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A Comparative Study Between Tablet and Laptop PCs: User Satisfaction and Preferences

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Despite their popularity, usability studies concerning Tablet PCs are lacking. This study aimed at determining user satisfaction and preference aspects of Tablet PCs in comparison to laptop PCs and pen-and-paper environments. Several common computer tasks were examined in an experimental environment on 34 college student participants. User satisfaction and preferences were measured by comprehensive questionnaires. An analysis of variance was used for the empirical comparisons. Participants did not have any difficulty in reading, direct manipulation, and form filling tasks. There was a perception of a high number of errors by the participants for the writing task in Tablet PCs. Overall, participants found the general computing capabilities and portability of Tablet PCs impressive. However, the majority did not prefer Tablet PCs to laptop PCs to meet their everyday computing needs. Results can help designers improve the overall usability of the Tablet PC and help its development as a major computing medium.

1. INTRODUCTION

Mobile computing has become highly popular in the last decade, and advances in computer and mobile device technology allow users to meet their computing needs from every place at any time (Sears & Arora, 2002). Following the success of desktop computers, laptop computers have become highly popular as portable versions of desktops with the full functionality of desktop computing and the portability that allows users to carry them anywhere. Although in the early days of laptops the price of a laptop with the same functions of an equivalent desktop could be two to three times higher, the difference in prices shrank in the mid-
late ‘90s. With advances in Liquid Crystal Display technology, hard disk, mobile processor, and wireless communication capabilities (such as Wi-Fi networks), laptop computers became highly affordable, managing to deliver high performance in computing. In May 2005, laptop computers for the first time outsold desktop computers in a single calendar month (Sandoval, 2005).

Despite the high popularity of laptop computers and their great advantage in portability, laptop computers still have disadvantages when there are portability requirements. One major issue concerning the limitations of laptop computers is the obligation to use the keyboard and a pointing device (a touch pad, eraser head pointer, trackball, or an external mouse). In addition, there is a trade-off between a laptop’s functionality and its weight. The mobility hindrances and the inability for easier data input have resulted in the development of a computing device that has the functionality of a computer as well as the mobility and data input freedom of pen and paper. This idea resulted in the development of the Tablet PC.

The Tablet PC aims at taking the mobility of laptop PCs one step further by giving users the freedom to carry a tabletlike computer with an optional attached keyboard that can be folded and integrated into the device body. More important, the Tablet PC has a magnetic pen (or stylus) to input text into the computer in natural handwriting via the handwriting recognition software it contains. The magnetic pen commonly used in Tablet PCs for data/text entry is a special pen (which can also be called a special stylus) with a magnetized tip. The Tablet PC screen accepts entry only through this magnetic pen, preventing any accidental contact with the Tablet PC screen (such as accidental touches on the screen by fingers or fingernails) from registering as data entry. From this point on, the names magnetic pen and stylus are used interchangeably throughout this study.

Tablet PCs are gaining a market share slowly but steadily, with expected Tablet PC sales in the United States to hit about 14 million by 2009 (Spooner & Foley, 2005). However, despite a body of research involving desktop and laptop interface usability, explicit usability studies that focus on Tablet PC interfaces are rare. Empirically exploring usability issues can eventually lead to a better understanding of the Tablet PC phenomenon and its potential as a major computing medium. Because of a lack of literature on empirical studies in the area, this research examines the usability, user preference, and user satisfaction issues with Tablet PCs from a comparative perspective. Because of their proximity and relevance, laptop PCs were chosen as a comparison medium in this study, along with pen and paper as a second comparison medium because of the need to compare the text entry and mobility aspects of Tablet PCs to a widespread medium with relatively similar functions and user goals.

The inclusion of pen-and-paper tasks should be approached with caution. Obviously, the pen-and-paper environment does not satisfy the computing needs of today’s average computer user. The reason for including this medium is to understand the usability, user preference, and user satisfaction issues of Tablet PCs in comparison to a proven, widespread medium. For example, if the writing task on a Tablet PC is found to be as comfortable as on the pen-and-paper medium, then it is reasonable to conclude that Tablet PCs are meeting user expectations in this task domain.
This comparative study aims at determining user attitudes concerning Tablet PCs, how they are perceived as a mobile computing medium that is radically different from others, and eventually determining the potential of Tablet PCs in meeting all computing needs of users.

Refining the aforementioned general research questions, this study focuses on usability with respect to common computing tasks on Tablet PCs in a comparative manner. Several tasks are used and studied to compare different media (Tablet PCs, laptop PCs, and pen and paper), followed by questionnaires measuring comfort levels, perceived convenience, and mobility, among others, of the Tablet PCs. User performance was also measured as part of this study but is briefly discussed because of the satisfaction and preference focus.

A variety of tasks are routinely performed by computer users. To exactly understand the usability preference and satisfaction issues among Tablet PCs, laptop PCs, and pen and paper, a representative set of tasks had to be chosen. For this purpose, four main tasks were chosen that are most commonly performed on computers: reading comprehension, typing/writing, direct manipulation, and form filling. All these tasks are also commonly used when users are on the Web (Ozok & Salvendy, 2000). It was concluded that allowing users to perform these types of tasks would result in the accurate and representative measurement of their preferences and satisfaction in each medium comparatively.

In the next sections, an overview of the current literature on the Tablet PC history and usability is given first. This is followed by the sections on experimental methodology, results and discussion, and conclusion and recommendations.

2. LITERATURE REVIEW

2.1. History of Tablet PCs and Tablet PC Usability

The concept of Tablet PCs has been around for more than a decade since their formal introduction in 1989 (Warkentin, Bekkering, Schmidt, & Johnston, 2004). However, Tablet PCs have been limited to niche markets until 2002. The biggest boost to the medium came with the release of commercial Tablet PCs (a move that was led by Microsoft) in the fall of 2002. The few initial reviews on Tablet PC usability issues were positive to a great extent (Arar, 2001; McLeod, 2003). The initial concept of Tablet PCs first started in late 1980s and was largely based on the idea of a highly portable device eliminating the keyboard and allowing users to input data into computers with their own handwriting (Wahl, 2003). The developments in neural network and fuzzy logic technology allowed more accurate handwriting recognition algorithms in the 1990s, but technical difficulties, including handwriting recognition issues as well as the development of a dedicated operating system, portability, and screen visibility, have delayed the large-scale deployment of a commercial product that has a wide variety of usage domains. Wahl indicated that newer Tablet PCs do well in bridging the gap between the paper and digital worlds. For example, users can use the “digital ink,” namely, the ability to scribble notes over typed text. This feature is available in almost all programs including Microsoft Office and Adobe Acrobat. Further, Tablet PCs also do
well in converting handwriting to text. The prices of Tablet PCs vary from about
$1,000 to $4,500. All Tablet PCs come with wireless Internet connectivity cards. Tablet PCs are used in a variety of areas where portability and easy note taking are key, and the leading areas in Tablet PC use include academia, construction, and other field businesses; government entities; and many other domains where mobile computing is essential.

Newer Tablet PCs are lighter (under 3 lb) and have longer battery life (Gros, 2004). Tablet PCs are seen as the next step in mobile computing, allowing tremendous flexibility in using e-mail and accessing the Internet (Levack, 2003). Further, Miller (2002) predicted that Tablet PCs might support the revolution of “electronic newspaper,” changing news delivery entirely where at one point in the near future, news content may be beamed to the Tablet PC wirelessly every morning.

Tablet PCs are already used actively in retail and services as well, including restaurants and wine-tasting places. With advances in technology, Tablet PCs have become sophisticated. In 2005, Gateway developed a model that consists of a Tablet PC and laptop PC hybrid that functions under both operating systems and allows the users to use full Tablet PC and laptop PC functionalities. With respect to software, it should be noted that the major difference between Tablet PCs and laptop PCs is that the former uses the Tablet PC edition of the desktop/laptop PC operating system, which has some limited capabilities in comparison to its equivalent desktop-based operating systems but allows major handwriting recognition and on-screen scribbling capabilities.

Although the Tablet PC is a highly commercial product, because of its relatively new introduction, scientific research on the use of Tablet PCs has been lacking. Early studies in Tablet PC domain consisted of product tests and evaluations of specific-brand products (Gros, 2004; Miller, 2002) as well as marketing studies on future prospects concerning Tablet PC industry (Pienta, 2004). These early scientific studies concluded that Tablet PCs did in fact have a place in meeting the day-to-day computing needs of consumers and workers alike and that there is a substantial market for Tablet PCs to establish themselves in as a serious contender to laptop computers (Gros, 2004; Miller, 2002).

Some preliminary studies focused on basic usability issues concerning Tablet PCs. Specifically, the most often evaluated and studied issue was the use of the electronic pen for inputting data into the Tablet PC. Pienta (2004) concluded that although note-taking capabilities of Tablet PCs are highly advantageous compared to laptop and desktop computers, it is too soon to tell whether Tablet PCs will be the next wave of personal computers. A body of research was conducted by Microsoft on how people used Tablet PCs in their day-to-day tasks with specific emphasis on the use of the handwriting recognition capability of the medium (Microsoft Corp., 2003, 2004), and indicated that handwriting is a preferable as well as an adequately accurate form of data input in Tablet PCs. These findings are also corroborated by other researchers in the area (Walker, 2001). These studies generally indicate that the handwriting recognition capabilities provide a great convenience advantage to the medium by allowing users to enter data without a keyboard; in the meantime, more improvements in handwriting technology as well as in other usability areas, including screen size and visibility and interface
intuïtiveness, are essential to broaden the medium’s appeal to larger masses. Furthermore, the findings concerning users’ comfort and performance using handwriting to input data to their Tablet PCs are in accordance with earlier studies. Those studies concluded that recognition accuracy is highly correlated to users’ acceptance of media that uses handwriting as the primary means of data input (Frankish, Morgan, & Hull, 1996). Moreover, keeping the error rates at a minimum is a persistent challenge in this type of data input (Frankish, Morgan, & Noyes, 1994). It should be noted that pen gestures have been difficult to recognize in the computer environment for some time (Long, Landay, Rowe, & Michiels, 2000), and problems still continue on the path to perfect this mechanism. Others indicated that free-form handwriting is a concept highly difficult to interpret (Bargeron & Moscovich, 2003). Yet more studies indicated low precision rates in computer recognition of handwriting (Levin, Clough, & Sanderson, 2003). Same precision issues occurred in manipulation of menus on Tablet PCs (Fitzmaurice, Khan, Pieke, Buxton, & Kurtenbach, 2003). On the other hand, Tablet PCs offer promising results in note-taking tasks that require both speed and accuracy, for example, for in-class students (Berque, Bonebright, & Whitesell, 2004). Similarly, McClard and Somers (2000) indicated that participants found early versions of Tablet PCs as a fun medium and ideal for e-mail and chatting, Web surfing, and casual scribbling. However, they do not suggest that Tablet PCs will replace regular desktop and laptop computers anytime soon. Finally, McClard and Somers indicated that Tablet PCs have been found useful in small-scale group presentations and are good at maintaining audiences’ attention.

Right before the official commercial release of Tablet PCs in November 2002, Dray, Siegel, Feldman, and Potenza (2002) conducted a study presenting preliminary usability issues in a field trial concerning Tablet PCs. Although explicit results of their study are not discussed in their article, Dray et al. concluded that integration of a new technology evolves over time, and this is the case with Tablet PCs. They indicated that participants most frequently used Tablet PCs in their daily routines such as sending e-mail, surfing the Web, and word processing. Feedback concerning the usability and related design issues were then integrated onto the design of the first-generation Tablet PCs.

In March 2006, Microsoft announced the next mobile computer expected to hit the consumer market sometime in 2008. The Origami, also called the Ultra Mobile Personal Computer, is expected to have the full functionality of a PC with the size slightly bigger than that of a Personal Digital Assistant. An on-screen thumb keyboard is expected to be the main tool for data input to the device along with the stylus. Usability and user preference issues concerning this new mobile device remain to be explored in the near future.

The currently available literature contains practically no significant scientific studies on usability of Tablet PCs. User surveys are firmly established as a method to determine user satisfaction and preference issues concerning specific media or features (Ozok & Salvendy, 2000; Wei & Salvendy, 2000). Because of the lack of empirical usability studies concerning Tablet PCs, especially in the user preferences and user satisfaction domains, this study aims at examining the usability issues concerning Tablet PCs empirically and uses a survey approach to do it.
3. METHODOLOGY

An experiment was designed to measure the user satisfaction and preference issues concerning Tablet PCs in comparison to laptop PCs and pen-and-paper media. This section consists of an explanation of the measured independent and dependent variables. Next the participant group is described, followed by an overview of the experimental procedure. Finally, the tasks in the experiment, the interfaces, and the user survey are explained.

3.1. Independent and Dependent Variables

The experiment was a within-subject design and consisted of 4 tasks across three different media (Tablet PC, laptop PC, pen and paper), totaling 12 tasks. The different tasks and different types of media therefore constituted to the independent variables. After the completion of each task, participants were presented user satisfaction and preference questionnaires. These satisfaction and preference items constituted the dependent variables. The individual satisfaction and preference items contained in the questionnaires are discussed in section 3.5.

3.2. Participants

Thirty-four students from the Department of Information Systems at University of Maryland, Baltimore County, were recruited for the tasks in the experiment. Almost all of the participants were full-time undergraduate students. The participant age mean was 24.6 (SD = 5.22). Nineteen participants were male and 15 were female, allowing a fairly balanced gender distribution among participants. All participants were offered extra credit in their classes for participation in the experiment; no monetary compensation was provided. A tech-savvy group like this participant group was chosen mainly because using a Tablet PC requires some experience with computers. The particular participant group was experienced with computers, and it is believed that the target users for Tablet PCs are expected to have a relatively good level of experience with computers in general. In addition, college students are representative of a population of daily computer users. Therefore, it was concluded that having a sample group of college students was appropriate for this study.

Participants spent 50.5 hr on average per week using a computer (for work, academic, and entertainment purposes). Twenty-eight participants (82%) were Information Systems majors, with 2 (6%) Economics majors and 1 (3%) Psychology major. Three participants (9%) indicated that they had not decided on their major, despite taking at least one class from the Information Systems department. All participants but 1 were in pursuit of their bachelor of science degree, and 1 participant was pursuing a master’s of science degree. None of the participants had an area of specialization as part of their degree. The highest degree earned was high school for 17 (50%) participants, associate degree for 15 (44%) participants, and bachelor of arts/sciences for 2 (6%) participants. Main interests of participants included watching movies (30 participants), sports (23 participants), outdoor
activities (22 participants), reading (16 participants), and academics (12 participants). Twenty-six participants (76%) heard about Tablet PCs but never used one, 7 participants (21%) used one at least once (but not on a regular basis), and 1 participant (3%) had never heard of a Tablet PC. All of the participants have been living in the United States for more than 2 years. A preliminary power analysis from Thieman and Kraemer (1987) indicated that the number of participants was sufficient for adequate power to measure the dependent variables in the experiment.

3.3. Experimental Procedure

As indicated previously, four tasks were used in the experiment. The first task was a reading comprehension task followed by a typing (or writing in the Tablet PC and pen-and-paper media) task. This was followed by a direct manipulation task, where participants were asked to change the size, minimize, maximize, open, close, and click or tap on certain areas on open windows on the computer screens. Finally, because of the common use of online forms in online transactions (including e-commerce), there were two screens in which participants completed online forms on generic, nonpersonal information. More details on the exact nature of each task can be found in the next section.

The experiments were conducted in two separate human–computer interaction laboratories on the same floor in the same building on a university campus. Each laboratory consisted of a single room of about 200 square feet; the rooms were about 50 feet apart from each other. In the first experimental room where participants started the experiment, they were greeted and allowed to read and sign the consent form. Following a brief training session, they were presented a Tablet PC. Following a brief computer survey concerning demographics, they were asked to complete the four different tasks on the Tablet PC. At the end of each task, they were asked to complete a questionnaire regarding their opinion and satisfaction concerning the task they had just completed. At the end of the fourth task, after filling out the last questionnaire concerning that particular task, they also filled out an additional questionnaire concerning their overall satisfaction and preferences with the medium. These questionnaires are discussed in detail in section 3.5.

This initial procedure was followed by asking each participant to take the Tablet PC and move to the second laboratory. This change of venue process had the main goal of allowing the participant to get an impression concerning the mobility of the Tablet PC medium. In the second laboratory, they were asked to abandon the Tablet PC and were presented a new set of four tasks on a laptop PC followed by a questionnaire. These laptop PC tasks were similar in length and nature to the Tablet PC tasks but different in content to avoid learning effect. Each task was again followed by a questionnaire. In the final phase, the participants were asked to carry the laptop PC to the first laboratory (again, for the purpose of having them evaluate the mobility, this time of the laptop PC medium), abandon it there, and do a similar set of tasks with pen and paper. This time direct manipulation was excluded because this task is not applicable to pen-and-paper interfaces. A similar questionnaire was presented for the pen-and-paper tasks, followed by a
final questionnaire measuring overall user satisfaction and preference issues focusing on the Tablet PC, resulting in four questionnaires.

It should be noted that the presentation order of the three media to the participants was randomized, meaning half of the participants received the Tablet PC tasks first, and half of them received the laptop PC tasks first. This was done to assure any recency effects and potential bias toward the media received first, second, or last. The experiment was set up this way because of the possibility of the participants becoming frustrated toward the later tasks and giving poor satisfaction marks. Figure 1 presents the main route some participants traveled with the computing media in the experiment. Because of the randomization, this path differed among participants (half the participants carried the Tablet PC first, and the others carried the laptop PC first).

The laptop and Tablet PCs were chosen with equivalent specifications to prevent any effects that may be a result of differences in technical specifications between the two media. The Tablet PC used in the experimentation was a COMPAQ Presario 100 Tablet PC with 600 MHz Intel Pentium processor, 128 MB of memory, and a 12.1-in. screen. The laptop computer used was a Gateway 2000 with 600 MHz Intel Pentium processor, 128 MB of memory, and a 12.1-in. screen. The Tablet PC weighed about 2.5 lb, and the laptop PC weighed just about 3.0 lb.

3.4. Tasks and Interfaces

The Tablet PC and laptop PC interfaces were similar in shape and size. In this study, the two types of PCs as well as the pen-and-paper environment are often referred to as “media.” The interfaces of the two media largely consisted of Web screens. Similar presentations were provided for the pen-and-paper tasks as well. Four most common computer tasks were identified for the experimentation. As indicated earlier, these four types of tasks are commonly used in computer tasks in usability testing experimentation (Ozok & Salvendy, 2000). The first task consisted of reading a simple text on the laptop and Tablet PC screens as well as on paper. The text was a general article about computer networks and was divided into three equally long parts. For each task the text was about 20 lines long. The
participants were asked to read the text carefully. To ensure the participants’ careful reading of the text, it was indicated to them that later they might have to answer some questions about the text, although such questions were not asked.

The second task consisted of typing a five-line text on the laptop PC screen and writing a same-length text on the Tablet PC screen with the special magnetic pen as well as on paper with an ordinary pen. Words that are not well known and/or difficult to type were avoided from this text. Presenting this task had the primary goal of allowing the participants to determine how preferable and satisfactory text writing on the Tablet PC screen could be and to compare the Tablet PC text entry task to those on a laptop PC as well as pen and paper. The participants were asked to copy a text on the screen on a specific place at the bottom of the screen.

The third task was a direct manipulation task. This task applied only to the laptop and Tablet PC media and was not applicable to pen-and-paper tasks. Participants manipulated screen elements using the mouse or the magnetic pen. They were asked to close and minimize a window each, then scroll down to the bottom of a window that contained a lengthy text (about two screens of scrolling). This was followed by maximizing a window, resizing a window to a smaller size, and finally dragging a square on the screen on top of another square. When each task was completed, the participant was automatically directed to the next task by the software.

The last task included form filling, where participants filled out some electronic forms with simple information, with the equivalent paper forms in the pen-and-paper task. In the electronic versions, participants were asked to enter text on the specified areas on the screen and click on radio buttons (small circular boxes to the left of the options, where only one can be marked) and check boxes (small square-shaped boxes to the left of the options, where more than one can be marked). Equivalent tasks were presented in the pen-and-paper version, where participants wrote and marked the options with a pen. Figure 2 presents sample screens from each of the tasks. The screens looked identical in laptop and Tablet PC media. Learning effect was not deemed as a significant factor in the form-filling task because of the content of the form-filling task. Participants were asked questions the answers to which they easily knew, such as their highest academic degree earned, their age, their hobbies, and so on.

For all tasks, participants were not allowed to open any new windows or close the existing windows unless explicitly asked to do so in the direct manipulation tasks. After each task, participants were presented a satisfaction questionnaire concerning the medium they just completed the tasks on (Tablet PC, laptop PC, or pen and paper). At the end of the last task, participants were also presented a general questionnaire concerning the Tablet PC user satisfaction and user preference issues. These questionnaires are discussed in the next section.

### 3.5. User Satisfaction and Preferences Questionnaires

The questions of the user satisfaction and preferences questionnaires were in part based on the Job Satisfaction Questionnaire by Hackman and Oldham (1985). The questionnaires covered task-based and general satisfaction items regarding the
FIGURE 2  Sample screen shots from the four tasks on Tablet PC and laptop PC interfaces.
participants’ experience with the different media and gave the opportunity to compare their preferences concerning the laptop and Tablet PC media with pen and paper as well as each other. The individual items in the questionnaires included overall easiness and convenience of the task with the medium, screen brightness to complete the tasks, perceived number of errors committed while completing the task, perceived task efficiency and effectiveness, enjoyment factor, preference regarding using the medium for the current task, overall satisfaction, ease of use, portability, one’s own perceived overall performance, comfort level, fun factor using the media, meaningfulness of tasks, the feeling of proficiency while completing the tasks, likelihood to recommend using the medium to peers, preference of the Tablet PC to a laptop computer for all computing needs, speed of getting tasks done, one’s opinion about oneself improving after using the Tablet PC, amount of independent thinking involved using the medium, challenge offered by the medium, and mental effort involved in using the medium.

Because the survey was repeated for each medium and once more at the end for measuring general satisfaction, the Cronbach’s alpha internal reliability coefficient was calculated for the four different versions of the survey. The Cronbach’s alpha coefficients varied between 0.72 to 0.80. These values led the authors to the conclusion that all of the questionnaires had adequate internal reliability as according to Cronbach (1990), a value of 0.70 or higher is acceptable for confirming the internal reliability of a questionnaire.

The questionnaire items are presented in Tables 1 through 5 (along with the analysis of variance and Duncan’s Multiple Range Test results) in the next section. Most questions were posed as statements (such as “The task was easy”), and for each question (sometimes referred to as “item” in this article), a 5-point Likert

Table 1: Reading Task Analysis of Variance Results from Survey Items

<table>
<thead>
<tr>
<th>Question No. &amp; Description</th>
<th>Tablet PC M</th>
<th>Laptop PC M</th>
<th>Pen-and-Paper M</th>
<th>F</th>
<th>p</th>
<th>Duncan’s Grouping Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-1: Ease of task</td>
<td>4.15</td>
<td>4.32</td>
<td>4.41</td>
<td>0.75</td>
<td>.468</td>
<td>None</td>
</tr>
<tr>
<td>2-2-x: Screen brightness</td>
<td>4.44</td>
<td>4.38</td>
<td>—</td>
<td>0.09</td>
<td>.768</td>
<td>None</td>
</tr>
<tr>
<td>3-3-x: Good screen size</td>
<td>4.06</td>
<td>4.5</td>
<td>—</td>
<td>4.17</td>
<td>.045</td>
<td>Tablet–laptop</td>
</tr>
<tr>
<td>4-4-2: Perceived low number of errors</td>
<td>4.21</td>
<td>4.03</td>
<td>4.09</td>
<td>0.19</td>
<td>.830</td>
<td>None</td>
</tr>
<tr>
<td>5-5-3: Portability helping</td>
<td>3.32</td>
<td>3.35</td>
<td>3.85</td>
<td>1.89</td>
<td>.155</td>
<td>None</td>
</tr>
<tr>
<td>6-6-x: Ability to do casual reading</td>
<td>3.68</td>
<td>3.91</td>
<td>—</td>
<td>0.85</td>
<td>.357</td>
<td>None</td>
</tr>
<tr>
<td>7-7-4: Perceived ability to perform the task effectively</td>
<td>4.03</td>
<td>4.29</td>
<td>4.47</td>
<td>2.57</td>
<td>.081</td>
<td>Tablet–Pen &amp; Paper</td>
</tr>
<tr>
<td>8-8-5: Perceived ability to perform the task efficiently</td>
<td>4.00</td>
<td>4.27</td>
<td>4.47</td>
<td>2.79</td>
<td>.066</td>
<td>Tablet–Pen &amp; Paper</td>
</tr>
<tr>
<td>9-9-6: Overall satisfaction with the reading task</td>
<td>4.06</td>
<td>4.29</td>
<td>4.06</td>
<td>1.81</td>
<td>.170</td>
<td>None</td>
</tr>
</tbody>
</table>

Note. N = 34. Statistically significant differences are marked in bold. Question numbers are presented in the order of Tablet, laptop, pen and paper.
scale was used, from 1 (strongly disagree) to 3 (neutral) to 5 (strongly agree). These types of scales are deemed appropriate for studies of this nature (Medsker & Campion, 1997). Most of the questions were posed as positive statements, indicating a positive attribute of the medium such as screen brightness being good, the task being easy, and so on. Some questions were deliberately reversed either for measuring the Cronbach’s alpha coefficient or when measuring a negative aspect of the item (such as the mental effort involved) was deemed more appropriate in the questionnaire. Main empirical findings from the experiment are discussed in the next section.

4. RESULTS AND DISCUSSION

The main goal of this research study is to determine the main differences in user preferences and satisfaction between Tablet PCs, laptop PCs, and pen-and-paper environments. In this section, the differences among the task-specific satisfaction and preference points are discussed among the three media. Differences in the final questionnaire responses concerning overall satisfaction are also discussed. An analysis of variance (ANOVA) was primarily used to determine statistically significant differences in satisfaction and preference characteristics. Some questions did not have correspondence in all of the media, for example, screen size questions are irrelevant to pen-and-paper tasks. Therefore, some analyses contained two treatment factors instead of three. The analysis is discussed in a task-by-task manner first. A significant ANOVA result indicates that the scores of at least two media differ from each other with statistical significance. Consequently, for those characteristics with significant ANOVA results, the Duncan’s Multiple Range Test was applied on the treatments to determine which treatments were different, meaning which media were different from each other concerning the survey score for the particular task. The ANOVA results for reading, writing/typing, direct manipulation, and form-filling tasks are discussed in the next sections.

4.1. Reading Task

Reading is arguably the most common task performed on a computer environment. For the purpose of determining the user preferences among the different media, a text was presented to the participants in each media to read. To prevent learning effect, the reading tasks were chosen as similar in length (about 20 lines each) but different in content. Following the completion of the reading task in each medium, participants were asked to respond to the reading-related user satisfaction and preference questions.

The ANOVA was conducted on nine characteristics of user satisfaction and preferences for the three media. In certain cases, because of the lack of applicability of a characteristic in a medium, an ANOVA was run on two media instead of three. The ANOVA and Duncan’s Multiple Range Test results are presented in Table 1.

The characteristics that were analyzed include ease of the reading task with the medium, screen brightness of the medium, screen size of the medium, perceived
number of mistakes made using the medium, portability helping while completing the task on the medium, overall ability to do casual reading on a daily basis with the medium, perceived ability to perform the task effectively and efficiently (two separate questions) on the medium, and overall satisfaction with the reading task. Logically, the characteristics screen brightness, screen size, and overall ability to do casual reading on a daily basis with the medium are not applicable to pen-and-paper tasks, and therefore the pen-and-pencil medium was excluded from the analyses for these characteristics. Table 1 indicates that, for the reading task, the ANOVA detected three significant differences among the nine characteristics of user satisfaction and preferences. Subsequent Duncan’s Multiple Range Tests indicated that the participants found the screen size significantly worse ($F = 4.17, p = .045$) with Tablet PCs ($M = 4.06$) than with laptop computers ($M = 4.50$), although it should be noted that both scores are very high for a 5-point scale. Similarly, for perceived ability to perform the task effectively, a significant difference was detected ($F = 2.57, p = .081$) between the Tablet PC ($M = 4.03$) and pen-and-paper scores ($M = 4.47$) and for perceived ability to perform the task efficiently ($F = 2.79, p = .066$) between the same scores (Tablet PC $M = 4.00$, pen-and-paper $M = 4.47$). Again, the scores for these items in general are observed as very high.

Overall, it can be concluded that although the users indicated slight problems with screen size, efficiency, and effectiveness while reading from a Tablet PC screen, there are no significant problems for participants reading from a Tablet PC screen. Participants gave high scores to reading from a Tablet PC screen. Therefore, this study suggests that reading tasks on a Tablet PC can be conducted just as satisfactorily as on a laptop PC.

4.2. Writing/Typing Task

As a task just as common as reading, a large percentage of data entry is commonly done on desktop and laptop computers via the keyboard. Advances in handwriting recognition technology allow users to use natural handwriting on the computer screen, which is achieved by the special magnetism-sensitive surface. Although a few brands of Tablet PCs do not require magnetic pens and allow writing on the screen with a regular, nonmagnetic stylus, most Tablet PCs require a special magnetic pen for the user to be able to write or draw on the Tablet PC. Tablet PCs also allow special functions with the magnetic pen—for example, repeated scratching on a screen area can allow the text to disappear.

The ANOVA and subsequent Duncan’s Multiple Range Tests were conducted to determine users’ comfort levels and preferences concerning the characteristics of text entry between a laptop PC with a keyboard, a Tablet PC with a magnetic pen, and regular pen and paper. The results of the ANOVA procedure and Duncan’s Multiple Range Test are presented in Table 2.

Characteristics of comparison between the media in this writing/typing task included ease of the writing/typing task with the medium; difficulty in typing or using the stylus/pen (analyzed in two separate questions; one between the regular pen on paper and magnetic pen on Tablet PC screen and one between all three media); overall satisfaction with the writing/typing task; perceived ability to
perform the task effectively and efficiently (two separate questions) on the medium, perceived (low) number of errors; and the opinion on whether or not typing, the magnetic pen, or the regular pen is a convenient way of text input. Of the eight characteristics analyzed, five had significant differences among the media scores. The analyses indicated that the participants found using magnetic pen of the Tablet PC ($M = 3.65$) significantly more difficult ($F = 5.60, p = .021$) than using the pen on a paper ($M = 4.26$). Although the score for using the magnetic pen is higher than the middle value of 3.0, this finding is to some extent consistent with the indication in the literature (Frankish et al., 1996) that although handwriting recognition systems have significantly evolved in the past couple years, using the magnetic pen/stylus on the Tablet PC is not yet a direct substitute for writing with a pen. Participants also indicated that they were significantly less efficient ($F = 5.50, p = .006$) using the stylus of the Tablet PC ($M = 3.38$) than typing with the laptop keyboard ($M = 4.26$) and significantly less effective ($F = 3.30, p = .041$) using the stylus of the Tablet PC ($M = 3.56$) than using the laptop keyboard ($M = 4.21$). Similarly, participants indicated that they made significantly more errors ($F = 8.00, p = .001$) in writing on the Tablet PC using the magnetic pen ($M = 2.94$) than typing using the laptop keyboard ($M = 3.53$) as well as writing on paper with

<table>
<thead>
<tr>
<th>Question No. &amp; Description</th>
<th>Tablet PC $M$</th>
<th>Laptop PC $M$</th>
<th>Pen-and-Paper $M$</th>
<th>$F$</th>
<th>$p$</th>
<th>Duncan’s Grouping Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-1: Ease of writing/typing task using the medium</td>
<td>3.77</td>
<td>4.21</td>
<td>3.91</td>
<td>1.46</td>
<td>.237</td>
<td>None</td>
</tr>
<tr>
<td>2-x-2: No difficulty using the stylus/pen</td>
<td>3.65</td>
<td>4.26</td>
<td>—</td>
<td>5.60</td>
<td>.021</td>
<td>Tablet–laptop</td>
</tr>
<tr>
<td>4-2-3: Overall satisfaction with the writing/typing task</td>
<td>3.65</td>
<td>4.18</td>
<td>4.03</td>
<td>1.97</td>
<td>.145</td>
<td>None</td>
</tr>
<tr>
<td>5-3-4: Perceived ability to perform the task efficiently</td>
<td>3.38</td>
<td>3.97</td>
<td>4.26</td>
<td>5.50</td>
<td>.006</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>6-4-5: Perceived ability to perform the task effectively</td>
<td>3.56</td>
<td>4.21</td>
<td>3.97</td>
<td>3.30</td>
<td>.041</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>10-5-7: Difficulty to use the stylus/type/use the pen</td>
<td>3.76</td>
<td>4.15</td>
<td>4.21</td>
<td>1.61</td>
<td>.210</td>
<td>None</td>
</tr>
<tr>
<td>11-6-8: Perceived low number of errors</td>
<td>2.94</td>
<td>3.53</td>
<td>4.00</td>
<td>8.00</td>
<td>.001</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
</tbody>
</table>

Note. $N = 34$. Statistically significant differences are marked in bold. Question numbers are presented in the order of Tablet, laptop, pen and paper.
a pen \((M = 4.00)\). Finally, participants found typing on the keyboard \((M = 4.32)\) a significantly more convenient way of text input \((F = 6.65, p = .002)\) than using the stylus on the Tablet PC \((M = 3.41)\) as well as using pen and paper \((M = 3.62)\).

The findings in general indicate closeness in the satisfaction of text entry between typing on a laptop and using the stylus on a Tablet PC. It can be concluded that whereas using the magnetic pen on a Tablet PC is not as convenient as typing, it is still to some extent quite satisfactory with most scores being above the middle score of 3.0, although participants make quite a few errors in text entry while using the magnetic pen. Again, these errors are likely due to inaccuracies in handwriting recognition software and may improve in the near future with advances in the technology. Actual errors were also recorded in this experiment and are briefly discussed at the end of this article.

4.3. Direct Manipulation

The direct manipulation task is chosen as the next task because of the popularity of direct manipulation tasks in computers, such as minimizing, maximizing, resizing, and closing windows. They are conducted via mouse on the laptop computer and via the magnetic pen on the Tablet PC, and they are obviously not directly applicable to pen-and-paper tasks. Therefore, the ANOVAs and Duncan’s Multiple Comparison Tests were conducted for characteristics between two media—laptop and Tablet PCs only. These tested characteristics included ease of the direct manipulation task with the medium, perceived ability to perform the task effectively and efficiently (two separate questions) on the medium, responsiveness of the screen to stylus or mouse movements, perceived (low) number of errors, perceived lack of efficiency conducting the task, and the overall satisfaction with the direct manipulation task on the medium. The ANOVA and Duncan’s Multiple Range Test results are presented in Table 3.

Of the seven items of satisfaction concerning direct manipulation, no characteristic had any significant differences in scores between the two media. Therefore,

<table>
<thead>
<tr>
<th>Question No. &amp; Description</th>
<th>Tablet PC (M)</th>
<th>Laptop PC (M)</th>
<th>(F)</th>
<th>(p)</th>
<th>Duncan’s Grouping Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-x: Ease of task</td>
<td>4.21</td>
<td>4.44</td>
<td>1.15</td>
<td>.287</td>
<td>None</td>
</tr>
<tr>
<td>4-3-x: Perceived ability to perform the task effectively</td>
<td>4.18</td>
<td>4.26</td>
<td>0.16</td>
<td>.693</td>
<td>None</td>
</tr>
<tr>
<td>5-4-x: Perceived ability to perform the task</td>
<td>3.97</td>
<td>4.18</td>
<td>0.66</td>
<td>.419</td>
<td>None</td>
</tr>
<tr>
<td>6-5-x: Responsiveness of the screen to stylus/mouse movements</td>
<td>4.09</td>
<td>4.12</td>
<td>0.02</td>
<td>.892</td>
<td>None</td>
</tr>
<tr>
<td>7-6-x: Perceived low number of errors</td>
<td>4.15</td>
<td>4.15</td>
<td>0.00</td>
<td>1.000</td>
<td>None</td>
</tr>
<tr>
<td>8-7-x: Perceived inefficiency</td>
<td>3.85</td>
<td>3.79</td>
<td>0.03</td>
<td>.859</td>
<td>None</td>
</tr>
<tr>
<td>9-8-x: Overall satisfaction with the direct manipulation task</td>
<td>4.09</td>
<td>4.24</td>
<td>0.39</td>
<td>.537</td>
<td>None</td>
</tr>
</tbody>
</table>

*Note. \(N=34\). Question numbers are presented in the order of Tablet, laptop, pen and paper.*
this study suggests that Tablet PCs are a good alternative to laptop PCs for direct manipulation tasks and users can fulfill direct manipulation tasks just as well on Tablet PCs as on laptop PCs. The preference and satisfaction levels not differing between the two media may be because of the convenience of using a penlike device for simple tasks and using the Tablet PC for tasks that involve tapping on the screen or dragging screen elements. It can be concluded that the use of magnetic pen in the Tablet PC environment is just as convenient as using the mouse with the laptop PC.

4.4. Form Filling

Form-filling tasks are common mainly because of the popularity of the World Wide Web and e-commerce, where participants enter information on the screen. The forms on the computer screen are in most cases consistent with similar forms in paper-based environments. The ANOVAs and Duncan’s Multiple Range Tests were conducted for the three media (unless indicated otherwise in parentheses) on ease of the form filling task with the medium, perceived ability to perform the task effectively and efficiently (two separate questions) on the medium, and preference to use the stylus or pen rather than the keyboard in the form filling tasks (for Tablet PC and pen-and-paper tasks only). The ANOVA and Duncan’s Multiple Range Test results are presented in Table 4.

Of the four characteristics of satisfaction, three characteristics were found to have significant differences among the different media. Regarding the overall ease of the task using the medium, participants indicated that performing the form-filling task was significantly \((F = 11.11, p < .001)\) more difficult with the Tablet PC \((M = 3.56)\) than with the laptop PC \((M = 4.38)\) and using pen and paper \((M = 4.53)\). Similarly, participants found performing the task significantly less

<table>
<thead>
<tr>
<th>Question No. &amp; Description</th>
<th>Tablet PC (M)</th>
<th>Laptop PC (M)</th>
<th>Pen-and-Paper (M)</th>
<th>(F)</th>
<th>(p)</th>
<th>Duncan’s Grouping Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-1: Ease of task</td>
<td>3.56</td>
<td>4.38</td>
<td>4.53</td>
<td>11.11</td>
<td>&lt; .001</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>5-2-3: Perceived ability to perform the task effectively</td>
<td>3.26</td>
<td>4.53</td>
<td>4.47</td>
<td>22.11</td>
<td>&lt; .001</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>6-3-4: Perceived ability to perform the task efficiently</td>
<td>3.12</td>
<td>4.44</td>
<td>4.53</td>
<td>29.08</td>
<td>&lt; .001</td>
<td>Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>7-x-2: Preference to use the stylus/pen rather than laptop keyboard in form-filling tasks</td>
<td>3.06</td>
<td>3.53</td>
<td>—</td>
<td>2.00</td>
<td>.162</td>
<td>None</td>
</tr>
</tbody>
</table>

Note. \(N = 34\). Statistically significant differences are marked in bold. Question numbers are presented in the order of Tablet, laptop, pen and paper.
effective ($F = 22.11, p < .001$) with the Tablet PC ($M = 3.26$) than with pen and paper ($M = 4.47$) and with the laptop PC ($M = 4.53$) and less efficient ($F = 29.08, p < .001$; Tablet PC $M = 3.12$, pen and paper $M = 4.44$, laptop PC $M = 4.53$). The general indication of these findings is that text entry and markings are more conveniently done with a laptop PC than a Tablet PC. The reason for this preference may be because participants are highly used to filling out forms online using desktop or laptop PCs. However, participants indicated that they did not have a strong preference regarding using the Tablet PC magnetic pen versus the laptop keyboard ($F = 2.00, p = .162$, Tablet PC $M = 3.06$, laptop PC $M = 3.53$). Therefore, it can be concluded that although participants generally find using a keyboard an easier, more effective, and efficient way to perform form-filling tasks, filling electronic forms are still acceptable via Tablet PCs and the magnetic pen.

### 4.5. Overall Satisfaction

The overall satisfaction questions presented at the end of the experiment allowed the researchers to compare the overall satisfaction levels of participants in laptop PC, Tablet PC, and pen-and-paper environments. The characteristics of overall satisfaction comparing the three media included overall satisfaction with the medium, overall task effectiveness, easiness to carry the medium around (Tablet PC and laptop PC only), the portability of the medium being a great help (Tablet PC and laptop PC only), overall perceived well performance using the medium, overall perceived (low) number of errors using the medium, the feeling of proficiency with the tasks performed, perceived meaningfulness of the tasks on the medium, comfortably using the medium for everyday computing needs (Tablet PC and laptop only), the medium being fun to use, the probability of the medium being able to take care of users’ every computing need (Tablet PC and pen and paper only), ability to work fast using the medium, difficulty using the medium, the users’ opinions about themselves improving after using the medium, satisfaction with the amount of independent thinking involved using the medium, the fondness level with the challenge using the medium offered, and the mental effort required while using the medium. The ANOVA and Duncan’s Multiple Range Test results are presented in Table 5.

Of the 17 characteristics of overall user satisfaction examined, 14 significant differences between the three different media were detected. Highest overall satisfaction with the medium was with laptop PCs ($M = 4.32$), which was significantly higher ($F = 2.86, p = .062$) than Tablet PC ($M = 3.85$) and pen-and-paper ($M = 3.82$) scores. Participants also found their overall task effectiveness significantly higher ($F = 2.65, p = .076$) with laptop PCs ($M = 4.21$) than with Tablet PCs ($M = 3.65$). As a highly important finding, participants found Tablet PCs ($M = 4.18$) significantly easier to carry around ($F = 10.97, p = .002$) than laptop PCs ($M = 3.32$). The finding is important especially coupled with the fact that the score for Tablet PC is relatively low (slightly higher than the middle value of 3.0). The finding is promising as it indicates that the portability of Tablet PCs is a major factor of satisfaction where Tablet PCs are superior to laptop PCs, and the finding can have significant implications in areas where portability of the computer is important in...
<table>
<thead>
<tr>
<th>Question No. &amp; Description</th>
<th>Tablet PC</th>
<th>Laptop PC</th>
<th>Pen-and-Paper</th>
<th>Duncan’s Grouping Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–1–1: Overall satisfaction with the medium</td>
<td>3.85</td>
<td>4.32</td>
<td>3.82</td>
<td>2.86 .062 Tablet–laptop, laptop–pen &amp; paper</td>
</tr>
<tr>
<td>3–3–3: Tasks being effectively performed on the medium</td>
<td>3.65</td>
<td>4.21</td>
<td>3.94</td>
<td>2.65 .076 Tablet–laptop</td>
</tr>
<tr>
<td>4–4–x: Overall easiness to carry around</td>
<td>4.18</td>
<td>3.24</td>
<td>—</td>
<td>10.97 .002 Tablet–laptop</td>
</tr>
<tr>
<td>5–5–x: Portability being a great help</td>
<td>4.06</td>
<td>3.65</td>
<td>—</td>
<td>2.58 .113 None</td>
</tr>
<tr>
<td>6–7–5: Overall perceived well performance</td>
<td>3.74</td>
<td>4.12</td>
<td>4.21</td>
<td>2.94 .058 Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>7–8–6: Perceived low number of errors</td>
<td>3.38</td>
<td>4.00</td>
<td>4.15</td>
<td>6.28 .003 Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>8–9–7: Feeling of proficiency with the tasks performed</td>
<td>3.71</td>
<td>4.15</td>
<td>4.18</td>
<td>2.84 .063 Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>9–10–8: Perceived meaningfulness of tasks</td>
<td>4.06</td>
<td>3.82</td>
<td>3.91</td>
<td>0.65 .526 None</td>
</tr>
<tr>
<td>11–12–9: The medium being fun to use</td>
<td>4.15</td>
<td>3.79</td>
<td>2.38</td>
<td>23.7 &lt; .001 Tablet–pen &amp; paper, laptop–pen &amp; paper</td>
</tr>
<tr>
<td>15–12–12: The probability Tablet PC/pen &amp; paper can take care of all computing needs</td>
<td>3.14</td>
<td>—</td>
<td>1.94</td>
<td>16.97 &lt; .001 Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>16–13–13: Ability to work fast using the medium</td>
<td>3.59</td>
<td>4.29</td>
<td>4.18</td>
<td>0.17 .843 None</td>
</tr>
<tr>
<td>17–14–14: Difficulty to use the medium</td>
<td>3.59</td>
<td>4.29</td>
<td>4.18</td>
<td>0.0 .021 Tablet–laptop, Tablet–pen &amp; paper</td>
</tr>
<tr>
<td>19–16–16: Satisfaction with the amount of independent thinking involved using the medium</td>
<td>3.76</td>
<td>3.68</td>
<td>3.18</td>
<td>4.32 .020 Tablet–pen &amp; paper, laptop–pen &amp; paper</td>
</tr>
<tr>
<td>20–17–17: The challenge the medium offers</td>
<td>3.47</td>
<td>3.53</td>
<td>2.21</td>
<td>16.44 &lt; .001 Tablet–pen &amp; paper, laptop–pen &amp; paper</td>
</tr>
<tr>
<td>21–18–18: Mental effort using the medium being too high</td>
<td>2.24</td>
<td>1.94</td>
<td>1.65</td>
<td>2.81 .065 Tablet–pen &amp; paper</td>
</tr>
</tbody>
</table>

Note. N = 34. Statistically significant differences are marked in bold. Question numbers are presented in the order of Tablet, laptop, pen and paper.
users’ day-to-day tasks, such as fieldwork in some professions. It should be noted, however, that the portability of the Tablet PC ($M = 4.06$) was not indicated as a significantly ($F = 2.58, p = .113$) greater help than that of the laptop PC ($M = 3.65$).

The participants indicated that they perceived their overall performance as significantly higher ($F = 2.94, p = 0.058$) using pen and paper ($M = 3.65$) than using the Tablet PC ($M = 3.74$). However, the overall perceived performance using the Tablet PC was not significantly higher than using the laptop PC ($M = 4.12$), and the score for the Tablet PC is also relatively high. Therefore, it can be concluded that participants did not have a significant issue concerning their own performance using the Tablet PC, making it a reliable medium for the computing tasks. Participants indicated they conducted significantly more errors ($F = 6.28, p = .003$) using the Tablet PC ($M = 3.38$) than using the laptop PC ($M = 4.00$) and pen and paper ($M = 4.15$). This finding should be taken into consideration carefully, as participants were all novice with the Tablet PCs. Hence, comparing perceived error rates with laptop PCs and pen and paper may not be fair. It is plausible that with training and exercise the error rates using the Tablet PC stylus (magnetic pen) may be significantly reduced. Similarly and most likely due to the same reason, participants felt significantly less proficient ($F = 2.84, p = .063$) with the Tablet PC ($M = 3.71$) than with the laptop PC ($M = 4.15$) and with pen and paper ($M = 4.18$).

Participants indicated that they would use Tablet PCs ($M = 3.44$) significantly less comfortably for their everyday computing needs ($F = 8.14, p = .006$) than laptop PCs ($M = 4.15$). The results may be an indication that although participants have relative trust on Tablet PCs for meeting their daily computing needs (as demonstrated by the Tablet PC score being above the middle score 3.0), they are just not ready yet to replace their regular laptop PCs with Tablet PCs.

Scoring a high point for the entertainment factor, participants indicated that the Tablet PC ($M = 4.15$) was significantly more fun to use ($F = 23.70, p < .001$) than using pen and paper ($M = 2.38$). The score was also higher than using the laptop PC ($M = 3.79$). To some extent supporting and complementing the result concerning the use of Tablet PCs comfortably for everyday computing needs, participants indicated that Tablet PCs ($M = 3.14$) are significantly more likely to take care of their daily computing needs ($F = 16.97, p < .001$) than pen and paper ($M = 1.94$). It should be noted that the score for Tablet PCs is relatively low, once again indicating that users are not completely ready to adopt Tablet PCs for all their computing needs, although the computing capabilities of Tablet PCs are quite acceptable. Participants also found the Tablet PC ($M = 3.56$) significantly more difficult to use ($F = 4.00, p = .021$) than pen and paper ($M = 4.18$) and laptop PC ($M = 4.29$). This question is reversed, hence a low score indicates higher level of difficulty. The finding is again indicative of participants’ caution toward Tablet PCs and the comfort level being relatively low, most likely because of their high-level experience with regular (in this case, laptop) computers. Participants’ opinions about themselves improved more significantly with Tablet PCs than pen and paper ($F = 4.77, p = .011$), they found Tablet PCs allowing them to think more independently ($F = 4.32, p = .02$), and they enjoyed the challenge Tablet PCs offered compared to the pen-and-paper medium ($F = 16.44, p < .001$). In accordance with the scores concerning the “fun” factor Tablet PCs offer, the overall challenge the Tablet PC offers to the users is promising and can be viewed as a
positive factor concerning the user acceptance of the medium. Participants did not find Tablet PCs faster or slower to work with than any of the other media ($F = 0.17, p = .843$). Finally, participants indicated that using the Tablet PC ($M = 2.24$) requires significantly more mental effort ($F = 2.81, p = .065$) than laptop PCs ($M = 1.94$) and pen and paper ($M = 1.65$). However, because the overall mental effort score is relatively low (below 3.0) for Tablet PCs, the mental effort issue can be concluded as not a hindering issue for users’ computer needs.

As indicated earlier, user performance data in the form of task completion time and number of errors were also collected during this study to determine possible performance issues using Tablet PCs in comparison to equivalent tasks on laptop PC and pen-and-paper media. Reading on a Tablet PC took similar time ($M = 117.6$ sec) to reading on a laptop PC (96.5 sec) and on paper (106.6 sec). However, it took participants significantly longer to complete the writing task on a Tablet PC ($M = 420.1$ sec) than on a laptop PC (93.8 sec). Similarly, participants took an average of 167.4 sec to complete the form-filling task, compared to an average of 93.8 sec on a laptop PC. The direct manipulation tasks took an average of 220.22 sec to complete on the Tablet PC versus 94.4 secs on the laptop PC. Regarding the errors, participants on average made 25.4 errors on the Tablet PC, 9.5 errors on the laptop PC, and 0.8 errors with pen and paper. Although some of the performance values are high for Tablet PCs, they should be approached with caution. It is likely that most errors are because of handwriting recognition and participants’ lack of expertise with the medium. These issues are likely to improve with repeated use. Participants also have years of experience with similar tasks on laptop PCs and pen and paper. In addition, when they were asked about it, participants usually indicated they did not have any major performance issues. Therefore, it can be concluded that user performance is not a major negative issue in the context of Tablet PC use for the time being.

The analyses indicated that although users perceived portability as a major advantage for Tablet PC users, Tablet PCs are not perceived as a direct replacement for laptop PCs. In a number of characteristics of user satisfaction and preference, however, Tablet PCs do not score significantly different than laptop PCs. Final conclusions and implications of these and other main findings are discussed in the next section.

5. CONCLUSION AND RECOMMENDATIONS

This research aimed at empirically testing user preference and satisfaction issues concerning Tablet PC use from a comparative perspective, with the comparison being executed between Tablet PCs and two other computing/storage media that are most commonly used.

A direct comparison of all the media on all of the points concerning computing, specifically mobile computing, may be unfair, as all media are not created equally, with some being more concentrated on specific tasks and others concentrated on mobility with some compromise on functionality. The Tablet PC certainly would qualify for the latter category initially; however, with advances in technology, the “compromise” is arguably shrinking, with the full functionality of
a laptop PC being slowly combined with the mobility of a Tablet PC in newer models, as discussed earlier.

The Tablet PC is being promoted as “the next step in computing” (Walker, 2001) and is expected to be adopted by a large percentage of computer users for whom mobility is a major issue of preference. Therefore, this study has focused on comparison of user preferences and user satisfaction as part of usability issues among the media, mainly between Tablet PCs and laptop PCs. It should be noted that the number of comparisons that are not statistically significant is not necessarily an indication of failure on the medium’s part. Rather, the results partially indicating Tablet PC superiority for different tasks point to the direction of future success of the medium in specific areas and tasks.

A task-by-task as well as overall analysis of the capabilities of Tablet PCs in comparison to laptop PCs and pen and paper indicated some promising results, including that although there are some negative issues concerning the use of Tablet PCs, a number of Tablet PC functionality characteristics are either commensurate with those of laptop PCs or to some extent better than laptops. The issues concerning the characteristics in specific tasks include the following.

The first task, the reading task, was aimed at empirically determining screen visibility and size issues in comparison with laptop PCs and pen and paper, mainly asking the question whether users can read comfortably and without any major problems on a Tablet PC screen. The results indicated a relatively high level of promise. Participants did not indicate any problems with reading from the Tablet PC screen, except for finding the screen relatively smaller than that of laptop computers. Although participants found overall task efficiency and affectivity lower with Tablet PCs, this is an expected result because of the much higher longevity of laptop computers. Overall, it can be concluded that there are no major difficulties in the reading task and users can successfully conduct reading tasks on Tablet PCs.

In the writing/typing task, however, one major item was the perceived inaccuracy of the handwriting recognition system. Although participants indicated that they didn’t have a problem using the stylus/magnetic pen, they did indicate that they felt like they committed many errors and found this type of data entry less convenient than the laptop interface they use on a highly regular basis. Similar to the reading task, participants again were not entirely happy with their task efficiency and effectiveness. In short, it can be concluded concerning this task that although users felt comfortable using the Tablet PC magnetic pen/stylus, the handwriting recognition software may need more advances to improve its accuracy and provide a more reliable and comfortable experience to the Tablet PC users in data entry tasks.

Even more encouraging results were obtained for conducting direct manipulation tasks on a Tablet PC, as the medium to conduct these tasks is again the magnetic pen/stylus. When manipulating screen elements using the magnetic pen, participants did not have any significantly lower preferences or satisfaction characteristics than using the laptop direct manipulation interface. Therefore, the magnetic pen/stylus medium used in the direct manipulation is concluded to be a convenient, effective, and efficient medium.

For the form-filling task, findings were similar to those of the writing/typing task. Participants did not find using an online form as easy on a Tablet PC using
the magnetic pen/stylus as on a laptop PC environment they are so used to. Mainly, participants indicated they did not find the Tablet PC medium as easy, efficient, and effective to use as laptop PCs. It should be noted that form filling requires a lot of cursor targeting and text entry, and mostly a combination of both. Because of the advent of e-commerce, many computer users fill out electronic forms on a regular basis using desktop and laptop interfaces. Therefore, this regular use may be the reason behind the laptop computer being found a more efficient and effective way to fill out electronic forms, with fewer perceived and real errors. It is concluded that the clicking and handwriting areas being separate on the Tablet PC screen is likely to have caused the inconvenience, as participants needed to tap on the desired electronic form area and then write on the handwriting area of the Tablet PC. It should be noted that touch pads that are commonly used in laptop computers were not covered as a comparison item in the tasks that involved data entry. Rather, the overall more common data entry with a mouse was compared to the Tablet PC data entry.

More interesting, overall general satisfaction responses indicated that primarily, participants did not find using the Tablet PC medium significantly more difficult to use than laptop PCs, although parallel to the other, task-specific findings, they indicated they committed more errors and were less efficient and effective in their daily tasks while using a Tablet PC. They found the tasks equally meaningful but showed some hesitancy in comfortably using Tablet PCs to meet all their daily computing needs. Maybe most important, participants found Tablet PCs fun to use, not particularly slow to work on, and highly mobile.

This study is a first attempt at empirically measuring usability of the Tablet PC medium from a user opinion perspective. Parallel to this research, research has been conducted in the exact same experimental environments concerning user performance, in the form of measuring user task completion time and errors. A study in the near future will include performance comparisons among the different media and the correlation between the real and perceived performance values for each medium.

The findings of this study indicate that the Tablet PC is a medium that shows promise for the future of mobile computing. The hands-on problems, most significant in data/text entry, may be solved in time with advances in hardware and software technology. Eventually, it is conceivable that the keyboard will be entirely eliminated from computing, opening room for voice recognition and/or pen-based data input. (Although Tablet PCs have a voice recognition system built in, its usability was not studied in this research.) The freestyle handwriting capability is no doubt the most significant innovation that Tablet PCs bring to users. In addition, being able to carry the Tablet PC easily is proven to be another high point of preference.

The study is limited in comparing the Tablet PC usability issues, as it is a sole examination of user satisfaction and preferences via questionnaires. Additional usability issues such as user performance were explored to a limited extent, and the tasks covered in the study are far from comprehensive. In addition, the experiment was conducted with a first-generation Tablet PC. As Tablet PCs mature, gain more market share, and get richer in technical capabilities, more usability studies will no doubt be necessary to explore user preference, satisfaction, and general usability issues.
This is one of the first empirical scientific studies on usability issues of Tablet PCs and is potentially useful in understanding the hands-on user issues concerning this emerging medium. The future of Tablet PCs and their market penetration remains to be seen, but this study empirically proved a relatively high level of promise concerning the medium’s visibility in the future of personal computing.

REFERENCES


