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Tablet PCs in a paperless classroom: Student and teacher perceptions on screen size

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*A paperless classroom, when all materials required to complete a class are available in an electronic form, has been shown to have positive impacts on student and teacher motivation, engagement, productivity, and efficiency. Recent trends suggest that of all of the technological tools available, tablet **PC**s can support many aspects of a paperless classroom for both students and teachers. A variety of resources describing the development and implementation of courses using tablet **PC**s are currently available, though comparatively less research specific to individual stages of the process or details involved in selecting appropriate tools has been performed. The current study was designed to provide preliminary evidence for how the screen size of a tablet **PC** affected interactions with electronic handouts from an English language class. Teachers and students completed tasks on both a 10-inch tablet **PC** as well as on the miniature version of the same tablet, to determine the impact screen size had on usability. It was found that while teachers significantly preferred interacting with classroom materials on the regular-sized tablet, students did not show preference toward either device for classroom use. However, students suggested that for everyday use, such as doing homework, the miniature version was preferred. The implications the results make on materials design and mobility as a component of a paperless classroom are discussed.*

Introduction

In the last decade, research on the use of technology in the classroom has increased exponentially. Technology, for many, has become an integral part of the classroom environment and a plethora of literature

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now exists to describe the features of technologies that seem promising in improving education (Bransford, Brown, & Cocking, 2000; Roschelle, Pea, Hoadley, Gordin, & Means, 2000).

With such a wide range of options, selecting the right tools for incorporating technology into the classroom and deciding which methodology to adopt present challenges to administrations and instructors. Recent efforts seem to be characterized by several trends: smart classrooms allow teachers to employ tools such as interactive whiteboards (Armstrong *et al.*, 2005), personalize the learning environment with automatically-adjusting lighting levels (Cooperstock, 2001), or combine lecture video or audio capture (Shi & Xie, 2003) with comments or annotations (Cook & Das, 2007). Adaptive or personalized eLearning employs intelligent tutoring and adaptive media techniques to provide content which matches the requirements or abilities of different learners (Antona *et al.*, 2010). Finally, learner-centered approaches take traditional educational practices and adapt them to the available technology, allowing learners to interact directly with the technologies in the classroom (Antona *et al.*, 2010).

One outcome of the inclusion of technology in the classroom is that classes can be administered entirely electronically in what has now become known as a paperless classroom. Paperless classrooms have been shown to not only have notable cost benefits (Arney, Jones, & Wolf, 2010), but also to increase productivity and efficiency for both students and teachers (Shepherd & Reeves, 2011), while improving engagement and motivation (Teeter, Madsen, Hughes, & Eagar, 2007). Naturally, a shift of this nature, from a traditional paper-based system to an electronic one, also entails much rethinking about how teachers, students and materials can interact with each other both in the classroom and outside of it. Paperless materials may not function in the same way as they did when they were paper-based and supplementary or new materials are often required (Meyer, 2008). On the other hand, considering that materials for courses sometimes take years to develop, not utilizing the planning and time that was previously devoted to those materials seems nonsensical. Fortunately, there are many ways to take advantage of paper-based materials converted to an electronic format (Wang, 2010), as well as many options to transform existing paper-based systems currently in operation directly into paperless systems (Lutes & Harriger, 2003; Shepherd & Reeves, 2011; Slowinsky, 2000).

Given that an institution or instructor makes the decision to go paperless, both initial financial investments in technological support tools and significant time investments in the redevelopment of courses and materials to suit the new learning environment are likely required. There are countless factors that may weigh-in on the decision to purchase any given tool. These may include cost, previous performance records, appearance or color, available add-ons, speed, materials, where it was made, among many more. In any case, the applicability or usefulness of any device to the classroom tasks at hand should be very carefully considered since research has shown that the haphazard use of technology can have a negative effect on learning and aspects of the learning process (Pelgrum & Plomp, 2002; Wenglinski, 1998). For example, reading from computer screens has been found to be more fatiguing and less efficient than reading from paper (Learn & Mirski, 2003; Mills & Weldon, 1987).

Tablet PCs in the classroom

Recently, tablet PCs, devices which allow the user to input directly to the screen, such as the iPad from Apple, the Galaxy Tab from Samsung or equivalents from Sony, Motorola,

Toshiba, Amazon and other companies, have enjoyed significant popularity within both the educational sector and outside of it. Since the release of the modern tablet version in 2010, US sales alone increased from 11.5 million to 53.2 million in 2012 with similar trends occurring worldwide (European Travel Commission, 2012). Previous research on using tablet PCs in the classroom has shown that they provide distinct advantages over using notebooks or laptops (Cicchino & Mirliss, 2004), particularly for activities such as managing and projecting class lessons or grading assignments using annotation tools (Cohen, 2009).

A major focus has been on the development and usage of tablet PC-based interactive systems for use in classrooms (Anderson *et al.,* 2004; Berque, Bonebright, & Whitesell, 2004). The objectives of such systems are usually to increase interactions between the instructor and the individual student with the ultimate goal of supporting or enhancing student learning (Koile & Singer, 2006). To provide an example, one such system called Classroom Presenter, is used to support the following type of student-teacher interaction: throughout a lecture, the instructor will ask students to solve a problem or respond to a question. The students prepare the answer on their tablets and then submit their solutions wirelessly to the instructor. The instructor views all of the responses and selects one to display for the purposes of providing feedback, annotating directly on to the response in front of the entire class. The students can then annotate their own solutions based on the instructor's feedback (Anderson *et al.*, 2006).

Although research on tablet PC usage in the classroom has become relatively prevalent, due to it being in its early phases this research has focused mostly on the overall experience or process employed to introduce and use the tablets for a particular course. Comparatively less research on the different stages or details of these procedures and the effect they have on learning has been performed. For instance, a major constraint imposed by the use of tablet PCs is the small screen size. Popat and Stead (2004, p. 167) note that "dealing with size is one of the critical challenges in developing mobile learning elements". Reading on small screens has been found to be even more fatiguing than simply reading from a computer screen, particularly if the text is being read several times or if it is long (Barton & Collura, 2003). How to adjust the learning materials to reduce these effects remains largely unknown and at the very least, materials designers need to be aware of the different demands that smaller screen sizes impose on learners and learning materials. This also presents a challenge for those looking to transform existing paper-based courses into an electronic format. In the event that no adjustments to paper handouts are initially possible, the selected tool should be tested to ensure that users can comfortably interact with materials on the screen and that the materials can still function as intended.

Choosing the right tools

Given that the Japanese higher education market is currently facing declining student enrollment nationwide as well as an increasing number of universities (Hays, 2009), the administration at Hiroshima Bunkyo Women's University decided to create an IT strategy that would boost their competitiveness and increase enrollment. The cornerstone of this strategy was the decision to distribute tablet PCs to all faculty members and incoming students from April 2013, with the intention to better equip students for life after graduation and to support faculty in improving the pedagogic content of curricula. The decision to distribute devices rather than request students bring their own was made to ensure that tablet computer coverage was universal, and to reduce the risk of compatibility issues that

could occur with devices from multiple manufacturers. Although going paperless was not a specific aim of introducing tablet PCs, the university administration made it clear to faculty that tablet PCs should be utilized in class, and that going paperless was a viable option for doing so.

Currently, the dominant player in the tablet PC market is Apple. Although its market share is gradually falling as other companies release rival tablets, Apple's market share stands at 58% (International Data Corporation, 2013). Apple's tablet PC, the iPad, is even specifically marketed towards educational institutions: "iPad is transforming the way teachers teach and students learn" quotes Apple's website, "[inspiring] creativity and hands-on learning with features [not available] in any other educational tool" (Apple, 2012). Due to their versatility, iPads have been argued to make a paperless classroom practical and functional (Shepherd & Reeves, 2011) while allowing for a more natural interaction than other types of technology (Antona *et al.*, 2010). When compared to other tablet PCs available, the administration deemed the user-friendliness and simplicity of the iPad to be more important than the more readily customizable but complex tablet computers offered by rival manufacturers.

In addition to the iPad, Apple also offers the iPad mini – a smaller, thinner and cheaper version. Whereas the iPad measures 25 × 19cm (9.6 × 7.5inches), the iPad mini, at 20 × 13.5cm (7.9 × 5.3 inches), is 5 × 5.5cms smaller. It is also 23% thinner and 53% lighter than the iPad (Apple, 2012). When it came to choosing which iPad model to distribute to students, the smaller size of the iPad mini was believed by the university administration to be advantageous to students because it is possible to hold it in one hand, thus allowing for easier use outside the classroom, such as when commuting. It was also assumed that students would be more willing to carry a lighter, smaller device in their bags every day. Furthermore, the fact that the iPad mini is a more recently released device could be seen to show that the university is at the cutting edge of educational technology.

Ignoring cost, the main difference between these two products is the screen size. For teachers who have an abundance of tailor-made, paper-based materials to suit the needs of their students, screen size of a device might affect how the materials can be interacted with. Since commonplace paper in Japan is 29.7 × 21cm and is slightly larger (4.7 × 2cm) than the iPad and significantly larger (9.7 × 7.5cm) than the iPad mini, the assumption that the same classroom materials can be used in the same way on both devices is a focus of the current study. While Apple argues that both tablets are ideal candidates for supporting a paperless classroom, the differences in screen size between the two devices may alter the user experience. Since previous research has not specified precisely what the impact of screen size is on usability on a tablet PC, the current study was designed to determine if the screen size of a miniature-sized tablet is sufficiently sized for interaction with classroom materials originally intended to be paper-based.

Methods

Participants

Participants in this study were 18 first year students and 11 English lecturers from Hiroshima Bunkyo Women's University, a small private university in Western Japan. Students were selected randomly from three different classes and participated voluntarily in the study. The 11 teachers also participated voluntarily.

Of the 11 teacher participants, several already owned tablet PCs (mostly iPads) for personal use but had never attempted to use them in the classroom for educational purposes. On the other hand, none of the student participants owned iPads, but some had experience with using Apple's operating system (iOS) on other Apple devices. Students did however, have public access to a small number of iPads in the university's self-access learning center, although these were not for classroom use. It was therefore both the students' and teachers' first time interacting with classroom handouts on a tablet PC.

Instruments

Although the iPad was in its fourth generation at the time of this study, the iPad 2 was chosen for data collection. The iPad mini and the iPad 2 have the same processing chip and screen resolution, meaning that the results should not be affected by performance differences that would be apparent between the iPad mini and the more powerful fourth generation iPad (Apple, 2013).

Once classroom handouts were converted into PDF files, the application GoodReader (Good.iWare, 2012), a PDF annotation tool, was employed for annotation. Of all of the free PDF annotation applications available in Apple's application store, GoodReader appeared to be the most comprehensive in terms of features available.

Procedure

A series of tasks representative of how a PDF file on a tablet PC might be utilized in the classroom was developed for testing on both an iPad 2 and an iPad mini. Since the current paper-based handouts used in the classroom are to be transferred into an electronic form (a PDF file), the series of tasks (described in English for the teachers, and Japanese for the students) was intended to mimic some of the processes involved in downloading and annotating a file, as would be done in a classroom scenario. The tasks were as follows: to open the application, mock download a PDF (by typing an internet address, or URL, on the device's on-screen keyboard), open a pre-loaded PDF, annotate it with shapes (by inserting and then manipulating the location of arrows), navigate to a different page of the handout and annotate the file with text (by typing in and manipulating the location of words using the device's on-screen keyboard). Each participant used both devices; half used the iPad mini first, and half used the iPad 2 first.

Both student and teacher participants completed a two-part evaluative survey on SurveyMonkey while carrying out the tasks on the tablets (SurveyMonkey, 2012). The first part contained questions regarding the ease of use of each device for the specific tasks outlined in the instructions (typing a URL, annotating a PDF with arrows, annotating with text etc.). The second part of the survey contained four Likert-scale questions related to the ease of typing and overall satisfaction for each device and additional questions inquiring about which device the participants found easier to use, which they would prefer to use in the classroom and which they would prefer to use at home, for homework. Participants could opt to write comments at their discretion.

Results

The results presented in Figure 1 and Figure 2 illustrate the student and teacher ratings on their experience interacting with the iPad 2 and iPad mini. The overall difference is shown, such that a positive difference represents a preference for the iPad 2, and a negative overall difference reflects higher ratings on the iPad mini. No bar reflects that there was no difference in ratings between the two devices.

As can be seen in Figure 1, teachers demonstrated a clear preference for the iPad 2 whereas students exhibited little to no differences in their preference ratings between each device. In fact, students reported no differences in overall typing evaluation and overall satisfaction between each device.

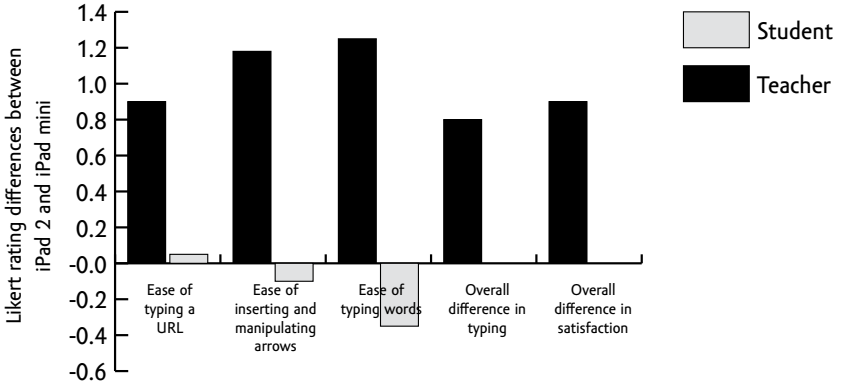

Figure 1. Difference in Likert ratings between iPad 2 and iPad mini for teachers and students (a positive difference is associated with a preference for the iPad 2 and no bar represents no difference in preference between the two devices).

Figure 2 shows the overall usability results as well as which device was recommended for classroom use by each group of participants. Again, teachers exhibited a clear preference for the iPad 2, whereas the students reported only a slight preference for the iPad mini in terms of usability. Students also gave higher ratings for the iPad 2 when asked which device they would recommend for usage in the classroom. However, the opposite was found to be the case when students reported their preferences for usage at home: 78% of the students indicated that they would prefer to use the iPad mini.

The comments also demonstrated that the teachers heavily favoured the iPad 2. The main concerns that teachers raised while using the iPad mini were related to the difficulty of typing, the difficulty of manipulating items on the screen, and the size of the screen itself in that it was too small to see the whole page at once. For the iPad 2, all ten teacher comments were positive in nature. Eight of the comments specifically referred to the larger screen size as a factor, with easier typing and manipulation of objects on the screen also mentioned. Conversely, the student comments reiterate the student (and the administration's) belief that the smaller size of the iPad mini would be easier for use at home. One particular student comment contrasts the two devices and rather accurately summarizes

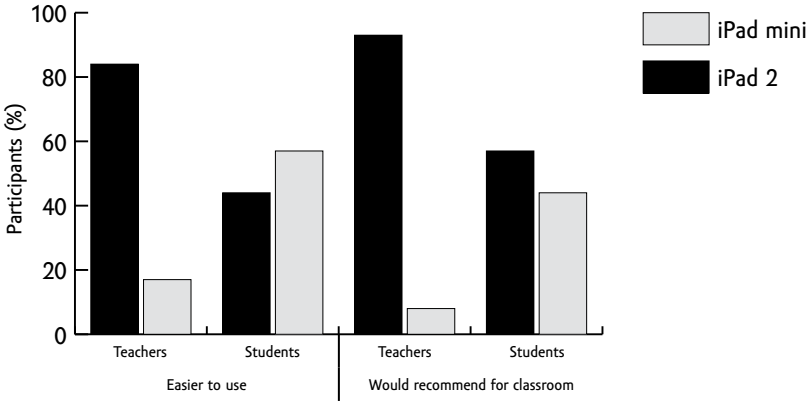

Figure 2. Participant responses for each device regarding usability and recommendations for usage in the classroom.

the overall findings of these surveys: while both devices are easy to use, the iPad 2, due to its larger screen size, is easier to use in the classroom, but the iPad mini is preferable to use everywhere else as it is easier to carry.

Discussion

In the current study, teachers and students interacted with English class handouts that had been converted into **PDF** format, on both a regularly-sized tablet and the miniature version of that tablet. Both groups provided feedback on their experiences to determine whether the size of the screen had any impact on usability. It was found that teachers overwhelmingly preferred the regularly-sized tablet, indicating that it was easier for typing **URL**s and words and also easier for inserting and manipulating shapes. Students, on the other hand, did not report much difference in their preferences between the two devices.

The discrepancy between students' and teachers' preferences may be explained when prior experiences with mobile devices are considered. Many of the teacher participants already own either iPads or other regularly-sized tablets. While no controls were employed to measure previous experience with tablet **PC**s, it is likely that student participants were far less accustomed to using them when compared to teachers. Teachers therefore found the miniature tablet to be more difficult to interact with since they were comparing their experience with the mini to previous experiences using tablet **PC**s close in size to the iPad 2. The higher teacher ratings toward the iPad 2 may simply have reflected greater familiarity with the device, rather than greater ease of interaction. On the other hand, students accustomed to using smart phones could be less likely to consider the smaller screen size of the mini tablet an issue.

The overall difference between the views of teachers and students can also possibly be attributed to envisioned use of the device by each group. Teachers' comments suggest that

they are focused solely on educational use in the classroom. In this respect, some students also appeared to agree that the larger screen size of the regularly-sized tablet was preferable. However, the screen size was the limit of teachers' focus. Students, on the other hand, appeared to consider the practicalities of using the tablet outside the classroom, where the overall smaller size and reduced weight of the mini version becomes advantageous. In this respect, students have raised an important point and have also confirmed the initial assumptions of the administration: the iPad 2 may be more appropriately sized for use in the classroom but not necessarily outside of it. Indeed, an underlying theory of the paperless classroom is that learning can occur easily outside of the classroom. In fact, students are typically expected to interact extensively with classroom materials outside of the classroom, so if they are less willing to transport larger devices to class and back home in the first place, the educational advantage the portable device may provide is potentially nullified.

Despite all of this, this study is certainly limited for several reasons and it should be taken as a starting point for other work. Firstly, extensive research into which application was most suited to meeting the needs of the classroom handouts was not performed. This meant that the student and teacher evaluations were perhaps only specific to using GoodReader on the two tablets, rather than being an evaluation of screen size. Fortunately, in terms of PDF annotation tools, there are a lot of options: Note Taker, pdfill, pdfsam and CUTEPdf are a few free options available for PDF annotation. It is however, now evident that both students and teachers will require training on whatever PDF manipulation application is selected, prior to real-time classroom usage. Furthermore, the current results indicate that only asking students and teachers may not be sufficient if these devices are to be used beyond the real-world or paperless classroom: if the devices are also expected to be used for an institution's administrative purposes then all stakeholders should be involved in the surveying process.

Perhaps of greatest concern however, is the assumption that paper-based handouts, when converted to PDF format, can function similarly. One of the primary advantages to employing tablets in a paperless classroom is that it increases interactivity between students and their teacher, and also between students. However, a paper handout in electronic form without modification cannot offer any of these advantages, and as was found with the teachers in the current study, is perhaps even more frustrating to interact with. Despite the fact that teachers may have had previous success using handouts targeted to their own student populations, paper-based handouts transformed into an electronic format may not function in the same way, and might therefore negatively impact the learning process.

Conclusion

The present findings have highlighted some issues that students, teachers and administrations might consider before commencing the development of a paperless classroom or the mobile administration of a course. The current study suggested that the small screen size of a tablet PC might cause usability issues when interacting with classroom handouts originally designed to be used on paper, but that a smaller device is seen by students to be more advantageous for day-to-day usage. Using mobile devices in the classroom certainly implicates how learning materials should be designed (Ally, 2004), and for institutions introducing technology to their classrooms, further research is required so that any decisions about the selection of a particular device or paperless learning system are supported with empirical evidence.

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