Comparing Classroom Note Taking across Multiplatform Devices

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ABSTRACT
Many educators have suggested that note taking can be beneficial for the students' educational growth. Note taking is the core activity for students in a classroom and there been a large amount of research conducted, both from industry and from academia, into facilitating the note taking process. As such, there are many available systems for taking notes. However, what has not been given as much attention is how different devices, such as Tablet PCs and PDAs, effect this task. In this paper, we study students' current note taking behavior and the changes caused by the use of different platforms for this activity. Our goal is to provide ideas and general design guidelines for future note taking systems.

Author Keywords
Note taking, multiplatform devices, context

INTRODUCTION
More and more computing platforms are developed and coming out to our everyday life. Home appliances are also equipped with simple computers. We may argue that computers are everywhere nowadays. This multiplatform computing trend is also happening in the classroom. Increasingly, students are bringing various gadgets, like notebook computers, graphing calculators, cellular phones, and PDAs, with them to school. As more types of computing devices, with a greater variety of functionality, become available, people will want these devices to take over the roles of some of the more traditional devices. They will want to take pictures with their camera phones and transfer them to electronic photo albums instead of using a 35mm camera to create glossy prints. They will want to manage their calendars from their desktop and their PDAs rather than simply using a paper version. One issue raised by this migration to electronic devices is whether the new device supports all the tasks expected by the user. It may supply a plethora of new abilities, but it may come at the cost of other used and needed functions. Another interesting issue is to consider how the change in devices effects the tasks preformed.

Increasingly, information technology is moving from being technology-driven to being user-oriented and focused on ensuring that system functions and structures will work for the user. This is a change from looking at what the computer can do to looking at how the user can use the device to perform some action. A broad range of analysis involving human-computer interaction (HCI) has already recognized that system design can profit from explicitly studying the context in which users work [11]. To achieve systems that are more centered on the actions of the user, we should attempt to learn from the context that they occur in [7]. We need to understand what users think they are doing and how they use and manipulate items in their environment to achieve their goals. With this viewpoint, we can see that by changing the context of the action, through the addition new devices or the removal of old ones, we fundamentally change what is happening. We need to understand what that change is.

The activity of note taking in the classroom is an interesting one. What has traditionally been a very simple endeavor, which used little technology, is being radically transformed. Now, the use of computers in a classroom has become common. PowerPoint slides and projector have replaced blackboards in many places. While still in its early stages, it is becoming more common to find students who bring notebook computers to take their notes. This may increase as hardware prices decrease and more usable note taking software becomes available. This provides opportunities to leverage this technology and enhance the potential learning of the students. Many research groups have anticipated this change to an e-classroom and have suggested suitable and efficient use of handheld devices, Tablet PCs, and desktop computers for the note taking activity [1, 4, 5, 6, 10]. These generally focus on capturing part of the context, through methods such as video or audio capture, which surrounds the activity. However, less work has been conducted to see how this move to an electronic classroom will effect the notes taken and, consequentially, the learning of the students.

Research Questions
In this paper, we investigate what users require from a note taking system. To determine what kinds of actions note taking software should support, we have surveyed students about their note taking skills. We asked about what they think their current practices are and what they want from an electronic system. In addition, we have performed a study to see how different devices, specifically Tablet PCs and handheld devices, effect the note taking process. It is

important to ascertain whether the devices influence the quality of the notes taken or the amount of learning that occurs. Coupled with the results from the survey, this gives us an idea of what systems should be supporting to aid in this task and how the particular device will modify the process.

PREVIOUS WORK

A number of different approaches have been taken to support and enhance the task of note taking. One such effort is E-notes [16], which simply provides an electronic form of the lecture notes that can be printed and annotated in class. The notes can be provided in full or skeletal form. This method supports the students' current behavior with a minimal amount of change. Aside from the lecture slides, it does not provide any other features as benefits. That is not necessarily a bad thing.

Another note-taking system is eClass, formally known as the Classroom 2000 project [1, 3]. One portion of that system, StuPad [14, 15], provides a pen-based interface for capturing the notes from both the lecturer and the student. These two sets of notes are kept separate and can be navigated through using thumbnail-image scrollbars. While the interface is relatively simple, the extra navigation from moving through the separate sets of notes may distract from the actual note taking. This system also uses an extensive infrastructure in the classroom that limits the places where it can be used.

NoteLook [4] allows for the integration of notes and digital video. Users can grab screen captures from any of the room's active cameras and then annotate them. Automatic snapshot taking is also supported. Timestamps associate each thumbnail, ink stroke, etc., with the video streams, so the user can play the video at the time the object was made. Again, this system requires a significant infrastructure. The interface is fairly complex, which may hamper note taking. In addition, the automatic snapshots work well with only certain types of presentation, like those that rely only on slides, and, so, the act of grabbing screen captures to mark up may slow the process.

Silicon Chalk [12] is a commercial system similar to NoteLook, although it is oriented specifically towards a classroom environment. Video and audio, from the lecture's screen, are streamed to each participant's computer where the notes are then added. It does not currently support ink-based notes. While the system supports a number of useful features, it is not extremely easy to use. Managing the various windows is challenging and the interface is cluttered. The system focuses on supporting the total classroom experience by providing for pop quizzes, surveys, feedback from the students, and so on. This makes the program feel bloated and hard to manage.

NotePals [5, 6] is a shared note taking system that has the goals of being inexpensive and usable everywhere. Notes are taken on a PDA and are browsable from the web. To compensate for the small screen space, a sliding zoomed input window can be used to input information. This system was not designed for the classroom and focuses mainly on sharing notes. The zoom window increases the available writing space but also increases the navigation required. While that may be an acceptable tradeoff, the zoom window is shaped to be used for writing text and may actually hinder the drawing of diagrams.

Souvenir [13] is a media annotation tool for use in digital libraries. Freeform ink notes and typed text can be interspersed throughout the same document. Ink notes can be annotated with text for clarity. This system's purpose is to annotate media for the use of others rather than to support personal note taking. As such, there is more stress on producing quality, readable notes.

While not specifically a note-taking system, Classroom Presenter [2] is of a similar vein. The system uses a Tablet PC to allow the lecturer to add to the presentation as it progresses. It also supports integration of student devices that may be used for note taking.

Other works provide insights into the use and the lifecycle of notes [10] and into the design of software agents that use context to help find and deliver the right information at the right time [8].

Most of these systems deal with the new features that can be provided. Audio and video capture, sharing, and portability are among the benefits they offer. They are also focused on indexing the annotations with the other objects, like the video, so that the notes can be easily found again. They do not, however, spend much time considering the students' current practices and how well their system supports them. This is a major deficiency.

SURVEY RESULTS

Thirty-five computer science (CS) graduate students and HCI researchers were surveyed about their note taking methods and preferences. Participation was voluntary. The survey consisted of a total of thirteen questions that covered current methods, on paper and on the computer, the preferred method of input, review habits, the references that are useful for context, and use of electronic systems. Multiple choice, multiple answer, and essay questions were used. The survey itself can be found https://survey.vt.edu/survey/entry.jsp?id=1097779515845

The results represent a variety of typical users' opinions, which, we feel, is characteristic of basic classroom note taking behavior. In the following sections, we examine each of the questions in detail.

Current Methods

When asked about their current note taking methods, almost all of the respondents stated that they take notes in class. Of this group, 55% agreed that they write down most of what is written down by the professor. The percentage is only

slightly better (59%) when they were asked if they only write down the important parts of the written information. These two questions were fairly strongly negatively correlated (-0.63), which indicates that there is not too much overlap between the groups.

Oral information seemed to be of less importance to the students with only 12% agreeing that they write down most of what a teacher says. On the other hand, 88% said they write down only what they think is important. These two were also negatively correlated, but at a much weaker level (-0.23).

Current Methods on a Computer

In general, those that used computers for note taking in class indicated that they recorded less information than those who did not. The sample size for these questions was very small (n=5), so it does not lend itself to serious statistical interpretation. However, some of the comments about this question were very enlightening. One responder stated, "I don't use a computer, it distracts me." Another remarked, "I can strongly state that a laptop or desktop available to me in class will always be used to do work which I deem more important than the contents of the class." Therefore, at least in some cases, it appears that versatility and power of a computing device may actually be detrimental to the note taking process.

Drawing diagrams on the computer was a concern raised by several participants. Some answered that they just do not record those types of drawings in their notes. Others used other methods to supplement. One person would use paper and then transfer it if it was critical. A few others used structured drawing programs, PowerPoint, or a basic paint program to capture the information.

When asked about bringing a laptop to class, 59% thought that it was inconvenient. Surprisingly, when asked if they were willing to bring a Tablet PC or PDA instead, only about half of the people thought that was a reasonable alternative. So, there seems to be a good percentage of people that are resistant to bringing these general types of devices to class at all. Still, over three quarters of the survey participants thought that internet access in the classroom was important. This raises the question of whether Internet access would be a distraction to those taking notes. As already stated, some felt that computing devices posed problems, so, by adding in all that is available online, the problems maymight multiply.

Writing versus Typing

Unsurprisingly, three fourth of the respondents preferred writing on paper over typing while taking notes. For those who liked typing better, some of the reasons they gave were the ability to search, the data entry speed, the neatness of typing over their handwriting, and a perception that the data was safer. Even so, several mentioned that the lack of diagrams, arrows between topics, and similar drawings was a major issue with their notes. For those who favored writing, flexibility in placement, the amount of expression, and the writing speed were the most often given reasons. It is interesting to note that the rate at which they could enter the data was a major reason for both the groups.

There were a number of very important responses to why people liked writing that need to be considered. Several people remarked that placement of the notes was important. When taking notes on slides, the "notes are located at [the] relevant location." Others were concerned with editing issues. "...I can more freely write my thought[s] on paper using various size or shape font without selecting any menu." One person mentioned the "instant responsiveness" of paper and the lack of controls. By "instant responsiveness," we believe the participant meant the lack of device booting, program loading, and other processing delays that are associated with current devices. Another related the act of writing to the amount of recall:

> *I remember much more of what I hand write than what I type. In fact, most of the time, I won't remember much of anything that I type while I can remember a great deal more of what I hand write.*

The results from a study by Intons-Peterson and Fournier [9] confirm that the act of taking notes does improve the recall of the material, whether or not the notes are used later. If writing something down has an effect on the information learned, then there are important design implications here. While the Intons-Peterson and Fournier study used only hand written notes, it certainly may be true that typing has the same effect on other people, so it is important not to limit the input methods. Finally, one person made note of how the process of writing improved the notes taken:

> *It most likely has to be due to the conditioning received so far, comparing the 12+ years of writing the notes versus the 1+ year of actually attempting to type them. Typing the notes, while it tends to be faster than writing them by hand, does not have for me the same feeling of permanence as the paper notes. Also, I find it necessary sometimes to record the mistakes and the actual discovery process which I took to come to certain conclusions - to help in future parsing of the notes; careful computer editing can produce notes too summarized and abstract, leading to wasted time in understanding how I came to that conclusion.*

This begs the question of whether notes are more than an end result and, if they are, how this process influences their value.

One of the systems, Silicon Chalk [12], partially supports

features to review the note taking process. It allows the user to see, on a character-by-character basis, when the notes were taken. However, it does not show mistakes, corrections, or deletions made to them. If understanding the process by which they were taken is important to understanding the notes, then this does not provide sufficient data. A more complete view is needed.

Note Borrowing

A significant portion of the participants (68%) reported that they have borrowed notes from their classmates. The notes were most often photocopied or partially transcribed. In general, they obtained a paper copy of the notes.

Note Review

When questioned about when they review their notes, most stated that they looked at them only right before they needed them. That is, they used them to study for exams or right before doing homework or projects. One student responded, "I review in the evenings and just prior to class, if I review at all. Most of the reason I take notes is that it helps me remember (regardless what happens to the notes)." This furthers the notion that the process is important in note taking.

The ways in which the notes were accessed were fairly evenly split between sequential and random access (59% /41%) and most (79%) said it was easy to find specific pieces of information. The success in finding the information may be due, in part, to the way in which they organize their notes. One person commented that, "Sometimes it is hard to remember _when_ I wrote something down, so I can determine from that _where_ it is in the notes." So, it may be that time is an important index into a person's notes and this kind of interaction is generally supported by the current systems.

Context References

Everyone agreed that taking notes helped in their understanding of the material, but they were divided on what would be useful to them as references. Everybody felt that the lecture slides were important to have. Audio and video recordings were only moderately wanted. Interestingly enough, video was ranked as less important than plain audio.

Although they were not ranked as very important, audio and video are the central features in several of the current systems [4, 12, 14]. Since there is a fair amount of complexity incurred by integrating these things into the programs, this may not be the best approach as many people may not want them or use them. Silicon Chalk [12] will soon allow users to combine their notes with video and audio streams after the fact. This gives users the chance to choose what is important to them. This provides an important flexibility, but may not go far enough as the lecture slides are not available apart from the video stream. Perhaps a combination of Silicon Chalk's method and the approach used by E-notes [16], which simply provides a copy of the lecture slides, would be the most effective.

Respondents were rather indifferent about having access to the notes of others with 33% agreeing and 44% marking neutral. This seems a little odd considering that 68% reported that they have borrowed notes from their classmates. It is likely that the students view the borrowed notes as replacements for classes that they have missed rather than as supplements to their own notes. Systems, like NotePals [5], which are specifically for sharing notes among a group, may not be as effective in a classroom environment, although they certainly may have value in other settings. Other methods, such as email, may suffice for the students' sharing needs. The group was evenly divided over whether they used URLs or email addresses in their notes and only a small portion (<25%) indicated that they annotate their notes, with information from papers, the Web, or homework, after the fact.

Mode of Input

Typing was not rated as particularly natural or efficient, although, they thought it was more efficient than natural. This is likely to be strongly influenced by their typing ability. Since many of the participants found it faster to write than type, it is not unexpected to see low rankings here. Still, it is interesting to note that no one strongly agreed that typing was a natural way to take notes. It is no surprise that using a pen was judged to be both natural and efficient. As opposed to typing, people found it less efficient than natural. The use of a gesture recognizing language, such as Graffiti, was marked as slightly more natural than typing, but less efficient. In both aspects, the gesture recognizing languages received more negative responses and neither had anyone strongly agree with the statement. This may, in part, be a result of their lack of familiarity with these types of languages.

Most of the available systems recognized the need to support written input [2, 4, 5, 14] as it seems to be more natural to more people. Souvenir [13] went further to support both writing and typing, which provides an arguably better interface. Only Silicon Chalk [12] does not support ink-based interactions, which seems to be a major shortcoming.

Use of Electronic Systems

Over 60% of those surveyed had not used an electronic system. Of those who had, curiosity was one of the main reasons to try it out. Considering that only 5 respondents reported that they currently use a computing device for note taking, not many of those that tried these electronic systems switched from paper and pen. The limited availability of the hardware seemed to be one of the major reasons people had not tried it. They noted that they did not have access to the equipment and that it was too expensive for them to buy personally. The ease of use, the ease of input, and the naturalness of the systems were other major factors for people not using them. One remarked, "I tried taking notes

on a PDA with Graffiti. I found it to be too slow." Another had a more pragmatic reason for preferring paper. "I'd rather not stare at computer screens 24-7." As can be seen, there are a number of issues, ranging from economic to social to HCI, that are obstacles that prevent the adoption of some of these technologies. Some of these will lessen as prices drop and people become more familiar with the devices themselves, but there still seems to be problems with the interfaces provided for the note taking task.

SURVEY CONCLUSIONS

From the survey, we found that note taking appears to be a very personalized task. What is taken down, how it is taken down, and how it was accessed later varied from person to person. So did the desired contextual material. Everyone wanted copies of the lecture slides, but they were very divided on the others. Still, most of the people could find the parts of the notes that they wanted. This implies that an interface should be flexible during the note taking process and in organization of those notes.

Some of the results do place the usefulness of electronic note taking systems into question. There is an added complexity when using a computing device for this type of task and there needs to be a significant advantage to the user to justify its use. The results showing that most people do not modify their notes (or even review them) frequently imply that the benefit of easy modification, which comes with a digital medium, may not be that important. Similarly, since there was only a lukewarm response to the sharing of notes between students, that may also not be of much use. Maybe electronic systems can and will encourage more of these activities, but that has not been shown.

What has not been addressed is how these devices effect the note taking process. There is a question over if and how the quality of notes varies across devices. The verbosity, the types of references, the use of symbols, such as arrows, stars, smiley faces, etc., and the completeness of the notes may be influenced by the device. Similarly, the amount that is learned may be affected. These issues all need to be considered to effectively support the task.

NOTE TAKING COMPARISON

Experimental Design

To study the effects of different devices on the process of note taking, we ran a small study comparing Tablet PCs and PDAs against paper and pen. In the study, participants attended a short presentation (<30 minutes) and were asked to take notes. The presented material covered the idea of digital divides, which are disparities in the availability and use of technology along demographics such as race, gender, age, and socioeconomic status. This topic was chosen because it required no previous knowledge was likely to be unfamiliar to the participants. At the conclusion of the presentation, they were given a short quiz on the material. The quizzes consisted of six short answer questions about the lecture. The questions were designed to be open ended to help gauge the amount learned and to keep those who were given lecture slides from having an advantage. They were allowed to use their notes. These were followed by five questions about note taking and the interface that they used.

Thirteen students participated. Five people used paper and pen, four used PDAs, and four used Tablet PCs. For those who used PDAs, half used a program that allowed freeform ink notes and the other half used Graffiti or a soft keyboard for text entry. Those that used the Tablet PCs took notes with a prototype program that allows for the creation and manipulation of ink drawings. Two of the Tablet users were given copies of the lecture slides to take notes on.

Since the form factor of the PDA and the use of Graffiti cause the PDA's input methods to be significantly different from those of the other two treatments, we provided the PDAs to those participants who had the most experience with them. This was done to allow the users to spend more time focusing on taking notes rather than on interacting with the device. The input methods of the paper and pen and the Tablet PC were similar enough that we did not feel the need to attempt a similar correction.

Demographics

The participants ranged in class level from freshman to graduate and spanned the ages of 19 to 34, although most were in their early 20s. The majors were equally diverse and covered computer science, several varieties of engineering, chemistry, statistics, media studies, nursing, and interior design. Two were female.

Results

Paper and Pen

The five students had no difficulty answering the quiz questions. Not surprisingly, the amount of notes taken varied a fair amount. Two participants took roughly three fourth of a page while one person wrote a little over two pages. The average length was about one and one fourth pages.

Despite the variance in the length of the notes, the verbosity and coverage was fairly constant across all of them. Complete phrases were used consistently throughout and most or all of the sections of the lecture were present in the notes. Symbols were also consistently used. Every set of notes used underlining or braces for grouping information or showing divisions. Arrows, for showing references or for indicating increases and decreases were also very common.

The data from the participants using paper and pen reinforced the responses from the survey. The users liked the fact that the interface is so convenient and easy to use. They also mentioned that concerns, such as cost or providing power to the device, did not apply. As with the survey, one person mentioned that he liked the interface because the act of writing aided in his retention of what was written. They did also point out the downsides of paper and

pen. Another issue brought up was that the notes were in their own handwriting, and, therefore, sometimes difficult to read. Others said that reorganizing the information at a later date was problematic and that it was too easy to lose the notes.

PDAs

As mentioned before, four students were given PDAs to take notes for this experiment. Two of them used a combination of Graffiti and a soft keyboard to record their notes. This was somewhat problematic for one of the users, as he was unfamiliar with the version of Graffiti supported by the PDA. To compensate, he used a combination of Graffiti and the soft keyboard. The other Graffiti user did not experience any problems. The other pair used an interface that allowed for freeform ink notes and did not have any difficulty with the interface.

The quiz results for this group has some interesting aspects. Although most of the questions were answered correctly, there were more errors than in the paper and pen condition. One person missed a single question while two of the others missed two questions each. The fourth student answered them all correctly. There was a distinguishable difference between answers by the students who could enter only text information and those who had more flexibility. One of the quiz questions asked about information contained in a pie chart on one of the slides. Both of the students using ink notes drew a copy of the diagram in their notes and were able to answer the question correctly. (See figure 1 for a sample of the notes.) However, neither of the two people using text notes could answer the question correctly. One person only transferred a portion of the information from the chart into his notes. He captured only some of the high-level data and, as a result, did not have enough information to answer the question correctly. The other student did not attempt to record the pie chart at all. This clearly shows the value of the more flexible interface.

On the other hand, the group entering text had a higher verbosity than the pair that drew their notes. They were more likely to use complete phrases, similar to paper and pen, while shorter, more cryptic messages were common to the other set. This is very likely due to the amount of screen space available to the users. Since it only takes a few (readable) words to fully fill a PDA screen, users may shorten their responses to increase the amount of related information on the screen and to decrease navigation. A similar problem can be seen in the work on NotePals [5]. Of course, typed text can take up significantly less space and still be readable, so more information can be viewable at the same time. This allows the user to be more verbose.

As can be expected, there were great differences in the length of the notes for those using text entry and those who did not. The text notes were roughly a third the size of the others. This is somewhat attributable to the compactness of the typed text and the lack of diagrams, but it is still a significant difference. When these are accounted for, the text notes would fill approximately a fourth of a page worth of notes. The ink notes were less than one full page in length. That is about the same length as the shortest of the paper and pen. However, despite the variances in length, enough information was covered to account for most of the material presented.

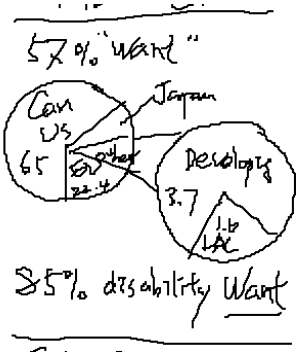

Figure 1. Note from the PDA with freeform ink notes

Again, it was unsurprising that the text treatments did not contain any symbols or emphasis in the notes. These are difficult to do with that particular interface. On the other hand, those using ink notes used underlining and boxes to emphasize parts of their notes in a manner similar to the paper and pen group. Arrows were also used as references to other information.

When asked about using a handheld device for note taking, the answer, regardless of input type, was that they felt limited by the interface. One issue mentioned was that Graffiti was hard to learn and use and slowed their note taking. As mentioned earlier, this may be partially overcome as users become more familiar with the input style. However, using the stylus to draw the notes had its own difficulties. They felt that it distorted their handwriting and made it harder to understand. Space was also a concern. Since the screen is so small, they were constantly scrolling to a new area in which to write and they found that using the tiny scrollbar to be somewhat problematic. However, there were some positive comments as well. They felt that the small size had some benefits as it was easy to carry around and they could access the PDA while holding it in their hands. They also liked that they could scribble information fairly quickly into the device. Overall, PDAs may be too inconvenient for note taking in a classroom, but they have the potential to be accepted in the future for other note taking activities because of their portability.

Tablet PCs

This group gave several incorrect or incomplete answers on the quiz. One person had no trouble at all. Two of the others either did not completely answer or answered incorrectly a single question. However, the last participant did not answer two questions and got a third completely wrong. This is interesting since the student was one of the two users with a copy of the lecture slides.

When compared to the notes from the paper and pen group, a lot of differences emerge. In general, the notes were shorter and less verbose. One student took about three-quarters of a page while another took barely one fourth. Neither of these sets of notes were very verbose and did not contain complete phrases. They also did not use arrows, underlining, or other such symbols to enhance the notes. The notes covered little of the lecture material. A third person, the other student with a copy of the lecture slides, took no notes at all.

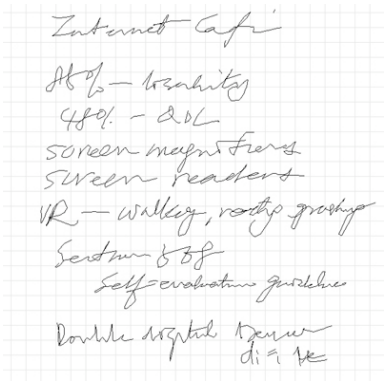

Figure 2. Notes from the Tablet PC (at 1/3 size)

The fourth participant's notes were in stark contrast to the others. In fact, they were more like those from the paper and pen group. They had a length of slightly more than two pages and were well fleshed out. They covered all the material and used underlining to differentiate sections. This supports the idea that the Tablet PC can be used as substitute for paper and pen, but the other results show that it may not be a trouble free transition.

When asked about the interface, one of the big concerns was that it did not feel like paper and pen. From looking at the notes, it seems obvious that the users wrote larger than they normally do and that their penmanship was worse. One person remarked that she had to change writing styles to understand what she was writing.

Another person mentioned that the screen size was a limiting factor. Since the users were writing larger, there would be more navigation required and fewer notes visible at the same time. This could certainly adversely effect the quality of the notes. Partially to blame here is the fineness of the pen input, so this effect may be ameliorated as the hardware improves.

Finally, there is the issue of the lecture slides. Since the lecture slides were almost universally asked for in the survey, two of those using Tablet PCs were given electronic copies to take notes upon. We hypothesized that this would increase the quality of the notes and aid in recall during the quiz. What we observed were two negative examples of their effects on note taking. One person took no notes at all while using the slides. Although the answers to the quiz questions were correct, it does raise a concern about whether their presence discourages students from taking notes. The other student faired poorly on the quiz when some of the needed information was easily interpretable from the slides. This, of course, shows that the extra support provided by the slides does not insure more learning. It is important to note that sample size is very small and that the slides may be very useful in other cases, but it does give a warning.

CONCLUSIONS

One very important aspect for all these interfaces was the speed at which notes could be taken. This echoes some of the results from our survey. Independent of the devices, people complained that their interface was slow to use and that they would like to speed up the process. It would appear that this is one of the critical factors to be considered for any note taking system. This is, of course, a difficult problem as different people have different proficiencies with the various input methods. Some people write faster than they type and others type much quicker than they write. Providing both methods of input is a start, but there are other factors as well. Navigation and mode switching, between writing and erasing or typing and selection, slow down the process and must be considered.

Even though all the devices we used in the study had a pen input, the input method was still a considerable issue. The pen inputs on the Tablet PCs and the handhelds could not come close to that of paper and pen in terms of fineness and control. That can be seen in the larger and worse handwriting on both devices. The current hardware does adequately emulate the abilities of paper for this function. The users try to compensate, but it does seem to have an effect on the amount and the quality of notes taken. Those participants that seemed to have the most difficulties with the interface appeared to have the most incomplete notes. These changes, in turn, may effect the learning process.

Certainly, it is very disconcerting that those users who incorrectly answered one or more of the quiz questions were all users of one of the electronic devices. Familiarity with the device may go a long way to improve this, but being unfamiliar with the device does not seem to be the only factor at play here. This study is too small to adequately determine this, but that data hints at its validity.

The input problem is exacerbated on the PDA because of its small form factor. The small screen limits the amount of data that can be viewed at once and increases navigation. The small stylus, just because of its size, can also be more difficult to use than a standard size pen.

Now, despite this problem, we did find participants on both a Tablet PC and a PDA who produced notes very similar to those produced on paper. This shows that people can overcome, at least partially, the differences in the interface to achieve their goal. For example, one person doubled the size of her writing and switched to cursive while using the Tablet PC and this was enough of a change to let her take notes effectively. This may not have been the ideal interface

for the task but it did the job. On the other hand, another user also wrote much bigger than normal but he still could not make the program work for him. This suggests to us that people can adapt if the interface is flexible enough to allow them. To the first person, a zoom feature may have made the task that much easier. The second student may have required a completely different ability.

Finally, we take a step back and try a different view, a view similar to that of Lin, et al. [10] who suggest that a note's lifecycle may be best supported as paper in some stages and in electronic form in others. While the work focused on notes used as reminders rather than notes taken in a classroom, it is applicable in many ways. Most note taking systems focus on capturing the notes at their creation and perhaps this is not the best approach. In our haste to provide useful functionality and to ease other actions, such as sharing, we may be making the creation of notes more difficult. By adding so many other sources of information, we may be discouraging people from making their own record. As mentioned before, the work by Intons-Peterson and Fournier shows a relation between the note taking process and recall. If our systems make the task harder or reduce people's tendencies to take notes, then we have just made the problem worse.

Perhaps the approach taken by E-notes [16] is a wise one. It does not radically change the students' behavior and only provides a little bit of extra scaffolding, in this case, the lecture slides, to help them along. Additionally, perhaps there should be more focus on providing transitions between the paper and electronic states and utilizing the best of all of them rather than trying to emulate one with another. While that is certainly a difficult problem to tackle, the benefits seem to be worth it.

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