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The Effectiveness of PDAs for Enhancing Collaboration in M-Learning

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ABSTRACT

University students live in an increasingly mobile society and they carry increasingly sophisticated mobile devices, including wireless personal digital assistants (PDAs). For the first time, mobile technology and student lifestyle choices are converging to allow mobile learning (m-learning) to be a viable choice for delivery and execution of coursework material. This study addresses the question: In what ways do mobile devices change student interactions in an e-learning, collaborative education exercise? An experimental design methodology is used with control (desktop users) and experimental (PDA users) groups. The study finds that students who use PDAs tend to write shorter messages than desktop users and mobile learners tend to go online more often. The results are inconclusive regards time online per session. The study concludes with implications for instruction and instructors.

Keywords

mobile learning, m-learning, e-learning, personal digital assistant, PDA, collaboration

INTRODUCTION

The Evolution of Mobile Learning

Since the time of Socrates, traditional pedagogical learning has been personal contact between students and an instructor in a classroom setting. Technological devices such as the blackboard and educational innovations such as the textbook and case-based instruction facilitated the face-to-face delivery of instructional material and the learning process, but education still mostly occurred in the physical confines of a classroom.

In the 1990's, the widespread adoption of personal computers and the emergence of the Internet encouraged the development of e-learning (electronic learning). E-learning enables individuals to learn and collaborate together from wherever they can make an Internet connection – from work, home, or their tertiary institution. Today numerous courses, fully-developed degree programs, and even entire universities offer education delivered exclusively online in Web-based courses (Polsani, 2002).

One of the most popular aspects of e-learning has been the ability for students to collaborate on learning projects through electronic discussion boards (Nichols, 2002). In a typical discussion board, the instructor poses a question or a problem and students post messages that gradually evolve to the desired answer to the question or solution to the problem. Discussion boards are one of the most frequently used features of learning management systems such as Blackboard and WebCT. Collaboration through discussion boards is an effective way of applying instructional learning, improving acquisition and retention of knowledge, and it promotes teamwork, a key workplace skill.

As suggested above, e-learning is almost always viewed as occurring on a desktop computer at a home, workplace or university computer laboratory. Increasingly, it doesn't have to be this way. Midway through the first decade of the 21st century, a variety of mobile devices are available that allow students to make mobile connections from anywhere – a bus or car, a restaurant or pub, a park or beach. Just as the blackboard and textbook facilitated more effective classroom learning, so mobile computing devices such as wireless PCs, smartphones and, especially, PDAs (personal digital assistants) promise to greatly facilitate delivery of e-learning.

Mobile learning (m-learning) is the use of mobile devices such as PDAs to facilitate the education process. M-learning is a pedagogical revolution that provides the student with increased flexibility and mobility in the learning process.

Students are likely to welcome increased mobility in their learning activities. Most students work full- or part-time and many non-traditional students have families. Any learning resource that can be utilized during gaps in a student's hectic lifestyle is a

valuable asset to them. While it is impractical to carry textbooks or access Internet-connected computers at all times, it is possible to have access to a substantial amount of learning resources digitally in a PDA. Of particular interest in this study, the wireless PDA provides an electronic channel for omnipresent collaboration.

Personal Digital Assistant

A personal digital assistant or PDA is a small, lightweight, portable mobile computing device. The traditional use of the PDA is for personal information management and typical PDA applications include appointment calendar, task list, contact list, and notepad. Contemporary PDAs are far more advanced. Many PDAs now include still and video digital cameras, an audio notebook, digital music, workplace applications (e.g., Pocket Word, Pocket Excel, Media Player) as well as virtual (screen-based) and thumb QWERTY keyboards. Most of these fully-functional PDAs also include wireless connectivity through infrared, Bluetooth, WiFi or cellular telephone connections, including 3G connectivity.

The use of PDAs in education is still in its formative stages, although as mobile technology becomes more sophisticated and the price falls, it is expected that educators and students will increasingly utilize this technology in the learning environment.

Purpose of the Study

The purpose of this study is to assess the impact of PDAs on collaboration activities of students in an m-learning environment. This study addresses the question: In what ways do mobile devices change student interactions in an e-learning, collaborative exercise? It is hoped that this research will develop a better understanding of PDA use for instructional purposes in the tertiary education sector.

The study achieves these goals by an experiment in which university students are assigned to two groups and asked to collaborate in a typical learning exercise using an electronic discussion board. A control group of students (the e-learning group) is restricted to the use of desktop computers to complete the exercise while the experimental group of students (the m-learning group) must use wireless PDAs.

The primary data source is analysis of discussion logs. Pre- and post-test surveys of both groups will measure changes in perceptions of the use of mobile technology for learning.

LITERATURE REVIEW AND HYPOTHESES

Mobile Learning

The earliest recorded use of mobile learning was at a business training school in Singapore. Given the state of mobile technology at the time, the goals were understandably modest, consistently mostly of reminders and text quizzes sent to the students' mobile phones. The participants valued the convenience of the mobile interaction and appreciated the fine factoring of information, but there was considerable skepticism that this would become a viable way to offer education (Houser, Thornton, and Kluge, 2002).

Emerging mobile technologies hold great promise for educational institutions, which are seeking to deliver the learning experience to an increasingly geographically distant and time-challenged student population (Hill, 2002). Similarly, m-learning liberates e-learners from the desktop environment and extends the discussion to a geo-dispersed environment, taking the paradigm from "push" and "pull" to a "reach" orientation (Hill, 2002). Learning outcomes may be enhanced as well because there is evidence that the daily and persistent use of computing leads to increased learning (Seppala, Sariola, and Kynaslahti, 2002). The core attribute of mobile learning is that it enables the learner to be able to experience the authentic joy of learning at any place and any time (Seppala et al., 2002).

Mobile Devices in Education

It seems only a matter of time before mobile devices will play a significant role in education. Wireless laptops have equivalent functionality as desktop computers, but can be used anywhere a wireless connection can be made. PDAs perform similar, scaled-down, functions as desktop computers, and with the advantages of simplicity (e.g., easier to learn and use) and improved access and portability (e.g., instant on, being usable anywhere at anytime) (Savill-Smith and Kent, 2003). Wireless PDAs are relatively inexpensive compared to full-sized desktop and laptop computers, and especially so when the marginal cost of ownership is considered (i.e., a wireless PDA is only slightly more expensive than a full-featured mobile telephone, which most students would own anyway).

A distinctive m-learning role for the PDA is as a portable recording device. In field studies, data can be loaded directly into the PDA and then later uploaded into the desktop application by an infrared, Bluetooth or USB connection (Pinkwart, Schafer, and Hoppe, 2002). In laboratory experiments, a personal computer may be cumbersome or intrusive, but a PDA can effectively replace the experimenter's notepad.

Another important role for PDAs is to enable students to share information and coordinate their tasks more effectively in support of collaboration in an education environment. (Milrad, Perez, and Hoppe, 2002). PDA-based solutions for student collaboration are of significant interest for education because they enable a transition from occasional, supplemental use of information technology, to a more frequent integral use. Accordingly, hypothesis 1 in this study is:

H1: The experimental group will go online more frequently.

The semi-ubiquitous availability of wireless access means the experimental (mobile) group is likely to be online more frequently. This extends the findings for wireless laptops in Sotillo (2003) to PDAs. In contrast, the control (desktop) group can only work when in the physical proximity of a desktop computer, and so they are likely to be on less frequently. This hypothesis will be measured by the number of sessions over the test period and the total number of messages posted.

In summary, PDA technology has great potential for use in m-learning, improving the way instructors teach and the way students learn (Zurita and Nussbaum, 2004). Two specific studies that focused on the use of PDAs to enhance student collaboration are discussed in the next section.

However, mobile devices also possess inherent limitations that can pose problems for m-learning activities. The limited bandwidth of current mobile architectures creates update issues (e.g., the transmission of large, multimedia content such as pictures, audio notes, and lecture slides) and concurrent modification conflicts (e.g., when concurrent changes of group collaborative material may created conflicts) (Lara, Kumar, Wallach and Zwaenepoel, 2001). Bandwidth limitations will be reduced with 3G technologies, but 3G networks and 3G-enabled devices are not yet widespread.

Another limitation is the small screen size, typically on a PDA a 95mm, 240-by-320 pixel screen is approximately one-sixth the size and one-fourth the resolution of a 380mm, 640-by-480 standard desktop monitor (Comerford, 2000). Most Web pages are designed to be displayed using desktop computers with large and high resolution screens. When viewed through a PDA, the pages can be viewed only with extensive scrolling, and some features may not load at all (Chu, 2001).

A similar limitation is the slow input of text. Although average input speeds on a PDA with a virtual or thumb QWERTY keyboard – 25 words per minute – is much faster than typical cell phone keypad entry – typically 10 words per minute – it is still much slower than the average 60 words per minute on full-size desktop and laptop keyboards (Houser et al., 2002). Accordingly, hypothesis 2 in this study is:

H2: The experimental group will enter fewer words per time on task.

It is expected that each message left by the experimental group will be smaller than the messages posted by the control group due to human-computer interface (HCI) factors such as small screen and keypad sizes. HCI research by Clement and Victors (2002) suggests it will take the experimental (mobile) group longer to read the relevant information due to the small screen size and take more time to key in words due to the PDA keypad area being greatly smaller than a desktop computer keyboard. The number of words entered per message will test this hypothesis.

Finally, the operating costs for accessing learning materials via mobile devices is much more expensive than with desktop computers. Desktop Internet access is inexpensive, in New Zealand as little as US$7 per month for unlimited dial-up access or freely available in university computer laboratories. On the other hand, PDA Internet access will incur data download charges in addition to relatively expensive call rates for time online. Combined with slow download speeds and slow input, the cost of m-learning will be a deterrent for many students. This is the key justification for hypothesis 3:

H3: The experimental group will be online for a shorter duration per session.

The ease of making a Web connection and the relatively high cost means that the experimental (mobile) group is likely to experience quick-on-and-off sessions on the task. In contrast, the control (desktop) group is more likely to experience get-stuck-into-it sessions and so be online for longer periods of time per session. This hypothesis will be measured by examining the number of minutes online per session.

The Use of PDAs for Student Collaboration

Asynchronous collaborative tools such as e-mail and discussion boards facilitate the exchange of an individual's work, which can then be integrated into the entire team's project. Online collaboration allows learners to work together in real time ubiquitously (Wiley, 2001) and collaborative learning has frequently been seen as a stimulus for cognitive development through its capacity to stimulate social interaction and learning among group members (Zurita and Nussbaum, 2004).

Obviously, effective collaboration depends on the student being able to articulate feelings and thoughts to peers. Discussion among participants is essential for collaborative learning (Lundin and Magnusson, 2003) and when learners are geo-dispersed, tools for mediating and enhancing collaborative discussions are needed. There have, in fact, been very few studies that empirically examine the use of PDAs in m-learning activities.

One such study was the use of PDAs in a Computer Engineering course at the Penn State Abington campus in Fall 2000 (Avanzato, 2001). In this study, 24 students in a sophomore-level digital systems course were provided with a Palm IIIx PDA which was used for exchange of course materials (e.g., lecture notes were transferred to the PDAs via infrared beaming) and for project work (e.g., a digital circuit schematic database, software for truth table and K-map generation), but no interactive collaboration over a wireless network was involved, at least in part because wireless PDAs were not yet generally available.

The use of PDA technology as an instructional tool was highly rated by the students and the instructor. The investigation and testing of software tools demonstrated the usefulness of the PDA to enhance learning in the classroom and lab. The success of this pilot project led to the integration of handheld computers into a number of courses at Penn State Abington (Avanzato, 2001).

Another research study with relevance to the current study was a wireless pilot project at Montclair State University (MSU) in New Jersey (Sotillo, 2003). Five graduate students in applied linguistics used wireless laptops for collaboration with others on research projects. Although laptops, not PDAs, were used, the study featured student-centered, collaborative work with students able to meet virtually and communicate anywhere and at a most convenient time through a number of wireless access points on the MSU campus.

The students agreed that the major benefit of the study was that ubiquitous access to the Internet and mutual collaboration increased their productivity. The study concluded that wireless-enabled laptops made it possible for students to use their time more efficiently, access databases and information from the Internet more easily, and work collaboratively (Sotillo, 2003).

The use of wireless laptop computers in the MSU study emphasizes that PDAs are not the only way of conducting m-learning activities. However, as best as we can determine, the current study is the first research study to focus on the use of PDAs for student collaboration in m-learning.

METHODOLOGY

Research Approach

The research methodology used in this study is an experimental design. Experiments are studies in which the researcher manipulates a variable in the experiment and observes how it affects the subjects in question. Specifically, the researcher manipulates the independent or explanatory variable and then observes whether the dependent variable is affected by the researcher's intervention (Cooper and Schindler, 2003).

This study uses a pre-test post-test control group design, as shown in Figure 1. In this figure, O1 and O2 represent, respectively, pre- and post-test observations of the experimental group and O3 and O4 represents pre- and post-test observations of the control group. X represents the introduction of the experimental stimulus to the group, which is the collaboration exercise in this study. The effect of the experimental variable (E) will be measured by E = (O2 – O1) – (O4 – O3).

O1	X	O2
O3	X	O4

Figure 1: Pre-test Post-test Control Group Experimental Design

Specifically, in this study pre-test surveys (O1 and O3) are used to measure participant's attitudes about the use of mobile devices for m-learning. Then the experiment is conducted and post-test surveys (O2 and O4) are used to assess changes.

Description of the Experiment

In early October 2004 fourteen senior undergraduate and graduate students at Massey University in New Zealand were recruited for participation in the experiment. The participant numbers were limited by the number of PDAs available for the experiment – seven iPaq h4350 PDAs manufactured by Hewlett-Packard.

Randomization is normally used in experiments to insure internal validity (Campbell and Stanley, 1963). However, in this study seven students with PDA experience were assigned to the experimental (mobile) group and the remaining seven students were placed in the control (desktop) group. This process insured both groups were experienced users of the technology, either PDA or desktop computer. Assignment of non-experienced PDA users into the experimental group would have introduced the possibility that the results would be due to lack of experience with the technology. The equalization of technology experience is thought to have contributed more to internal validity than the random assignment of student to groups, at least in this study.

Pre-test surveys were administered in mid-October and the week-long experiment began on October 24, 2004. Experimental conditions for both groups were identical, except for the limitations on devices that could be used (i.e., PDAs only by the experimental group and desktop computers only by control group). Both groups were asked to determine business goals, products, and a target audience for a funky new restaurant/nightclub in downtown Auckland. The discussion board was hosted by WebSiteToolbox

The experiment ended on October 30th and the post-test survey was conducted shortly afterwards.

RESULTS

The conduct of the experiment was considered a success except that one member of the control (desktop) group did not access the discussion board or complete the post-test survey. So the final results are reported for a control group of six participants. The impact of this experimental mortality (i.e., differential loss of experiment subjects from comparison groups (Campbell and Stanley, 1963)) is not considered to have materially affected the results.

Hypothesis 1: The experimental group will go online more frequently.

This hypothesis was tested by measuring the total number of messages posted and by pre- and post-test survey questions.

During the experiment, the mobile group posted 72 messages (10.2 messages per person) and the desktop group posted 55 messages (9.2 messages per person). Furthermore, while the pre-test survey showed that most (4 of 6) of the desktop group did not feel the restriction to desktop access would limit their ability to contribute, the post-test survey revealed that half (3 of 6) of the desktop group felt that they found it hard that they could only post messages in the physical proximity of a desktop computer. Finally, when expectations about "did you go online more than you expected?" were reported, two members of the mobile group (29%) answered yes and only one member of the desktop group (17%) answered yes.

While these results could hardly be called conclusive, the results do support the acceptance of hypothesis one. Additionally, a t-test based on standard statistical approximates gave a p-value of 0.288, meaning that one could not reject the hypothesis that there was no difference in the mean number of messages between the experimental and control groups. These findings are consistent with the findings of previous studies (e.g., Sotillo, 2003) that mobile devices encourage students to go online more frequently.

H2: The experimental group will enter fewer words per time on task.

This hypothesis was tested by measuring the number of words entered per message and by pre- and post-test survey questions.

Over the week of the experiment, the experimental (mobile) group posted 3,836 words in 72 messages or an average of 53 words per message. Over the same period, the control (desktop) group posted a total of 4,241 words in 55 posts or an average of 77 words per message. A t-test based on standard statistical approximates gave a p-value of <0.0005, meaning that there was very strong evidence that the experimental (PDA) group used fewer words in their messages than the control (desktop) group.

The participants' responses to the pre-test and post-test surveys also support the acceptance of the hypothesis for the reasons that are reported in the literature. First, as reported above, 6 of the 7 PDA users anticipated small screen and keyboard size would be a limitation on their ability to collaborate with group members. Post-test survey results were consistent with this, 6 of the 7 reported reading and replying using a PDA was "poor" or only "good".

In the pre-test survey, all seven of the experimental (mobile) group members replies "yes" to the question "Would you post shorter messages on a discussion board if you used a PDA compared to a desktop computer?" In the post-test survey six of the seven PDA participants reported they posted longer messages than expected. Interpreting these results, the experimental group felt they would be posting "really short" messages. In the end they posted "short" messages, in contrast to the "long" messages posted by the control (desktop) group.

Of all three hypotheses, hypothesis two received the strongest support for acceptance.

Hypothesis 3: The experimental group will be online for a shorter duration per session.

This hypothesis was tested by measuring the number of minutes online per session by each group member and by pre- and post-test survey questions.

Table 1 shows self-reported results for the post-test survey question "On average, how many minutes per session did you spend online?". Self-reported results are used here because, contrary to expectations, WebSiteToolbox was unable to provide actual data. Participant-time-per-session either from the session logs or participant logs is something that can be improved in future studies.

Minutes online	1-10 minutes	11-20 minutes	>20 minutes
Desktop	2	4	0
PDA	3	3	1

Table 1. Minutes Per Session Online

The results appear to be inconclusive. While slightly more mobile participants were online for 1-10 minutes per session, one mobile participant reported being online for more than 20 minutes per session.

Other results from the post-test survey provide some insight to these data.

- In line with expectations, the experimental (mobile) group found reading messages and writing a reply to be somewhat difficult. Specifically, three PDA users said reading and writing using the PDA was "poor"; three said "good" and only one said "excellent". In contrast, all six desktop users reported reading messages and writing replies to be "excellent".

  So the longer time online may be partially attributable to HCI factors associated with using PDA devices, rather than any inherent desire or advantage for quick-off-and-on sessions.
- Contrary to expectations, the majority (4 of 7) of the mobile group did not find the cost of going online to be a factor that limited their time on line. This was consistent with pre-test expectations (4 of 7 did not see high cost as a limiting barrier). In this experiment at least, the factor of relatively high cost of a mobile online connection did not seriously limit the ability of the experimental (mobile) group to participate.
- Despite the results reported in Table 1, most of mobile group (5 of 7 participants) reported their experience was "quick-on-and-off" sessions whereas half of the desktop group (3 of 6) reported "get-stuck-into-it" sessions.

In summary, hypothesis three cannot be accepted or rejected. Lack of accurate and detailed data and a number of somewhat conflicting results mean this result is inconclusive.

CONCLUSIONS

As discussed in the previous section, the strongest result from this study is that students using PDAs in collaboration activities will tend to write shorter messages than students using desktop computers. It is no secret that through text messaging students learn to include significant content in brief communications. Brevity of messages should not be a problem in collaboration exercises for m-learning.

The findings also support the proposition that students using PDAs will go online more often. Most instructors would consider this a positive factor because a key part of a collaboration exercise is keeping up with the discussion and contributing early and often.

The results of this experiment are inconclusive, at best, about time online per session. The only firm observation that can be made is that usability problems associated with small mobile devices such as PDAs may lead to longer-than-expected sessions.

Limitations of the Study

In hindsight, there are some ways in which the study could have been improved. We offer them here for the reader's information and for consideration by future researchers:

Participant numbers were low – limited by the number of PDAs available – and students were not assigned to groups randomly – due to the need to have experienced PDA users be assigned to the experimental group. While we believe the results are credible and valid, in an ideal study a larger number of PDAs would be available and all participants would be equally experienced in the use of desktop computers and PDAs.

The experiment was conducted over a seven day period. This was necessary due to timing constraints, but in future studies it would be better if the study period was much longer in order to get a more realistic picture of collaboration activities. A more extended study would also allow measuring changes in the variables over time.

Similarly, the experimental week occurred during pre-exams study week, a very busy time of the semester for most students. Post-test survey results showed this negatively influenced the participation of the control (desktop) group – four of the six participants reported exams influenced their ability to post messages. Interestingly, only two of the seven PDA users reported a negative impact from the experiment being during study week. This is noteworthy because perhaps their ability to participate while mobile gave PDA users increased flexibility to participate in a time-pressured week. This is an unanticipated, positive outcome for m-learning.

A more sophisticated discussion board provider would have been able to deliver more precise data about session times, duration of sessions, and so on. A richer data set would have improved our ability to draw results and conclusions, especially on hypothesis 3.

Suggestions for Future Research

In addition to the suggestions offered immediately above, researchers interested in conducting research in this area should consider:

Further exploration of the underlying causes for these results is required. For example, hypothesis 3 presents somewhat confusing and conflicting results about usability and cost of mobile devices for student collaboration.

This study was restricted to PDAs. Future studies may be able to distinguish differences in student collaboration using different mobile devices, especially wireless laptop computers versus PDAs.

This study used a short and simple collaboration exercise. Research needs to be completed using a longer and more complex collaboration exercise, which is more typical in university environments.

Concluding Comment

This topic is an important research area as m-learning becomes a natural progression of e-learning, with its combined advantages of mobility and electronic content. The question is not "if" m-learning will be part of our university educational experiences, but "when" it will be a major avenue for student participation in learning.

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