporting between the two colleges, content tracking is reported for the months of October to December inclusive.

2.4 Access to College Services and Use of Other Applications

Self-report and server data were used to assess the value of mobile access to those college services formatted to the PDA and the benefits of other software applications in the iPAQ.

2.5 Teaching and Learning Strategies for Faculty

Faculty mid-semester and final survey forms explored faculty use of learning activities, college services, and other software applications in their teaching and learning strategies within and outside the class and

their perceptions of the usefulness of such materials to their teaching techniques and to student learning. They were also asked to report on their comfort levels with both the content and technology as factors that might affect their teaching strategies. The results of the students' mid-semester surveys were not shared with faculty to avoid faculty changing their teaching strategies during a very short evaluation study; in different circumstances, it would have been advantageous to provide faculty with such feedback.

2.6 Other Pertinent Data

2.6.1 Student support

Start-up training and Help Desk support were evaluated by student and faculty self-reports in the final survey process.

2.6.2 The PDA

Both faculty and students reported on their use of the PDA, their comfort with it, their assessment of its usefulness for learning or teaching, their acquired IT skills, what features they would like to see incorporated in a future PDA, and other related points, including whether they used their PDA or PC most often to access content.

2.6.3 Wireless networks

Students and faculty provided overall assessments of the wireless networks and made recommendations regarding future exploration of such networks in the final survey forms.

Bell Mobility provided information on wireless WAN use that showed

- the volume of student activity as measured in megabits of transferred information, and
- what the colleges would have been charged had the fee not been waived as Bell Mobility's contribution to the project.

Wireless LAN use could not feasibly be tracked by either college.

2.7 Evaluation Team Work Plan/Schedule

The work described in this report was completed within approximately 18 months and can be summarized as follows:

- November 2001 to February 2002: Formalization of team members, their roles and responsibilities and preparation of a high-level evaluation plan.
- March 2002: Facilitation of focus groups for the alpha testing of certain types of content for the PDA.
- April to August 2002: Design, administration and revision of all evaluation forms during the beta test of the course. A common form was drafted and then minimal customization occurred to meet individual college needs.
- September to December 2002: Data collection and partial analysis; recording all methods and pertinent observations about factors that affected the evaluation.
- January to April 2003: Data analysis and final report completed; proposals submitted for conference presentations and participation in project communication events as required.

Evaluation Team work occurred in a highly collaborative fashion facilitated by frequent conference calls (at least monthly) throughout the entire period with occasional in-person meetings. The only work undertaken separately by each college was minimal customization of the common survey forms, physical administration of the evaluation forms, and collection of other data. Statistical analysis of survey data was undertaken by NAIT. The Team Leader, engaged by McGraw-Hill Ryerson, facilitated the collaborative work, taking the lead in writing key evaluation reports to the Steering Committee and the Final Report.

3. Results and Discussion

The key finding within which the other results should be understood is that students and instructors recommended that the colleges continue to explore the potential of wireless networks and devices for teaching and learning, and for providing college services. The largely subjective results from this project are thus a pilot for this larger vision and are suggestive of possibilities that need to be confirmed in the future.

The results should be appreciated within the context of the need to balance evaluation design requirements with the practical realities of the partnership's needs. For example, at NAIT, staff met with students at the end of October to inform them of their options regarding extending their technology fee agreements for the equipment past the end of the project. Faculty testimonials were solicited for a November 2002 press release. The Content Development Team met weekly and faculty completed forms three times during the semester to enable McGraw-Hill Ryerson to develop training manuals for future publication. Conference presentations by faculty may have affected their perceptions of the project and their input to evaluation forms.

Response rates for the survey results contained in this report are summarized in Tables 4, 5, and 6.[5]

Table 4: Response Rates for Baseline Student Survey

Type of Group	**Respondents**		
	Enrolled	*Completed Form*	*Response Rate %*
PDA	110	105	95.5
Wireless laptop	21	21	100.0
Wired laptop	28	20	71.4
Control	141	*147	100.0
Totals	300	293	97.7

* Only 141 of the 147 who completed forms had actually signed consent forms agreeing to participate in the research. Because the forms are anonymous, the six forms cannot be identified and are therefore included in the data analysis.

Table 5: Response Rates for Mid-Semester Student Survey

Type of Group	**Respondents**		
	Enrolled	*Completed Form*	*Response Rate %*
PDA	110	83	75.5
Wireless laptop	21	16	76.2
Wired laptop	28	23	82.1
Control	141	*104	73.8
Totals	300	226	75.3

*It is not known how many of these are "extras," who did not complete the consent form.

Table 6: Response Rates for Final Student Survey

Type of Group	**Respondents**		
	*Enrolled**	*Completed Form*	*Response Rate %*
PDA	89	71	79.8
Wireless laptop	19	18	94.7
Wired laptop	28	26	92.9
Control	137	**92	67.2
Totals	273	207	75.8

[5] Requests for copies of the full set of research data should be e-mailed to mlearning@mcgrawhill.ca

* Enrolled equals the number of students who wrote the final exam.
**It is not known how many of these are "extras," who did not complete the consent form.

3.1 Student Profiles

3.1.1 Who are they?

Table 7 displays the number of students in the pilot. Students who started were those who signed a consent form or volunteered to participate. Students who ended were those who wrote the final exam. At each college, the number of PDA and Control group students is a total across two classes each. Class sizes of 14 and 15 (totalling 29) are very low. Seneca continued with two PDA sections only because of the college's previous commitment to release two faculty members, and because of the need for diversity in faculty approaches. Normally, Seneca allocates up to 35 students in a section. The difference between the numbers of PDA students at each college is believed to result from the higher charge that Seneca made for the PDA compared to what NAIT charged, i.e., $450 and $150 respectively.

Table 7: Student Numbers in Project at each College by Groups

Groups	Numbers of Students at each College				Totals	
	NAIT		*Seneca*			
	Start	End	Start	End	Start	End
PDA	80	64	29	25	109	89
Wireless laptop	*21	19	N/A	N/A	21	19
Wired laptop	*28	28	N/A	N/A	28	28
Control	81	71	*60	***66	141	**137
Totals	210	182	89	91	299	273

* NAIT laptop group is a mix of wireless and wired students; the Seneca Control group is a mix of those who signed consent forms and those who did not.
** Students in the Seneca Control group who had not originally signed consent forms completed final evaluation forms.
*** There seems to be more students because it was not possible to track the 60 (of 81) who signed consent forms. Of the 81, 66 wrote the final exam and completed project evaluation forms.

There was a retention rate of 80% in the NAIT PDA group and a rate of 83% in the Seneca PDA group. There is an 88% retention rate in the NAIT Control groups; the retention rate cannot be calculated for the Seneca Control groups because it was not possible to track the students who signed the consent forms (see also explanatory note to Table 7).

The PDA group at Seneca included students entering the Accounting and Finance program in the first semester and students in other Business programs taking ACC106 in a second or subsequent semester. Faculty felt this latter group of students might have been less motivated to succeed in accounting. Of the 29 students who agreed to participate, 22 were from the Accounting and Finance program, six were in the Business Administration program and one was in the International Business program. All of the Control group at Seneca were in the Accounting and Finance program.

All NAIT participants were full-time students in first semester of the Business Administration program. BUS106 Introductory Accounting is a core course for all first semester students. All PDA users were voluntary participants and scheduled as sections. There are 14 sections in the September cohort with an average section size of 42 to 45 students. There were enough volunteer participants to the project for two PDA sections and one laptop section. Sections are time tabled in course blocks so students in BUS106 together would be scheduled for the five other first semester courses together as well.

January 2002 baseline data on all first-year accounting students at both colleges indicate that the students recruited for the pilot project are fairly representative of the first-year accounting student population. Salient characteristics of the students in this study include:

- A majority of students in all groups rated themselves as competent in software applications such as e-mail and word processing.
- At least 90% of the students in each group had access to a computer at home.
- Very few (15 to 20%) of the students had previous experience learning with online curriculum materials.
- There were slightly more females than males in PDA and laptop groups; the Control group was split almost 50/50.
- There was no difference among groups in age; the vast majority of the students were under 24 years old.
- There was no difference among the groups in terms of grades; the majority had a grade of C or B (60 to 80%).
- The wireless laptop students had the least connectivity of all groups; the PDA and Control groups had 76% and 90% levels respectively.

Student income is not reported, as the data were considered unreliable; students did not understand the question.

3.1.1.1 Why did students sign up for the pilot project?

Students viewed the project as an opportunity to enhance their learning technology tools and saw the project as an inexpensive way to access leading-edge technology. The "cool" factor was also a significant attraction for most students. Convenient access to course materials, enjoyment, and improved chance to succeed were highest expectations of PDA groups. The laptop groups expected improved access to materials, improved chance to succeed and better management of course notes.

3.1.2 Who were the faculty?

All faculty had experience using online digital content. The Seneca faculty were experienced Blackboard users. The NAIT faculty knew WebCT and were trained in Blackboard to meet project requirements.

3.2 Student Success and Achievement of Learning Outcomes

"Although using the Internet and other electronic devices is helpful, it doesn't mean that it makes learning easy. You still have to work for it."

– Seneca Student
End of Semester Survey

3.2.1 Student self-report

Based on end-of-semester survey results, all student groups, including the Control groups, thought that the digital content helped them to learn accounting. While there were some differences, analysis revealed that they were not statistically significant, a not unsurprising finding given that all groups used similar content. On the other hand, when they had the chance at mid-semester to compare digital content with other teaching approaches, the PDA and Control students rated assignments, textbooks and classroom lectures in that order as more useful than digital content available through Blackboard or Blackboard Unplugged as learning tools (i.e., 4 or 5 on a 5-point scale). These results may be interpreted to mean that students value both digital and traditional learning activities.

"Flash problems on the iPAQ are the greatest contributor to my success in this course."

– NAIT Student
Mid-Semester Survey

Q1a. On a scale of 1 to 5 (where 1 is strongly disagree and 5 is strongly agree), please circle the number that shows how much you agree with the following statement: "Overall, the digital content available through Blackboard or Blackboard Unplugged helped me to learn accounting."

	PDA		Control	
	Number	*Percent*	*Number*	*Percent*
Disagree (1 or 2)	22	31.0	18	20.9
Neither Agree nor Disagree	21	29.6	27	31.4
Agreed (4 or 5)*	28	39.4	41	47.7
Totals	**71**	**100.0**	**86**	**100.0**

* tested for significance

Using the standard normal statistic to evaluate the null hypothesis—*that the proportion of Control students who agreed with the statement is equal to or less than the proportion of PDA students who agreed with the statement*—yields a low Z value of 1.04. Thus the null hypothesis cannot be rejected; the test fails to support the contention that Control students are more in agreement than the PDA students are with the statement that digital content helped them to learn accounting. Thus it can be concluded that the value of the digital content is independent of the device used to access it.

A different trend was evident when the issue was stated as one of overall satisfaction with a course taught "this way," i.e., whichever way the student experienced. As shown in the next two tables that summarize the replies to Question 18, the Control group students were **statistically significantly more satisfied with the course than the PDA students**; there was no statistically significant difference between the wired and wireless laptop students' level of satisfaction. It is thought that the PDA students' satisfaction may have been affected more by the technology than by the content (see Sections 3.2.4 and 3.5).

Q18. Indicate your satisfaction with taking a first-year accounting class that is taught in this way.

	PDA		*Control*	
	Number	*Percent*	*Number*	*Percent*
Dissatisfied (1 or 2)	25	20.6	12	4.5
Neither Satisfied nor Dissatisfied	17	25.0	28	31.8
Satisfied (4 or 5)*	26	27.9	48	40.9
Totals	**68**	**100.0**	**88**	**100.0**

*tested for statistical significance

Using the standard normal statistic to evaluate the null hypothesis—*that the proportion of Control students who are satisfied with their accounting class is equal to or less than the proportion of PDA students who are satisfied with the accounting class*—yields a Z value of 1.69. Thus the null hypothesis is rejected and it can be assumed that the proportion of Control students who are satisfied with the accounting course **is** significantly greater than the proportion of PDA students who are satisfied. Dissatisfaction with other factors such as features of the PDA or the functionality of the wireless WAN network might have had an impact on the level of satisfaction among the PDA students.

	Wireless Laptop		*Wired Laptop*	
	Number	*Percent*	*Number*	*Percent*
Dissatisfied (1 or 2)	3	16.7	2	8.3
Neither Satisfied nor Dissatisfied	4	22.2	3	12.5
Satisfied (4 or 5)*	11	61.1	19	79.2
Totals	**18**	**100.0**	**24**	**100.0**

* tested for statistical significance

Using the standard normal statistic to evaluate the null hypothesis—*that the proportion of wired laptop students who are satisfied with their accounting class is equal to or less than the proportion of wireless laptop students who are satisfied with the accounting class*—yields a low Z value of 1.29. Thus the null

hypothesis cannot be rejected and it is assumed that the proportion of wired laptop students who are satisfied with their accounting course **is not** significantly greater than the proportion of wireless laptop students who are satisfied. Wireless access to digital curriculum did not enhance student satisfaction with the class; indeed, such access detracted from student satisfaction, perhaps because of poor wireless WAN network functionality.

3.2.2 Grades

The average final grades at both colleges for all student groups (see Table 8) vary and are not totally consistent.

Table 8: Average Student Grades on Final Exams

College	Average Grades by Student Group			
	PDA	*Control*	*Wireless Laptop*	*Wired Laptop*
NAIT	60.72	*55.79	63.11	67.32
Seneca	59.95	64.89	N/A	N/A

* This group of students may not be typical (see below).

At NAIT, the average grade of the PDA students was **statistically significantly higher** than the average grade of Control students. Using the standard normal statistic to evaluate the null hypothesis—*that the average grade of the NAIT PDA students is equal to or less than the average grade of the NAIT Control students*—yields a Z value of 1.40. Thus the null hypothesis is rejected with 92% confidence; it can be concluded that introducing the technology into the classroom did not hinder the students in fall 2002.

However, these results showing that the PDA might have had a positive effect need to be interpreted with caution. Key issues to be considered include:

- Learning is multi-faceted process that should encourage caution in attributing a result such as this to only one factor, such as the effect of technology.
- The mean grade of the NAIT Control group may not be typical when compared to the results of previous years. Testing for significant differences between the class averages of Control students in fall 2002 (55.79%) and fall 2001 (64.18%) indicates that results of these two years are statistically different.
- The retention rate in the NAIT 2002 Control group was 88%, slightly higher than the 84% achieved in 2001. This suggests that more students persisted in 2002 despite poor grades thereby resulting in a lower average for the class of 2002. Students in both years had the same curriculum, instructors, and level of technology although the digital learning activities are different.

No significant differences of averages were detected between the wireless and wired laptop groups at NAIT. A larger sample size would be required to explore this variable further.

At Seneca, however, there was **no statistically significant difference** between the average grades of the PDA and Control group students. The pattern of the Seneca results, contrary to that at NAIT, could be interpreted to mean that the PDA had an adverse effect on student grades, an intriguing finding given that the small PDA class sizes (14 and 15) could have led to improved grades due to extra instructor attention.

"The greatest contributor to my success is the ability to access... additional material that examines... [course] material in new words."
– Seneca Student
Mid-Semester Survey

Factors that should be included in a consideration of this result include:

- The small number (25) of Seneca students completing the course in the iPAQ group may have contributed to lack of statistical significance.
- Attendance was very poor in one PDA class, which may have compromised the data since the number is relatively small at the beginning. Teacher's perception is that poor scheduling of the iPAQ class was the reason for poor attendance.
- As noted previously, some students in the iPAQ classes may not have been as motivated to excel in accounting as were the Control group students.

It could be argued that having the same person teach both the PDA and Control groups at both colleges might have affected marking. To counter this concern, almost all test questions were objective (usually numerical) questions so that there was not the same possibility for marking bias, as there would be in essay-type exams in the liberal arts. However, this structure maintained consistency within sets of groups, i.e., it permits comparison of PDA, laptop, and Control groups without the influence of a different instructor.

It was not possible to distinguish power users in this study since the evaluation team did not have consent to track individual results; only grouped data can be presented. If institutional policy permits, it would be interesting to know the relationship between factors such as grades and use of Learning Activities, or student self-report of high usage and willingness to purchase the PDA and other related factors.

3.2.3 Faculty perceptions of student learning

Although they were moderately satisfied with the wireless PDA as a learning tool (3 or 4 on a 5-point scale), instructors did not think that it contributed much to student learning (2 or 3 on a 5-point scale) and believed that students were dissatisfied with the iPAQ as a learning tool (2 or 3 on a 5-point scale). In the final survey, faculty also reported that the digital content helped them to teach accounting and that Interactive Exercises were the most useful type of content. Unlike the students, instructors thought that they had learned new IT skills that would be useful in future as a result of using the PDA.

3.2.4 Content

"The usefulness of all technology is directly proportional to the extent to which subject specific content is available. The interactive exercises used in the Mobile Learning Project engaged the students and as a result, they found the digital material to be very useful."

– Tilly Jensen, NAIT Instructor

3.2.4.1 Self-report

In the final survey administered at the end of the semester, PDA students reported that Interactive Exercises were most useful to their learning in a **statistically significantly higher proportion** as compared to the Control group.

Q1b. From the list below, indicate which type of digital content, available through Blackboard or Blackboard Unplugged, was the most useful for your learning (please select only one).

	PDA		**Control**	
	Number	*Percent*	*Number*	*Percent*
Learning Outcome Guide	1	1.7	8	10.5
Chapter Summary Reviews	10	16.9	18	23.7
Streaming Video Clips	0	0.0	1	1.3
Online Quizzes	18	30.5	24	31.6
Interactive Exercises	23	39.0	12	15.8
Conceptual Demonstrations	7	11.9	11	14.5
MS-Reader Chapter Summaries	0	0.0	1	1.3
Tetraccounting Game	0	0.0	1	1.3
Totals	**59**	**100.0**	**76**	**100.0**

When a statistical test of significance was performed, the absolute value of Z exceeded 1.96; the null hypothesis that the two proportions are the same was therefore rejected. Thus it can be concluded that the proportion of PDA students who indicated that the Interactive Exercise was most useful to their learning is significantly different from the proportion of Control students who indicated the same.

However, the effect should probably not be attributed to wireless mobility because, for example, students in the wired laptop group also reported that Interactive Exercises (IE) were the most useful type of content for their learning. A factor that may contribute to the significant difference between the PDA and Control groups is that the NAIT PDA students (80 of the 109 PDA students) had more exposure to the IEs in class than did the NAIT Control groups.

"The best thing is 'being connected' – it's 24/7 wherever I am. I can do my email on the bus and study anywhere. I can do a lot more compared to the standard ACC106 [student]."

– Seneca Student
Mid-Semester Focus Group

When PDA students' self-report Activity Logs were analyzed to appreciate their sense of how much they actually used the various types of content, the results showed that the content that students thought most helped their learning was also the content that they felt they used the most. Since analysis indicated that the pattern of use did not change between the two occasions when the form was completed, aggregate summary comments are made to highlight key trends:

- Actual times are not reported because, when the Activity Log results were compared to the server access data, researchers concluded that the Activity Log numbers were not reliable. However, it was interesting to note that time reportedly spent on each activity could consistently range from a low of 1 to 10 minutes to a high of 20 to 480 minutes within a seven-day period.
- Compliance in completing the Activity Logs was fairly good, i.e., 78 of 109 in mid-November and 65 of 109 at the end of the month.
- Interactive Exercises were reported to be used by the highest number of students and for the longest period of time.
- Taking all four types of quizzes as one category, students reported using Quizzes the next most frequently.
- Chapter Summaries were also highly used by students.
- Although Learning Activities were frequently accessed by PDA, the application with the highest maximum reported use overall was accessing other Websites and personal use of the PDA for games, music, etc.

A key issue that seemed to affect usage was that there were no timetabling gaps in the college with the large PDA class sizes (NAIT), with the result that students did not have "fragments of unused time" that could have been harvested for learning activities on the PDA.

3.2.4.2 Server data

As Table 9 documents, Interactive Exercises (22.8%) and Concept Demonstrations (16.1%) were the Learning Activities most frequently accessed by PDA, while Learning Objectives (48.1%) and Interactive Exercises and Chapter Reviews (each at 19.7%) were most frequently accessed by PC. Student chatter (18.8%) was also used often; it was accessible only by PDA. The server data reports upon which Table 9 is based were compiled using WebTrends (NAIT) and Webalizer (Seneca) software.

Table 9: Server Hits to Content Type by Device Type October – December 2002

Type of Content	Total Hits		Percentages	
Learning Activities	*PDA*	*PC*	*PDA*	*PC*
Learning Objectives	207	**8,270	10.2	48.1
Chapter Reviews	263	3,394	13.0	19.7

Streaming Video Clips	67	141	3.3	0.8
Key Terms/Glossary	12	69	0.6	0.4
Quizzes	215	873	10.6	5.1
Multiple Choice	86	298	4.3	1.7
True/False	58	210	2.9	1.2
Fill-in-the-Blank	34	144	1.7	0.8
Glossary Match	37	221	1.8	1.3
Interactive Exercises	460	3,391	22.8	19.7
Concept Demonstration	325	607	16.1	3.5
MS-Reader Summary	55	52	2.7	0.3
Tetraccounting Game*	38	394	1.9	2.3
Services				
Student chatter*	379	N/A	18.8	N/A
Totals	2,021	17,191	100.0%	100.0%

*Both colleges on NAIT server.

** Hits may be high because NAIT navigation was structured such that the Learning Objectives were a natural starting place where students went to link to other Learning Activities.

It is important to note that (1) all server access data include student, faculty, and other project stakeholders and (2) the PC data include desktop PC access by all students, i.e., PDA, laptop, and Control students. It is clear from the responses to the final survey that PDA students preferred to use their PC to access learning activities; fully 83% of survey respondents preferred to access the digital content via their PC; only 17% preferred to use their PDA.

A significant proportion of PDA use happened in class; 58% of respondents to the mid-semester survey indicated that they usually accessed Learning Activities on their PDA in class even though 31% of PDA students reported in that same survey that they did not typically bring their PDA to class. By the end of the semester, NAIT researchers and faculty noticed that students did not typically bring their PDA to class, whereas Seneca personnel reported that Seneca students continued to bring their PDA to class. (See also Section 3.4, Teaching and Learning Strategies for Faculty.)

Some students added comments to both the mid and final surveys that the PDA and laptop devices could be distractions when used in class because of such factors as noise, waiting for everyone to be connected, and distraction through using MSN Messenger, games etc. The PDA students commented that bandwidth was not adequate for the Streaming Video Clips.

3.3 Access to College Services and Use of Other Applications

Final survey results indicated that very few students (1.5%) reported that they used the PDA to access college services; e.g., the college portal, registration system, or learning commons. However, both student self-report through the Activity Logs and objective server access data showed high levels of activity with Student Chatter, a communication application developed specifically for the PDA. Students said that they used it more for personal communication than for their accounting course.

Those same final survey results indicate that Other Applications (applications that were integral to the PDA—that may or may not require a wireless card) were used considerably more than college services by the PDA students, with the encouragement of their faculty who made it clear that the PDAs could be used for activities other than learning. E-mail, which did require wireless connectivity, was used by 20% of the respondents to the mid-semester survey, the one time when students were asked about this in detail. "Cool factor" applications such as games and personal activities were used by almost 40% of the PDA respondents.

Faculty reported that they too used e-mail, calendar, contacts, tasks, and personal applications [music and games] for purposes unrelated to the accounting course.

3.4 Teaching and Learning Strategies for Faculty

"If you want students to use the technology you [the instructor] have to be consistent about using it. In every class we did at least one piece of work using the IPAQ... mostly the interactive ones such as the Journal Entries or the Concept pieces."

– Seneca Faculty Member

"From an instruction point of view, the technology in the classroom changes the instructor's role. Instead of primarily providing instruction to the students, the instructor now becomes a repository of knowledge to guide or mentor students through their curriculum."

– James Guthrie, NAIT Instructor

In the final survey, faculty reported that the digital content helped them to teach accounting but that the PDA device as such did not make accounting more interesting to teach. They thought that the most important new teaching strategy was more student interactivity with content. Instructors reported that they used the PDA in class and assigned it out of class and that they were comfortable using the PDA with the students. They also noted that use of the PDA enabled them to encourage independent student learning because they could adopt a coaching role.

In final interviews after the course was completed, faculty reported using a number of different teaching approaches with the content designed to be used on the PDA. For example, they projected the Conceptual Demonstrations in class to illustrate the conceptual points that were made in the lecture. Faculty walked students through the Interactive Exercises in class to demonstrate accounting practices and then asked students to work through the same exercises to enable them to practice those steps. Both Multiple Choice and Matching Quizzes were assigned as homework to students to provide a self-check of their progress. Faculty encouraged students to use the Conceptual Demonstrations and Interactive Exercises to review for exams.

One faculty member described the use of Interactive Exercises (IE) as a diagnostic tool. The instructor could quickly determine where the student was having problems and give remedial tutoring using the IE. Exercises specific to that issue could then be assigned as customized homework for that student.

The final survey identified a number of other issues important to faculty satisfaction. Functionality, the learner-content interactivity provided by Interactive Exercises, and content development teamwork contributed most to faculty satisfaction. Unreliable technology was the greatest contributor to dissatisfaction for faculty and was perceived by them to be the greatest contributor to student dissatisfaction. It is important to note that this pilot study of technology may not be predictive because initial negative experiences with the technology significantly impacted results for the balance of the semester.

3.5 Other Pertinent Points

3.5.1 Student support

At the end of the semester, both faculty and students rated the quality of training and technical support as acceptable. Approximately 75% of students rated them 3 or higher on a 5-point scale, as did 3 of 4 faculty. At mid-semester, the only time the question was asked, students indicated that their most frequently used source of technical advice was their instructor, the "first week" training, and other students in that order.

Access to knowledgeable Help Desk staff is a critical success factor. Both colleges reported that Help Desk calls related primarily to wireless WAN or LAN network issues. Instructors made more calls than students, perhaps because students indicated that they consulted faculty instead of calling the Help Desk directly. The percentage of calls decreased steadily from a high in September to a low in November. There is no pattern to the calls based on day of the week. Other users of the Help Desk were vendor representatives and technical staff.

Anecdotal evidence from student focus groups and faculty interviews indicated that it is critical to allocate sufficient time for both student and faculty training. For faculty, it needs to occur well before classes start so that they are completely comfortable using technology. Students indicated that such training should be in addition to "regular" class time so that time for subject specific learning is not prejudiced.

3.5.2 The PDA

Despite their frustrations, fully 50% or more of all student groups reported being satisfied (4 or 5 on a 5-point scale) with the course, with the laptop and Control groups having a larger percentage than the PDA groups. Nevertheless, a slim majority of PDA students (52%) would not recommend that colleges continue to explore the value of an iPAQ or some other PDA in teaching and learning. However, a majority of wired laptop and Control students would recommend that colleges continue to explore the value of the device.

"The iPAQ is too small and slow and is frustrating to use when I can just use a regular computer instead."

– NAIT Student
Mid-Semester Survey

In addition, 65% of the 69 PDA students who answered the question would not recommend that other students purchase a PDA, and 28% said it would depend on the cost. Second, at least two-thirds of all students in the laptop and Control groups had not heard about the PDA pilot from students in the PDA group during the semester. Virtually all of those who had heard from students in the PDA group did not wish that they had signed for the PDA group. Faculty were split 50/50 on recommending the PDA to other faculty, with cost being the main issue.

The final survey data confirmed a number of important points. Students indicated that faculty used the PDA in class, assigned it for use out of class, and were very comfortable using it themselves. However, use of the PDA was constrained by factors other than faculty behaviour and attitudes. First, roughly 80% of PDA students preferred to access digital content on their PC (faculty were split 50/50 on using the PC or PDA to access digital content when they were not in class). Although students were encouraged to access content with their PDA, they knew that they could also use a PC to do so because at NAIT, they were so informed by their instructors and at Seneca they saw content projected from a PC in every class. Second, most NAIT students reported that they did not bring their iPAQ to class; Seneca students claimed that they always did. These student self-reports were confirmed by researcher observation during the in-class visits to administer evaluation instruments. All instructors reported bringing their PDA to class. Third, PDA students brought both their LAN and WAN cards, as did three of four faculty (the fourth brought only LAN).

"If iPAQ's were cheaper, there would be more students in the iPAQ group. Some people just can't afford the extra cost."

– Seneca Student
Mid-Semester Focus Group

According to the PDA students, the two most desired changes to a PDA were to add a keyboard for text entry and increase the screen size (see Q7).

Q7. iPAQs differ from PCs or laptops. On a scale of 1 to 5 (where 1 is Not Important and 5 is Very Important), rate how important each of these features is to you.

Feature	% of PDA Students				
	1	*2*	*3*	*4*	*5*
Larger screen size	14.1	11.3	28.2	19.7	26.8
Portable keyboard	15.5	12.7	21.1	25.4	25.4
Portability	25.4	11.3	22.5	22.5	18.3
Combine PDA & cell phone	43.7	14.1	14.1	15.5	12.7

In their comments on this question, students also mentioned increased battery life or on-campus facilities for recharging and increased memory as important improvements.

For faculty, screen size and keyboard were also important improvements. Most faculty (75%) felt that combining a PDA and cell phone would be very important – a feature that was not a priority for students. In their interviews, faculty also mentioned increased memory as a useful improvement.

3.5.3 Wireless networks

"The iPAQ was great, but the problems with the WAN card [wireless network] persisted and I could not get online at home."

– NAIT student,
Mid-Semester Evaluation

A substantial majority of students in each type of student group in the project favoured colleges continuing to explore the value of using wireless networks in teaching and learning.

The on-campus wireless LAN network was perceived as good. In the final survey, the majority of the PDA and wireless laptop students were not dissatisfied with the quality of the campus wireless network, although they wished that more buildings were covered. Three of four instructors thought that the on-campus network quality was very good; the fourth thought that it was very poor.

The off-campus wireless WAN rating varied from very poor to very good, depending on location. Both faculty and students in Toronto gave positive ratings, while those in Edmonton gave negative ones.

Using data provided to the colleges by Bell Mobility, Table 10 shows wireless WAN usage, in terms of all data transferred, as measured in MB, and the cost of usage, as measured in Cdn$, above 10MB/month had Bell Mobility charged it. Using these data, very rough estimates can be made about the cost of such a project had wireless WAN access **not** been donated. It should be stressed that these are indicative of cost, not conclusive.

- The cost of a basic package of 10MB/month for all 125 PDA and laptop students would have been $50/month + taxes, unless a college negotiated a discount rate, which would total approximately Cdn$25,000 + taxes for a four-month semester.
- The cost of the excess usage above 10MB/month/student was $974 (NAIT PDA) + $251,118 (NAIT laptop) + $11,362 (Seneca PDA) = $263,454 + taxes for the entire semester.
- The total cost of the wireless WAN access (basic + excess) would thus have been $288,454 + taxes, yielding an average of $2,308/student + taxes. Laptop students accounted for $255,118 of the $288,454.
- The average cost per type of student per semester, exclusive of taxes, was $12,756 for each student in the NAIT laptop group, $113 each in the NAIT PDA group, which would be unrealistically low due to poor wireless WAN quality, and $592 for each Seneca PDA student. Based on the students' reaction at Seneca to investing $450 in the PDA device, the additional cost of wireless WAN use would be prohibitive.

Table 10: Usage by College PDA and Laptop Groups based on Bell Mobility Invoices

College	*All* Usage by Month in MB				*Excess* Usage by Month in Cdn$			
	Sept	*Oct*	*Nov*	*Dec+*	*Sept*	*Oct*	*Nov*	*Dec+*
NAIT PDA N = 74* Total Average	275.4 3.72	212.6 2.87	140.05 1.89	98.2 1.32	183.73 2.48	208.05 2.81	284.12 3.84	297.87 4.03
NAIT Laptop N = 20 Total Average	2,544 127.2	12,857 642.8	14,002 700.1	13,190 659.5	14,165 708.24	75,943 3,797	82,891 4,145	78,119 3,906

Seneca PDA N = 29 Total Average	462.1 15.93	691.2 23.83	1,157 39.90	N/A	1,635 56.38	3,387 116.79	6,340 218.62	N/A

*Invoices were not received for five NAIT students in the PDA groups.

+ Bell Mobility allowed students to use the wireless WAN up to and including December 31, 2002; the billing date on Bell Mobility's November invoice coincided with Seneca's final exam date so no invoice was assessed for December 2002.

These totals and averages may obscure variations in individual activity, although it is very difficult to draw any reliable, firm conclusions. The most salient are presented in Table 11; concerns about reliability of the billing data precluded any more detailed analysis.

Table 11: Variations in Wireless WAN Use among PDA Students

Type of Information	**College**							
	NAIT N = 74				Seneca N=31			
	Sept	Oct	Nov	Dec	Sept	Oct	Nov	Dec
Did not access 1X service	3	14	33	54	2	4	7	N/A
Low users <1 MB	17	21	20	12	2	4	7	N/A
High users >10MB	3	5	4	2	11	7	7	N/A
Maximum use in MB	22.05	23.84	51.95	29.07	132.2	341.4	893.4	N/A

Laptop data examined by the Evaluation Team indicate that virtually all 20 laptop students used excess airtime each month; no laptop user in any month had less than 1MB excess usage. The lowest level of excess use in any month was 7.01 MB and the highest level of excess use in any one month was 2,818.6MB; however, one student always used more than 2,000MB each month and it was a different person each time.

The data in Tables 10 and 11 seem to indicate that, with the right device, students will make extensive use of wireless networks and that there is considerable variation in individual levels of use. Whether they can/will pay for such use is another matter.

One reason for the higher WAN usage by Seneca PDA students may be the higher quality of the wireless network in Toronto compared to Edmonton during the pilot. Although the worst problems occurred early in the NAIT semester, it was challenging to persuade students that the network was improved and functioning reliably. However, high use by the laptop group means that network was not likely the only limit on PDA student activity; features of the PDA may also have had some effect given the comments by students shown above in Question 7 about desired changes to the PDA.

No wireless LAN data is available since it was not possible to separate data for the participants in this study from other wireless LAN users.

4. Continuing into the Future

As educators, we strive to ensure that our use of new technologies in teaching and learning is driven by our students' needs – and not just because it's trendy. At Seneca, we were pleased to have the opportunity to participate in the mobile learning project as part of our ongoing evaluation of the use of new technologies to enhance the teaching/learning process. Throughout this pilot project, students have consistently told us that having wireless access and the addition of digital resources is what really made a difference!

Cindy Hazell,
Vice-President, Academic, Seneca College

Overall this pilot project has provided excellent baseline data for use in planning future, more extensive projects. It is clear that the future of learning organizations is inextricably linked to the possibilities inherent in new learning technologies, wireless capabilities and curriculum designed to excite the student and enhance faculty effectiveness.

Shirley Holloway,
Vice-President, Academic and Student Services, NAIT

4.1 Lessons Learned

Five key lessons emerge from this pilot project that could be useful to anyone contemplating similar work in the future.

4.1.1 Reliable technology

4.1.1.1 Wireless Networks

For maximum success, the technology has to work reliably. While small screen size and the lack of a keyboard were noted as PDA limitations, they did not generate the level of dissatisfaction among PDA students that the poor wireless WAN network functionality did. Despite the dissatisfaction with network quality, students and faculty made stronger recommendations to the colleges to explore wireless networks than to continue using the PDA devices.

4.1.1.2 The PDA

Device features may be a critical factor, as poor network quality did not seem to adversely affect laptop wireless network usage. The device characteristics need to be matched to requirements of content. For example, nursing or geomatics might be worth considering because the PDA is used in their workplace practice and learning. Indeed, NAIT's geomatics program has decided to experiment with the iPAQs used in this pilot and, subsequent to the work described in this report, are devising uses related to surveying, reports from the field, etc. Screen size was an important issue in accounting because of "special needs" issues such as data entry and spreadsheet requirements, but it might not be so critical in subjects other than accounting. Despite the content challenges in this study, students and faculty did see a need for colleges to continue exploring wireless devices.

4.1.2 Multi-factor approach to assessment

The teaching/learning process is a complex one that needs to be reflected in the assessment of learning. As has been noted in the literature about other technology interventions, it is very difficult to isolate reliably specific cause and effect relationships.

Technology as an intervention is also multi-faceted, as demonstrated by the nuances in responses to satisfaction with the PDA, the wireless networks, and "the course overall." Again, attributing outcomes to one specific feature can be challenging.

4.1.3 Learner-content interactive design principles

Both PDA student self-report and server data clearly indicate that the Learning Activities with a high level of learner-content interactivity were the most used and were perceived as most helpful to learning. However, the content-rich nature of this project may have limited its success, since the emphasis on "trying all content types," which was clearly modeled by faculty during classroom time and in assignments, may have contributed to the PDA student groups preferring to use their PC. (This project's dual goals of applied research into many types of content and into the usefulness of the PDA may have inadvertently generated mixed messages for both students and instructors.)

Attempting to test all possible types of content on the device may not be the best strategy for future development. Designing more narrowly targeted interactive content that is ideal for small screen size in an environment where the network is reliable may have different results.

4.1.4 Consortium model

The Consortium's collective commitment to innovation, accountability, and credibility was important common ground between the public and private sector stakeholders. In addition, the model facilitated significant cost sharing and built upon the strengths of each member. However, funding may have focused disproportionately on PDA costs and faculty time for content development compared to other tasks, perhaps a necessary feature given the pioneering nature of the project.

4.1.5 Project management model

Project management is an effective approach at both the consortium and institutional levels. Leadership alignment and resource allocation both among external agencies and within each stakeholder is critical to success. External funding might also have enriched the project, even though some effort would have been diverted to seek it.

Investing effort in coordinating decisions in all areas is critical. Inefficiencies resulted when faculty release time was committed before network technology could be guaranteed and the timetable could not be changed

Because content usage was tracked by content type, e.g., Quizzes as a category compared to IE as a category, mapping the folder structure on the servers "up front" would have saved the Evaluation Team considerable time compared to doing it after the fact.

4.2 Recommendations

As already noted in section 3, **Results and Discussion**, both faculty and students recommended that colleges continue to explore the use of both wireless networks and devices. Four other points are offered to guide such future work.

4.2.1 Replicate accounting content with different wireless devices

Both faculty and students perceived the content to enhance learning; Interactive Exercises were particularly well received by both groups. However, the PDA device was seen as too small for accounting content and the PDA is not a tool commonly used in the accounting workplace except as a personal organizer.

4.2.2 Re-examine affordability issues

There are issues to be addressed regarding student accountability for, and ability to absorb, project costs, especially wireless WAN usage. While the PDA students in this project did seem to be representative of first-year accounting students, there may still be a lingering equity challenge if future projects were to make students accountable for their WAN usage as well as for purchasing the device.

4.2.3 Explore a range of content

The exploration of content delivery by PDA in only one subject in a student's timetable is not an adequate basis for long-term decisions. Students seemed to indicate that they would integrate wireless devices such

as a PDA and wireless networks into their college life more fully if such technology were used in more than one course.

4.2.4 Offer a diverse suite of college services

To learn anything useful, a range of services, formatted to the wireless device, has to be offered so that the wireless environment becomes a way of life for students.

5. References and Websites

Larson, K.D., Jensen, T., & Carroll, R. (2002). *Financial Accounting Principles*, 10th Canadian edition. Whitby, Ontario, Canada: McGraw-Hill Ryerson Ltd.

Websites

Project site http://www.mcgrawhill.ca/college/mlearning
NAIT demo site http://www.nait.ab.ca/mobilelearning
Microvideo site http://www.microvideo.com/mvlstrainer/college/

6. Mobile Learning Pilot Project Team Members

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Sandi Barber, Project Manager, NAIT, Edmonton
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Philip Mulder, NAIT, Corporation Communications, Edmonton
Santo Nucifora, Seneca, Toronto
Kieron Quigley, NAIT, Infrastructure & Applications, Edmonton
Cherryl Ramesar, Seneca, Toronto
Mike Ross, CGEY, Edmonton
Grace Walkus, SVP, McGraw-Hill Education Media Technologies, NY

Content Development Team

Sandi Barber, NAIT, Edmonton
Wayne Campbell, Seneca, Toronto
Ron Francis, Seneca, Toronto
James Guthrie, NAIT, Edmonton
Tilly Jensen, NAIT, Edmonton
Brook Nymark, McGraw-Hill Ryerson, Toronto
Beverly Pasian, Bodec Corporation, Toronto,
Kathy Siedlaczek, Seneca, Toronto
Garbis Yaghdjian, Seneca, Toronto

Instructors

Wayne Campbell, Seneca, Toronto
Ron Francis, Seneca, Toronto
James Guthrie, NAIT, Edmonton
Tilly Jensen, NAIT, Edmonton

Evaluation Team

Naomi Beke, NAIT, Edmonton
Katharine Janzen, Seneca, Toronto,
Dawn Mercer, Seneca, Toronto
Elaine Soetaert, NAIT, Edmonton

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For more information, please visit the Mobile Learning website at
www.mcgrawhill.ca/mlearning