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# Role Preference: Are Handheld Computers An Educational Or Personal Technology?

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**ABSTRACT**

As an educational delivery platform, current handheld computer technology provides a low-cost, networked, small-form factor appliance with sufficient machine resources to support instruction, learning, assessment, and collaboration. Yet, except in the fields of medicine and law, handheld adoption for collegiate classroom use has been minimal. This study presents the results of an empirical investigation of users and non-users of handheld technology in higher education. Faculty and student personal technology preferences, handheld usage practices, and experience profiles are presented. Results confirm handhelds are peripheral to most collegiate instruction with usage confined primarily to performing personal information management. When handhelds are used for education, they function as a portable extension of the personal computer. Implications for educational practice are presented.

**Keywords:** Handheld computer-assisted instruction; improving classroom teaching using PDAs; mobile interactive learning environments; PDA-enhanced courses.

## 1. INTRODUCTION

Today's wireless-enabled handheld computing devices provide a capable platform for "anytime, anywhere" teaching, learning, assessment, and collaboration (Jones and Johnson, 2002; Shields and Poftak, 2002; Yuen and Yuen, 2003). Much like universally available textbooks revolutionized modern education, ubiquitous mobile computing promises to transform the college and university-level instructional process (Weiser, 1998; Whinston, 1994). Yet, ten years after the introduction of the first commercial personal digital assistant, the Apple Newton Messagepad, "handhelds are still a novelty for many of the 14.5 million U.S. college students" (Fallon, 2002). Except in the fields of medicine and law, adoption of small form factor networked computing devices for collegiate classroom use has been minimal (Carlson, 2002; Collins, 2001; Fallon, 2002; Olsen, 2002; Roach, 2002; Shields and Poftak, 2002). The devices are used in many medical schools because medical software made especially for PDA's is widely available. Students in Samford University's pharmacy school are using Palm handheld computers to take note in class, check medical references, and compare interactions of prescription drugs in patients. Stanford University law students are participating in a study that examines the effectiveness of putting legal-study materials on PDA's (Carlson, 2002). Apart from course topic coverage as a systems deployment platform, handheld computers are noticeably absent from Information Systems education (Jones, 2000; Mull and Lutes, 2001).

While at least 50 higher education institutions have adopted campus-wide laptop computing initiatives (Brown, 1998; Notebook Universities, 2002; Thomas, Laxer, Nishida, and Sherlock, 2002), less than a handful of colleges have implemented similar ubiquitous computing programs based on handhelds. The University of South Dakota, for instance, began requiring wireless Palm computers of all incoming freshman starting Fall 2001(Carr, 2001). With a grant from Handspring in 2002, East Carolina University gave each student a Visor Deluxe equipped with application software that included an email client and web browser (East Carolina University, 2001). Fall 2002 at the University of Minnesota at Duluth (Young, 2001) and Spring 2003 at Winston-Salem State (Roach, 2002), entering students were required to buy wireless personal digital assistants (PDAs).

Implementation hurdles aside, early reports are generally positive on pilot projects to explore the pedagogical application of handheld computing and wireless

technology (Johnson, Jones, and Cold, 2002). Unfortunately, the literature in which the exploratory research is reported is primarily anecdotal and limited to educational trade publications and testimonials on vendors' web sites. The focus has been largely on discovering the impact of the technology on student behavior and the related effect on the learning environment. Further, this research has been interventionist in nature, in that the student and faculty populations are provided handhelds as part of the study or are required to acquire a handheld as a condition of college attendance. While such an approach to research on handheld usage may produce interesting observations, it is unnatural, ignoring individual choice. The findings are only generalizable to students and faculty given handhelds or required to obtain handhelds. Little, if anything, can be said of students and faculty, who in the general course of their college experience, have elected on their own to use or disregard such technology. What is needed is a survey of current collegiate handheld usage, untainted by researcher intervention. Descriptive data on faculty and student usage/non-usage patterns would provide valuable insight into the current role of handhelds in academia. Such insight would help faculty and administrators determine the appropriateness of today's wireless PDA technology as a platform for department-wide or campus-wide computing.

## 2. RESEARCH OBJECTIVES

To address the need for a coherent role for handhelds in academic computing, we have embarked on a multi-year research effort. To date we have completed a review of relevant literature (Johnson, Jones, and Cold, 2002; Jones and Johnson, 2002) and conducted exploratory survey research on the relative likelihood of use of various applications of handheld computers in higher education and the means for operationalizing universal access to handhelds (Jones and Johnson, 2003). This study extends our previous foundational work by examining the characteristics of both current users and non-users of handheld computers in higher education. Specifically, the following research questions were addressed:

- What is the demographic profile of the typical faculty and student handheld user? The typical non-user? Is there a significant difference in demographics between handheld users and non-users?
- What are the technology preferences of the typical faculty and student handheld user? The typical non-user? Is there a significant difference in technology preferences between handheld users and non-users?
- What is the handheld experience profile of the typical faculty and student user? Is there a significant difference in the quality and quantity of handheld experience among faculty and student users?

## 3. METHODOLOGY AND DATA COLLECTION

During April 2002 a handheld usage survey was conducted of the entire student and faculty population at a large comprehensive, four-year college, located in the U.S. intermountain west. The population frame was 22,609 students, 330 full-time faculty, and 864 part-time faculty. Students and faculty received campus email inviting them to complete an easily accessible web-based questionnaire. As an incentive to participate and as a way to keep the sample more random than voluntary, respondents were entered into a drawing for one of two new $150 handheld computers. Four separate survey instruments were used, each tailored to one of four respondent categories: (a) faculty—handheld user, (b) faculty—handheld nonuser, (c) student—handheld user, and (d) student—handheld nonuser. The following types of data were collected from all respondents: (a) demographics, (b) experience with other handheld technologies such as cell phones, and (c) technology adoption preferences.

Handheld users were asked to provide the following additional data: (a) level of experience with handheld computers, (b) type of handheld platforms currently owned and previously used, (c) communication capability of existing handheld, (d) primary means for learning how to operate a handheld, (e) primary reason for owning a handheld, (g) frequency of use by handheld application type (e.g. calendar, ToDo lists, to-do lists), and (f) handheld synchronization practices. Those who did not currently use handheld computers were asked to indicate (a) primary reason for not using a handheld, and (b) factors that may have contributed to discontinuance of use of a handheld, if one was previously used.

The survey was completed by 328 students, 49 full-time faculty, and 21 part-time faculty. Incomplete questionnaires and duplicates were excluded from the tabulation, leaving 386 useable responses for a response rate of 1.4%, 13.7%, and 2.2% respectively. Complete copies of the instruments are available from the authors. Sample survey questions are included in the appendix.

## 4. RESULTS AND ANALYSIS

### 4.1 Respondent Demographics

Survey participants answered several questions designed to provide data regarding respondent characteristics. As Table 1 indicates, faculty ($n$ = 64) respondents were typically 44.4 years old, male (76.6%), handheld computers users (51.6%), with a graduate degree (71.9%), six to fifteen years college experience (64.1%), teaching full-time (70.3%) in computer-related disciplines (25.0%). Students respondents ($n$= 322), although equally likely to be male (77.3%), were typically younger (26.5 years old), non-users of handheld computers (69.6%). The vast majority of student respondents were seeking bachelor's degrees (76.7%). Over 40 percent (44.4%) had declared majors in computer-related fields. College standing was somewhat unevenly distributed. Over thirty percent of respondents (31.1%) were sophomores while freshman accounted for only slightly more than sixteen percent (16.1%).

**4.2 Respondent Technology Profile**

Three factors were explored regarding technology preferences. Respondents were asked to (a) rate their predilection for adopting new technology, (b) indicate which personal electronic technologies they have tried, and (c) specify the primary reason for owning or not owning a handheld computer.

**4.2.1 Technology adoption profile:** In order to capture technology predilection, survey participants were asked to rate themselves on a three-item scale as either an early-, middle-, or late-stage technology adopter. Early stage adoption was defined as "someone who must be the first on the block to have the latest gadget", middle-stage adoption as "someone who is technically savvy and has the same gadgets that most everyone else is using", and late-stage adoption as "someone who only buys mature technology, gadgets that are usually a year behind the latest versions." Table 2 presents the tabulated results of the survey question, grouped according to handheld ownership and respondent category (faculty vs. student). As Table 2 indicates the majority or near majority of all respondents, regardless of category or handheld computer ownership, characterized themselves as middle-stage adopters. Over 60 percent of faculty handheld owners (63.6%), 58.1% of non-owning faculty, 48.0% of student handheld owners, and 55.8% of non-owning students reported a propensity to espouse new equipment in the middle of the technology cycle. For early- and late-stage adoption practices, the data diverged. On the whole, handheld users were three times more likely to be early-stage adopters (32.8%) than non-users (10.6%). Conversely, non-users were two times more likely to be late-stage adopters (33.3%) than were users (15.3%). A two-way contingency table analysis was conducted to determine if the observed relationship between technology adoption propensity and handheld ownership was statistically significant. Adoption profile and handheld ownership were found to be significantly related (Pearson $\chi^2$ (2, $N$ = 386) = 34.25, $p$ = .000). The proportions of handheld users who reported a technology adoption profile of early-, middle-, and late-stage were .62, .32, and .19 respectively. The probability of handheld users characterizing themselves as early adopters was about 3.26 times (.62/.19) more likely than as late-stage adopters. On the other hand, non-handheld computer users characterized themselves as late-stage adopters 2.13 times (.38/.81) more.

**4.2.2 Personal electronics usage:** Survey participants were provided a list of personal electronic devices similar in size and complexity to handheld computers and asked to indicate whether they had experience with the technology. Cell phones were the most frequently cited personal electronic device, regardless of respondent category or handheld ownership (Table 3). Over 90 percent (92.4%) of handheld users and over 80 percent (84.7%) of non-users reported experience will mobile phones. Among handheld users, personal music players such as a cassette tape, music CD, or MP3 "walkman"-style device were the next most reportedly used personal electronic technology (74.8%). For non-users, handheld video game consoles were the devices with which they had the second highest level of experience (74.9%). Both users (64.1%) and non-users (46.7%) claimed considerable exposure to pagers. Respondents were least likely to have experience using personal video players, although handheld users (22.9%) were more likely to employ this technology than non-users (3.1%).

A two-way contingency table analysis was conducted to determine if the proportion of device experience for handheld users and non-users was the same for each personal electronic technology. The first variable was handheld ownership with two levels (currently own, do not own). The second variable was experience with the individual electronic device, also with two levels (yes, no). Handheld ownership was found to be significantly related to device experience for every one of the surveyed personal electronic technologies: (a) cell phone (Pearson $\chi^2$ (1, $N$ = 386) = 4.58, $p$ = .032), (b) personal music player (Pearson $\chi^2$ (1, $N$ = 386) = 15.59, $p$ = .000), (c) pager (Pearson $\chi^2$ (1, $N$ = 386) = 10.58, $p$ = .001), (d) handheld video game (Pearson $\chi^2$ (1, $N$ = 386) = 5.83, $p$ = .016), and, (e) personal video player (Pearson $\chi^2$ (1, $N$ = 386) = 38.08, $p$ = .000). More handheld users have experience with cell phones, personal music players, pagers, and personal video players than non-users. Fewer handheld users than non-user have experience with handheld video games.

**4.2.3 Motivation for handheld ownership:** As part of the survey, existing owners of handheld computers were asked to specify their primary rationale for continued use of the technology.

Non-owner respondents, alternatively, were asked why they do not currently use (or why they discontinuing using) a handheld computer. For handheld owners, the continued motivation for personal digital assistant (PDA) use varied. In contrast, non-users were remarkably uniform regarding why they did not currently use or (discontinued using) handheld computers.

As shown in Table 4, the most frequently cited motivation for handheld ownership was as an electronic replacement for paper-based personal organizers (22.9%). Sixteen percent of respondents selected "memory aid" and 14.5% "reference tool" as primary motivators. Interestingly, 13.7% reported using a handheld computer because it had been received as a gift. About 10 percent of respondents (9.9%) claimed a handheld computer was an essential technical accessory. Combined, these five motivators accounted for 77.0% of the reported rationale for handheld ownership.

A two-way contingency table analysis was conducted to determine if the proportion for primary motivation was the same for faculty users and student users. The two variables were respondent category with two levels

(faculty, student) and primary motivator with the 14 levels reflected in Table 4. Primary motivation for handheld ownership was found to be significantly related to respondent type (Pearson $\chi^2$ (11, $N$ = 131) = 19.90, $p$ = .047). Faculty were more likely than student users to report using a handheld as a reference tool as a primary motivation for owning a PDA. Students, on the other hand, were more likely than faculty users to report using a handheld because it was given to them or that it was an essential technology accessory.

As depicted in Table 5, cost was the dominant reason cited by both faculty (64.5%) and students (78.6%) for not owning a handheld. "Data input difficulties" (4.3%) was the second most frequently cited reason for non ownership, followed by "lifestyle issues" (3.1%). A two-way contingency table analysis of the difference in proportions revealed primary reason for non-ownership was significantly related to respondent type (Pearson $\chi^2$ (6, $N$ = 255) = 16.76, $p$ = .010). Non-user faculty were more

**TABLE 1**
**Respondent Demographics**

| Demographic Category | Faculty ($n$ = 64; Response Rate = 5.4%) | | | Students ($n$ = 322; Response Rate = 1.4%) | |
|---|---|---|---|---|---|
| | *M* | *SD* | | *M* | *SD* |
| Average age (in years) | 44.38 | 11.53 | | 26.53 | 6.49 |
| Gender | *f* | % | | *f* | % |
| Male | 49 | 76.6 | | 249 | 77.3 |
| Female | 15 | 23.4 | | 73 | 22.7 |
| Handheld computer user | *f* | % | | *f* | % |
| Yes | 33 | 51.6 | | 98 | 30.4 |
| No | 31 | 48.4 | | 224 | 69.6 |
| Highest degree completed | *f* | % | Degree sought | *f* | % |
| Doctorate | 25 | 39.1 | Bachelor | 247 | 76.7 |
| Master | 21 | 32.8 | Associate | 56 | 17.4 |
| Bachelor | 10 | 15.6 | Master 13 | 4.0 | |
| Associate | 7 | 10.9 | 1 yr cert. | 1 | 0.3 |
| High school diploma | 1 | 1.6 | Non-degree seeking | 5 | 1.6 |
| College teaching experience | *f* | % | College standing | *f* | % |
| 11 – 15 years | 21 | 32.8 | Sophomore | 100 | 31.1 |
| 6 – 10 years | 20 | 31.3 | Junior 78 | 24.2 | |
| 3 – 5 years | 13 | 20.3 | Senior 77 | 23.9 | |
| Less than 1 year | 6 | 9.4 | Freshman | 52 | 16.1 |
| 1 – 2 years | 4 | 6.3 | Non-matriculated | 15 | 4.7 |
| Primary teaching discipline | *f* | % | College major | *f* | % |
| Computing/Networking Sciences | 10 | 15.6 | Computing/Networking Sc | 111 | 34.5 |
| Information Technology | 6 | 9.4 | Business Management | 36 | 11.2 |
| Business Management | 4 | 6.3 | Information Technology | 32 | 9.9 |
| Chemistry | 4 | 6.3 | Accounting | 12 | 3.7 |
| English | 4 | 6.3 | Behavioral Science | 12 | 3.7 |
| Math | 4 | 6.3 | Integrated Studies | 9 | 2.8 |
| Accounting | 3 | 4.7 | Multimedia Communication | 9 | 2.8 |
| Behavioral Science | 3 | 4.7 | Technology Management | 9 | 2.8 |
| All remaining disciplines | 26 | 40.6 | All remaining majors | 92 | 28.6 |
| Employment status | *f* | % | | | |
| Full-time | 45 | 70.3 | | | |
| Part-time | 19 | 29.7 | | | |

**TABLE 2**
**Technology Adoption Profile**

| | Combined | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| When most likely to adopt | *f* | % | *f* | % | *f* | % |
| Handheld Owners | | | | | | |
| Middle-stage | 68 | 51.9 | 21 | 63.6 | 47 | 48.0 |
| Early-stage | 43 | 32.8 | 8 | 24.2 | 35 | 35.7 |
| Late-stage | 20 | 15.3 | 4 | 12.1 | 16 | 16.3 |
| Non-Owners | | | | | | |
| Middle-stage | 143 | 56.1 | 18 | 58.1 | 125 | 55.8 |
| Late-stage | 85 | 33.3 | 10 | 32.3 | 75 | 33.5 |
| Early-stage | 27 | 10.6 | 3 | 4.7 | 24 | 10.7 |
| Totals | 386 | 100.0% | 64 | 100.0% | 322 | 100.0% |

**TABLE 3**
**All Personal Electronic Technologies Used**
*(Grouped by Handheld Computer Usage)*

| | Combined | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Category of Personal Electronics | *f* | % | *f* | % | *f* | % |
| Users of Handheld Computers | | | | | | |
| Cell phone | 121 | 92.4 | 31 | 93.9 | 90 | 91.8 |
| Personal music player | 98 | 74.8 | 11 | 33.3 | 87 | 88.8 |
| Pager | 84 | 64.1 | 20 | 60.6 | 64 | 65.3 |
| Handheld video game | 82 | 62.6 | 13 | 39.4 | 69 | 70.4 |
| Personal video player | 30 | 22.9 | 1 | 3.0 | 29 | 29.6 |
| Non-users of Handheld Computers | | | | | | |
| Cell phone | 216 | 84.7 | 26 | 83.9 | 190 | 84.8 |
| Handheld video game | 191 | 74.9 | 19 | 61.3 | 172 | 76.8 |
| Personal music player | 138 | 54.1 | 25 | 80.6 | 113 | 50.4 |
| Pager | 119 | 46.7 | 10 | 32.3 | 109 | 48.7 |
| Personal video player | 8 | 3.1 | 8 | 25.8 | 0 | 0.0 |

*Note.* Handheld computer usage reported separately in Table 1.

likely than non-user students to cite data input difficulties and lifestyle issues and less likely than students to cite cost as a factor in non-ownership.

Of the 255 survey participants who reported that they did not currently own a handheld computer, 112 (43.9%) had previously owned a PDA but had stopped using it. The most frequently cited single reason for discontinued use was device failure (31.3%). Device inadequacy, in contrast, accounted for 52.0% of the response and consisted of the following combined reasons: (a) applications not useful (17.9%), (b) insufficient memory (14.3%), (c) non-color display (6.3%), (d) difficult-to-read screens (6.3%), (e) synchronization problems (4.5%), and (f) printing problems (2.7%). Although there were differences in rationale frequency between faculty and student respondent groups, these differences were not statistically significant (Pearson $\chi^2$ (9, $N$ = 112) = 16.76, $p$ = .061).

**4.3 Handheld Computer User Profile**

In order to construct a handheld computer user profile, six factors were investigated. Current handheld owners were asked to (a) specify current PDA device type, (b) report on previous handheld devices owned, (c) indicate months experience with handhelds, (d) identify all approaches used to learn to operate a handheld, (e) characterize handheld synchronization practices, and (f) detail frequency of use for each handheld software application.

**4.3.1 Handheld devices in use:** As displayed in Table 6, the dominant handheld device currently in use by respondents was Palm-based (76.3%), with Windows-based handhelds a distant second (20.6%). The categorical proportions for each device were remarkably similar between faculty and student users. In fact, a two-way contingency table analysis of the difference in proportions confirmed handheld device type was not significantly related to respondent type (Pearson $\chi^2$ (4, $N$ = 131) = 1.39, $p$ = .846).

In addition to specifying which handheld device they currently use, respondents were also asked to identify all handhelds with which they had had previous experience. Respondents' previous experience essentially mirrored current usage.

**4.3.2 Handheld experience levels:** Respondents were presented six experience brackets ranging from less than three to over 60 months. As Table 7 portrays, the most frequently reported experience range was between 13 and 24 months (36.6%) with the next most frequently cited range as 25 to 60 months (22.1%). Combined, then, the majority of respondents (58.7%) had between one and five years experience with handheld computing. Only 6.1% of respondents reported less than three months experience with handheld devices. For the most part, categorical proportions for each device type were essentially similar between faculty and student users. Only the difference in proportions for previous Palm-based device experience was significant (Pearson $\chi^2$ (1, $N$ = 130) = 9.55, $p$ = .002). Proportionately more students (78.6%) than faculty (51.5%) reported having used a Palm PDA before.

**4.3.3 Approaches to learning:** Handheld computers are sophisticated personal electronic devices, complete with microprocessor, data storage, communication capabilities, an operating system, and application software. Respondents were asked to specify all means by which they learned to operate their palm-sized personal computer. More than one response was possible (Table 8). The most frequently cited approaches to learning were "Trial and error" (88.5%) and "Reading the user manual" (53.4%). Some 14.5% relied on "Tutorials". None of the respondents had taken a course in how to operate a handheld computer, even though both credit and non-credit courses in PDA's are offered in the community. Again, proportions for each questionnaire category were essentially similar between faculty and student users. Only the difference in proportions for "Read user manual" was significant (Pearson $\chi^2$ (1, $N$ = 131) = 8.83, $p$ = .003). Proportionately more faculty (75.8%) than students (45.9%) read the handheld computer user manual in order to learn to operate the device.

**4.3.4 Synchronization practices:** Many handheld computers users synchronize their PDA to a desktop computer either as a form of data backup or as a way to manage application files downloaded from a full-featured computer supported by a full-sized keyboard and display. Personal information management files such as calendar, ToDo lists, address book are readily synchronizable by most PDAs. Some handhelds also provide rudimentary display and editing capabilities for word processing, spreadsheet, and database files. Survey participants were asked to characterize their synchronization practices for personal organizer and document file types (Table 9).

Combined, almost 75 percent of respondents synchronized personal information files at least once a week (37.4%) or once a day (35.9%). Approximately 10 percent (10.7%) synchronized their calendar, ToDos, and address book several times a day. Combined, about 16 percent of respondents synchronized infrequently (9.9%) or not at all (6.1%). With regards to personal organizer file synchronization, there were no significant differences in faculty/student categorical proportions (Pearson $\chi^2$ (4, $N$ = 131) = 1.88, $p$ = .757).

As Table 9 depicts, respondents reported lower synchronization rates for documents. Only 42.8% of respondents synchronized their documents frequently, with 25.2% synchronizing at least once a week and 17.6% daily.

**TABLE 4**
**Primary Reason for Owning a Handheld**

| | All Owners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Response Category | *f* | % | *f* | % | *f* | % |
| Paper organizer too cumbersome | 30 | 22.9 | 9 | 27.3 | 21 | 21.4 |
| Need help remembering things | 21 | 16.0 | 3 | 9.1 | 18 | 18.4 |
| Need handy reference for info lookup | 19 | 14.5 | 10 | 30.3 | 9 | 9.2 |
| Was given as a gift | 18 | 13.7 | 3 | 9.1 | 15 | 15.3 |
| Essential techno-junkie accessory | 13 | 9.9 | 2 | 6.1 | 11 | 11.2 |
| Wanted to experiment with handhelds | 7 | 5.3 | 2 | 6.1 | 5 | 5.1 |
| Had to have one | 6 | 4.6 | 1 | 3.0 | 5 | 5.1 |
| More portable than other computers | 6 | 4.6 | 0 | 0.0 | 6 | 6.2 |
| Use it to listen to audio (MP3) files | 1 | 0.8 | 0 | 0.0 | 1 | 1.0 |
| Required by the college | 1 | 0.8 | 1 | 3.0 | 0 | 0.0 |
| Standard issue at the college | 1 | 0.8 | 1 | 3.0 | 0 | 0.0 |
| Need a device with multiple alarms | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Succumbed to peer pressure | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Other | 8 | 6.1 | 1 | 3.0 | 7 | 7.1 |
| Totals | 131 | 100.0% | 33 | 100.0% | 98 | 100.0% |

**TABLE 5**
**Primary Reason for Not Owning a Handheld**

| | All Nonowners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Response Category | *f* | % | *f* | % | *f* | % |
| Too expensive | 196 | 76.9 | 20 | 64.5 | 176 | 78.6 |
| Too hard to input data with stylus | 11 | 4.3 | 4 | 12.9 | 7 | 3.1 |
| Too structured for my lifestyle | 8 | 3.1 | 3 | 9.7 | 5 | 2.2 |
| Other-No felt need to own | 6 | 2.4 | 0 | 0.0 | 6 | 2.7 |
| Prefer paper organizer | 5 | 2.0 | 2 | 6.5 | 3 | 1.3 |
| Other-Do not have enough money | 5 | 2.0 | 0 | 0.0 | 5 | 2.2 |
| Too hard to use | 3 | 1.2 | 0 | 0.0 | 5 | 5.1 |
| Too bulky | 3 | 1.2 | 0 | 0.0 | 3 | 1.3 |
| Other-Previous unit broke | 3 | 1.2 | 0 | 0.0 | 3 | 1.3 |
| Other-Cost exceeds value | 3 | 1.2 | 0 | 0.0 | 3 | 1.3 |
| Other-Not powerful enough | 2 | 0.8 | 0 | 0.0 | 3 | 1.3 |
| Other-Prefer laptop | 2 | 0.8 | 0 | 0.0 | 2 | 0.9 |
| Other-Waste of time | 1 | 0.4 | 0 | 0.0 | 2 | 0.9 |
| Other-Unspecified | 7 | 2.7 | 2 | 6.5 | 5 | 2.2 |
| Totals | 255 | 100.0% | 31 | 100.0% | 224 | 100.0% |

**TABLE 6**
**Type of Handheld Currently Owned**

| | All Owners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Device Type | *f* | % | *f* | % | *f* | % |
| Palm-based: *Palm, Handspring, Clie* | 100 | 76.3 | 36 | 78.8 | 74 | 75.5 |
| WINCE/PocketPC-based: *iPAQ, etc.* | 27 | 20.6 | 7 | 21.2 | 20 | 20.4 |
| DOS-based: *HP* | 1 | 0.8 | 0 | 0.0 | 1 | 1.0 |
| Symbian-based: *Psion* | 1 | 0.8 | 0 | 0.0 | 1 | 1.0 |
| Other | 2 | 1.5 | 0 | 0.0 | 2 | 2.0 |
| Totals | 131 | 100.0% | 33 | 100.0% | 98 | 100.0% |

**TABLE 7**
**Experience with Handhelds**

| | All Owners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Months Experience | *f* | % | *f* | % | *f* | % |
| 13 – 24 months | 48 | 36.6 | 11 | 33.3 | 37 | 37.8 |
| 25 – 60 months | 29 | 22.1 | 9 | 27.3 | 20 | 20.4 |
| 7 – 12 months | 19 | 14.5 | 8 | 24.2 | 11 | 11.2 |
| 3 – 6 months | 19 | 14.5 | 3 | 9.1 | 16 | 16.3 |
| Over 60 months | 8 | 6.1 | 2 | 6.1 | 6 | 6.1 |
| Less than 3 months | 8 | 6.1 | 0 | 0.0 | 8 | 8.2 |
| Totals | 131 | 100.0% | 33 | 100.0% | 98 | 100.0% |

**TABLE 8**
**Approaches to Learning to Use a Handheld Computer**

| | All Owners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| How Learned | *f* | % | *f* | % | *f* | % |
| Trial and error | 116 | 88.5 | 30 | 90.9 | 86 | 87.8 |
| Read user manual | 70 | 53.4 | 25 | 75.8 | 45 | 45.9 |
| Worked through a tutorial | 19 | 14.5 | 4 | 12.1 | 15 | 15.3 |
| Read books | 12 | 9.2 | 5 | 15.2 | 7 | 7.1 |
| Personally tutored | 10 | 7.6 | 3 | 9.1 | 7 | 7.1 |
| Watched a demonstration | 4 | 3.1 | 2 | 6.1 | 2 | 2.0 |
| Took a course | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Other | 5 | 3.8 | 1 | 3.0 | 4 | 4.1 |

**TABLE 9**
**Frequency of Handheld Computer to Desktop Synchronization**

| | All Owners | | Faculty | | Students | |
|---|---|---|---|---|---|---|
| Synchronization Category | *f* | % | *f* | % | *f* | % |
| Synchronization of Personal Organizer | | | | | | |
| At least once a week | 49 | 37.4 | 11 | 33.3 | 38 | 38.8 |
| At least once a day | 47 | 35.9 | 13 | 39.4 | 34 | 34.7 |
| Several times a day | 14 | 10.7 | 5 | 15.2 | 9 | 6.1 |
| At least once a month | 13 | 9.9 | 3 | 9.1 | 10 | 10.2 |
| Never | 8 | 6.1 | 1 | 3.0 | 7 | 7.1 |
| Totals | 131 | 100.0% | 33 | 100.0% | 98 | 100.0% |
| Synchronization of Document Files | | | | | | |
| At least once a week | 33 | 25.2 | 7 | 21.2 | 26 | 26.5 |
| Handheld not capable of synchronizing document files | 29 | 22.1 | 8 | 24.2 | 21 | 21.4 |
| At least once a day | 23 | 17.6 | 4 | 12.1 | 19 | 19.4 |
| Never | 21 | 16.0 | 7 | 21.2 | 14 | 14.3 |
| At least once a month | 18 | 13.7 | 6 | 18.2 | 12 | 12.2 |
| Several times a day | 7 | 5.3 | 1 | 3.0 | 6 | 6.1 |
| Totals | 131 | 100.0% | 33 | 100.0% | 98 | 100.0% |

Twenty-two (22.1%) of respondents reported their handheld computer was incapable of synchronizing documents. A two-way contingency table analysis of the difference in proportions between faculty and students again revealed no significant differences (Pearson $\chi^2$ (5, $N$ = 131) = 2.92, $p$ = .712).

As Table 9 depicts, respondents reported lower synchronization rates for documents. Only 42.8% of respondents synchronized their documents frequently, with 25.2% synchronizing at least once a week and 17.6% daily. Twenty-two (22.1%) of respondents reported their handheld computer was incapable of synchronizing documents. A two-way contingency table analysis of the difference in proportions between faculty and students again revealed no significant differences (Pearson $\chi^2$ (5, $N$ = 131) = 2.92, $p$ = .712).

**4.3.5 Application usage profile:** All commercial handheld computers come with prepackaged application software to assist in personal organization management. Typical applications include calendaring, scheduling, task lists, address book, and memos. Many higher-end handheld devices come preconfigured with support for micro-versions of word processors, spreadsheets, presentation software, email, and web browsers. Almost

all handhelds allow application software installation so that minimally configured devices can be upgraded to run the type of software available on higher end machines. Custom software for academic computing is available for the popular handheld platforms (Yuen and Yuen, 2003).

In an effort to develop a profile of current handheld application usage, respondents were asked to specify how many hours they spend per week on any given automated task. Response options ranged from "none" to "more than 20 hours" with fine-grained increments of one-quarter hour increasing to coarser-grained increments of ten-hours (See Appendix 1). In order to analyze data, the discrete (ordinal) survey responses were converted to corresponding ratio data. Responses of "more than 20 hours" per week were excluded; these averaged less than one user per application category. Table 10 summarizes the results of the analysis, listing the average weekly usage of handheld applications from most used to least used.

Personal information management applications appeared to be the dominant application type in terms of weekly usage. Survey participants reported spending a little over 1 ¾ hours per week scheduling and calendaring ($M$ = 1.82), a little less than 1 ¾ hours taking or making notes ($M$ = 1.71) and managing task lists ($M$ = 1.66), and a little more than an hour per week managing an address book ($M$ = 1.17). Other applications used more than an hour a week included looking up reference information ($M$ = 1.07) and reading electronic texts ($M$ = 1.01). Combined these six applications accounted for two-thirds of the reported weekly usage or just over eight hours of the 12.67 hours (Table 11). The remaining four hours per week handheld usage were occupied by lesser tasks including writing documents ($M$ = 0.78), playing video games ($M$ = 0.67), doing homework ($M$ = 0.61), maintaining a database ($M$ = 0.59), using the built-in calculator ($M$ = 0.43), recording expenses ($M$ = 0.43), reading email ($M$ = 0.31), and playing music files ($M$ = 0.23). Few respondents reported using their handhelds for computer programming, web browsing, creating spreadsheets, reading maps, transacting business, drawing diagrams, or making cellular phone calls.

A series of independent-sample $t$ tests were conducted to determine if handheld application usage differed between faculty and students users. Unequal population variances were examined using Levene's test. Because unequal variances were found and because subsample sizes differed, the more conservative $t$-value for *unequal variances* was used to determine statistical significance.

Surprisingly, for most of the application categories (including all those used more than an hour per week) there were no statistically significant differences in weekly usage. Only five applications yielded significant $t$ tests. These were (ordered from highest to lowest hourly usage) (a) writing documents $t$ (128.53) = -2.15, $p$ = 0.033; (b) doing homework assignments $t$ (98.6) = -3.12, $p$ = 0.002; (c) using the calculator function $t$ (128.93) = -3.27, $p$ = 0.001; (d) recording expenses $t$ (122.31) = -2.82, $p$ = 0.006; and, (e) drawing diagrams $t$ (121.02) = -2.07, $p$ = 0.041. On average, students report spending more time than faculty using their handheld computers to (a) write documents ($M$ = 0.92 hours vs. $M$ = 0.35 hours), (b) do homework assignments ($M$ = 0.80 vs. $M$ = 0.02), (c) calculate ($M$ = 0.51 vs. $M$ =0.18), (d) record expenses ($M$ = 0.52 vs. $M$ = 0.15), and (e) draw diagrams ($M$ = 0.07 vs. $M$ = 0.02).

## 5. IMPLICATIONS AND CONCLUSION

As an educational delivery platform, current handheld computer technology provides a low-cost, mobile, networked, small-form factor appliance with sufficient hardware and software to support instruction, learning, assessment, and collaboration. The devices are built atop general purpose central processors enabled with operating systems capable of delivering general and customized computing. Nevertheless, this research shows that handheld users in academia view the devices primarily as a personal technology rather than an educational technology. Current usage practices are dominated by the automation of individual life management tasks from planning and scheduling to maintaining a list of personal contacts. This is not surprising given historical marketing efforts to position handhelds as "connected personal organizers" (3 Com, 1997). User perception rather than device capability appears to be a real hindrance to widespread adoption of handhelds in academia. Migrating to handhelds as the campus standard for academic computing presents real challenges, some of which may be difficult to overcome. A discussion regarding approaches to tackling those challenges follows.

### 5.1 Non-users

As this research shows, non-users have somewhat less experience with personal electronic devices than handheld users but still relatively high levels with devices that are as complicated, if not more complicated than PDAs. Eighty-five percent of
respondents had used a cellular phone; 75 percent a handheld video game. Further, the majority of non-users, like users, perceive themselves as middle-stage technology adopters. If the introduction of the Apple Newton is considered the beginning of the handheld technology cycle, then today, ten years later, is clearly somewhere in the middle stages. Comfort level with personal electronics technology, therefore, does not really seem to be a barrier to handheld computer acceptance among non-users.

What does seem to be a serious roadblock to PDA adoption is product price. Before non-users embrace handheld computers, the device cost will need to be addressed. Over 75 percent of non-user respondents believe current PDAs are too expensive. For student buyers, one solution is to require handhelds and bundle the cost into tuition or fees as is done at University of South Dakota (Carr, 2001). Another possibility is "renting to own", where students lease the equipment from the institution with an option to purchase (Campbell, 2003).

By recharacterizing handhelds as essential academic equipment rather than discretionary personal devices, students can seek financial aid to recover the cost. Faculty objections to high handheld prices could be overcome by moving the purchasing decision to the institution or by seeking funding through grants.

**TABLE 10**
**Weekly Usage of Handheld Applications (in fractional hours)**

| | All Users | | | Faculty | | | Students | | |
|---|---|---|---|---|---|---|---|---|---|
| Application Category | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* |
| Scheduling and calendaring | 1.82 | 1.97 | 127 | 2.05 | 2.06 | 32 | 1.74 | 1.95 | 95 |
| Taking or making notes | 1.71 | 2.63 | 131 | 1.81 | 2.74 | 33 | 1.68 | 2.60 | 98 |
| Planning and working with ToDo's | 1.66 | 2.01 | 129 | 1.97 | 2.47 | 33 | 1.55 | 1.83 | 96 |
| Managing an address book | 1.17 | 2.00 | 128 | 0.99 | 1.52 | 33 | 1.23 | 2.14 | 95 |
| Looking up reference information | 1.07 | 2.34 | 130 | 1.22 | 1.92 | 33 | 1.02 | 2.47 | 97 |
| Reading e-texts | 1.01 | 1.63 | 130 | 0.78 | 1.00 | 33 | 1.09 | 1.79 | 97 |
| Writing document | 0.78* | 2.06 | 131 | 0.35 | 0.72 | 33 | 0.92 | 2.33 | 98 |
| Playing video games | 0.67 | 1.23 | 131 | 0.56 | 1.10 | 33 | 0.71 | 1.27 | 98 |
| Doing homework assignments | 0.61* | 2.16 | 131 | 0.02 | 0.13 | 33 | 0.80 | 2.47 | 98 |
| Maintaining a database | 0.59 | 1.35 | 130 | 0.79 | 1.64 | 33 | 0.52 | 1.23 | 97 |
| Using the calculator function | 0.43* | 0.78 | 131 | 0.18 | 0.28 | 33 | 0.51 | 0.87 | 98 |
| Recording expenses | 0.43* | 1.05 | 131 | 0.15 | 0.29 | 33 | 0.52 | 1.19 | 98 |
| Reading/responding to email | 0.31 | 0.93 | 130 | 0.33 | 1.41 | 33 | 0.30 | 0.71 | 97 |
| Playing MP3 file | 0.23 | 1.55 | 130 | 0.00 | 0.00 | 33 | 0.31 | 1.79 | 97 |
| Computer programming | 0.17 | 1.37 | 130 | 0.02 | 0.10 | 33 | 0.22 | 1.58 | 97 |
| Browsing web | 0.13 | 0.74 | 131 | 0.03 | 0.17 | 33 | 0.17 | 0.85 | 98 |
| Creating spreadsheets | 0.13 | 0.46 | 131 | 0.08 | 0.35 | 33 | 0.14 | 0.49 | 98 |
| Reading maps | 0.12 | 0.73 | 130 | 0.05 | 0.16 | 33 | 0.14 | 0.84 | 97 |
| Transacting business | 0.10 | 0.62 | 131 | 0.02 | 0.09 | 33 | 0.14 | 0.71 | 98 |
| Drawing diagrams | 0.06* | 0.23 | 131 | 0.02 | 0.06 | 33 | 0.07 | 0.26 | 98 |
| Communicating using phone function | 0.03 | 0.27 | 130 | 0.01 | 0.04 | 33 | 0.04 | 0.31 | 97 |
| Other | 0.32 | 1.64 | 130 | 0.33 | 1.47 | 33 | 0.31 | 1.70 | 97 |

Note. Sample size (*n*) ranged from 127 to 131 because several respondents did not answer the questionnaire completely, leaving blank one or more questions related to handheld usage.
* $p < .05$

**TABLE 11**
**Average Weekly Usage of Handheld Applications**

| | All Users | | | Faculty | | | Students | | |
|---|---|---|---|---|---|---|---|---|---|
| Weekly Usage (in fractional hours) | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* |
| Number of hours | 12.67 | 12.78 | 122 | 11.01 | 9.96 | 32 | 13.26 | 13.64 | 90 |

from the institution with an option to purchase (Campbell, 2003). By recharacterizing handhelds as essential academic equipment rather than discretionary personal devices, students can seek financial aid to recover the cost. Faculty objections to high handheld prices could be overcome by moving the purchasing decision to the institution or by seeking funding through grants.

Once the major obstacle of price is overcome, the remaining hurdles to adoption appear to be device failure and device inadequacy. Device failure can be addressed through appropriate extended warranty programs that cover hardware/software breakage during the years required to complete an academic degree. Most of the device inadequacy issues can be dealt with through a combination of (a) device training, (b) platform configuration standards that insure adequate hardware resources (e.g., auxiliary keyboards) and appropriate software, and (c) *future* improvements in display technology.

The word "future" is emphasized above because today's PDA screen size and display technology are not completely adequate for those with less than perfect sight. While a recent experimental study showed that there was no statistical difference in the comprehension and retention of content read from paper documents vs. from e-text on a PDA across educational levels, survey data suggested that college students have a harder time reading e-content on a PDA than do middle or high schools students (Johnson and Rudd, 2003). Until PDA displays approach the ease of readability of laptops, more than likely, handhelds will be confined to the role of personal rather than educational technology. Fortunately, research is under way to amplify PDA image size (IBM Research News, 2003; Patch, 2003). When and if, (a) high cost to value, (b) device inadequacy, and (c) device failure are resolved, we do not see any other major impediments to non-user acceptance of handhelds as a "personal educator".

**5.2 Handheld Users**

For current handheld users, whether faculty or student, PDAs play a mixed role. Faculty spend more than 60 percent of their time (6.82 hours per week) using a PDA for personal information management (PIM). Students use their handhelds about the same number of hours per week for personal organization (6.2 hours per week); however, since, on average, students spend 2.25 hours more per week on their handhelds than faculty, the proportion of PIM usage is closer to one half (46.7%). Clearly, the primary role (but not necessarily the only role) of handhelds on campus is as an electronic organizer. What is interesting is the proportion of time spent by faculty and staff on tasks that could be classified as educationally-related.

Faculty spend just over three hours per week (3.03 hours or 27.5%) on such tasks as reference lookup, reading e-texts, writing documents, and responding to email. Students use their handhelds over five hours a week or almost 40 percent for educational tasks such as look up reference information ($M$ = 1.02 hours); read electronic texts ($M$ = 1.01 hours); write documents, ($M$ = 0.92 hour); do homework ($M$ = 0.81 hour); calculate ($M$ = 0.51); work with email ($M$ = 0.30 hour); write computer programs ($M$ = 0.22 hour); browse the web ($M$ = 0.17 hour); create spreadsheets ($M$ = 0.14 hour); and, draw diagrams ($M$ = 0.07 hour). Admittedly, some of these tasks might be personal in nature rather than academic. Regardless, the data would tend to support that at 27.5% weekly usage for faculty and 39.5% weekly usage for students, the secondary role for PDAs among collegiate users is as an educational technology. Whether handhelds supplant desktop PCS, laptops, or the newer tablet PCs as pedagogical platform of choice remains to be seen. What is certain is that even today, handheld computers have found something of niche in academic computing.

**5.3 Limitations of Study**

This study was undertaken to explore handheld computing preferences and usage in academia based on a survey of faculty and students at a large comprehensive four-year state college in the U.S. intermountain west. Our findings might not be representative of the entire country or of faculty and students at institutions of higher education in other countries. Our responses rates were lower than desired. Although all faculty and students were asked (and reminded) to participate in the web survey, the response rate for faculty and students was 5.4% and 1.4% respectively. It is possible participant responses were not representative of the survey population as a whole. Not withstanding these limitations, we believe those faculty and students participating in the survey provided valuable insight into current collegiate handheld computing practices.

Handheld technology continues to evolve, as do shifts in user preferences. Since this survey was administered, Windows-based handhelds continue to gain ground against Palm-based devices (Legard, 2002). Even though the survey results were overwhelmingly supportive of the Palm operating system as the platform of choice (76.3% vs. 20.6%), an updated survey should be conducted before deciding on one device over another for academic use.

Our research to date has provided a foundational context for understanding current handheld computer practices in higher education. Many questions remain regarding the integration of personal education devices into the learning ecosystem. To address those questions, our long term research initiatives include (a) a qualitative analysis of collegiate handheld computer usage based on field interviews and observations, (b) experimental design classroom research to determine the impact of handheld-mediated instruction on student learning and student-teacher interaction, (c) further investigation into programming and component-based development environments for enterprise application design and construction using handheld architectures (Jones, 2000), and (d) the development of a framework for integration of handheld technology into Information Systems curriculum at both the undergraduate and graduate level.

**5.4 Conclusion**

In the near future, mobile, wireless, "personal educators" may replace paper-based textbooks and shared desktop computers as the dominant educational infrastructure. Today, however, handheld computers are peripheral to collegiate instruction. Usage is primarily personal in nature, revolving around individual time and task management. When handhelds are, in fact, used for education, their function is as a portable extension of the personal computer. Information lookup, reading, and document creation are typical educational tasks. Rather than being integral to instruction and learning, handheld computers are underutilized as nothing more than homework aids.

As general purpose computers, the potential for handhelds is far greater. Real-time assessment, peer collaboration, instructional display, and personalized tutoring are all possible. But before networked, small-form factor computers are fully integrated into academic teaching and learning, several obstacles must be overcome. Platform cost, device inadequacy, and device failure hinder wider acceptance of handhelds as a portable computing solution. No doubt PDA price will be addressed by Moore's law; product quality by continuous improvement manufacturing. Device inadequacy, on the other hand, requires a technological fix. In the meantime, there is a small population of early- to middle-stage adopters who will continue to use their handhelds for dual roles–first, as a personal information manager, and second, as a synchronizable extension to a PC for performing some educational-related tasks.

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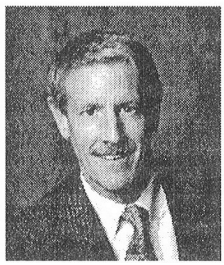

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