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Requirements for electronic note taking systems: A field study of note taking in university classrooms

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Abstract Note taking is the core activity for students in a classroom. There has been a large amount of research conducted, both from industry and from academia, into facilitating the note-taking process. There is evidence that shows that note taking can be beneficial for the students' educational growth. There are also many available systems for taking notes electronically (e.g. Tablet PCs, PDAs). However, what has not been given as much attention is how these electronic devices affect (or support) the note taking task. In this paper, we study university students' current note taking behavior and the changes caused by the use of electronic systems for this activity. The goal of our work is to identify issues that should be considered when evaluating electronic note taking systems and to formulate requirements for future electronic note-taking systems. Our findings show that while the technological support for writing with pens on electronic surfaces is quite advanced, the task of note taking in the classroom is not well supported. We identify the limitations of typical note taking systems and discuss the implications for the design of future note taking systems. Our work consisted of three parts: a survey of current note-taking practices, an observational study in a classroom environment, and a semester long case study of students using electronic note-taking devices. All of these activities took place at a large 4-year university. We found that the people reacted to note-taking devices very differently and that their current practices were not always well supported. The users all wanted to input information as fast as possible, in the manner they wanted but they were not always able to achieve that. Hardware limitations (i.e. screen size, responsiveness) added to this issue. We also found that the features that are well

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supported in an electronic medium (i.e. modification, reorganizing, multiple pen colors/styles, handwriting recognition, sharing) were not commonly used or wanted.

Keywords Note taking · Multiplatform devices · Context · University students · Higher education

1 Introduction

Today, new computing platforms are being developed and are being added to our everyday life. It is common to find people with laptops, PDAs, cell phones, and MP3 players. At home, we often find an extra desktop computer, several remote control devices, and even home appliances equipped with simple computers. Simply stated, 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. In the 2003–2004 academic year, Duke University provided to all first-year undergraduates students with iPods, to explore how the ubiquitous MP3 player could be used in an academic setting. As more types of computing devices 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 journals instead of getting copies of images from a book at the library. They will want to manage their calendars from their desktop and their PDAs rather than using a paper version. And they will use one or more of these electronic devices to take notes in the classroom, instead of using paper and pen.

There are several issues raised by this migration. First, do the new devices support all the tasks expected by the user? Some early note taking systems support handwriting recognition but do not support embedded drawings in the context where the notes are taken. Second, are the new abilities of the electronic devices available at the expense of other commonly used and needed functionality? For example, having your handwritten notes automatically transcribed to text affords new functionality, like being able to search over your notes. However, you also lose the graphical familiarity that comes with your notes. Students often write notes in the margin or sideways and use these later as a way to find information (by exactly recognizing these gestures and drawings). These are often lost or not possible in most systems that transcribe the notes or even interpret the drawings. Finally, how do these new devices change the task performed? Many systems reported in the literature talk about sharing notes with other students. But some systems support this task in a technology-centric way; they merge two sets of notes using time stamps or try to merge notes with the slides being shown at the same time (Abowd et al. 1997; Chiu et al. 1999). Sharing notes, done without support for electronic means, is as simple as making photocopies. This task is at times overblown with support of idealized techno-centric solutions that leave the original task either unsupported or significantly modified.

Increasingly, information technology is moving from being technology-driven to being user-oriented and focused on ensuring that system functionality will support 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 or support some user goal. A broad range of analysis in human-computer interaction (HCI) has already recognized that system design can profit from explicitly studying the context in which users work (Nardi 1996). To achieve systems that are more centered on the actions of the user, we should attempt to learn from the context in which they occur (Dourish 2001). We need to understand what users believe they are doing and how they use and manipulate items in their environment to achieve their goals. These are not new concepts, but they are important ones and ones that are often times overlooked. With this viewpoint, we can see that by changing the context of the action, through the addition of new devices or the removal of old ones, we fundamentally change what is happening. We need to understand the implications of that change.

The activity of note taking in the classroom is an interesting one to study. Note taking and note reviewing in classroom settings have been studied for years. It is clear that these activities are an essential part of everyday classroom activities possibly playing a more crucial role in large lecture-based classrooms. There is even evidence that shows that note taking benefits students in learning the material. Some of the issues in note taking activities are discussed by Grabe (2005).

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. It is quite common to find students who bring notebook computers to class to take their notes; and to a lesser extent, we now find universities that *require* their students to have notebook computers. Both of these trends 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. However, it also presents possible pitfalls if we simply assume that the presence of the technology alone is a guarantee of success. Many research groups have anticipated this move towards an electronic classroom and have suggested suitable and efficient use of handheld devices, Tablet PCs, and desktop computers for the note taking activity (Abowd et al. 1997; Chiu et al. 1999; Davis et al. 1998, 1999; Lin et al. 2004). 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 affect the notes taken and, consequently, the learning of the students.

In this paper, we investigate what users require from a note taking system in an effort to identify issues for evaluation of existing electronic note-taking systems, and to identify requirements for the design of future electronic note taking systems. To determine what kinds of actions note taking software should support, we conducted an online survey asking students about their note taking practice. We asked about what they believe their current practices are and what they want from an electronic note taking system. Next, we performed an observational study to see how different devices, specifically Tablet PCs and handheld devices, affect the note taking process. It is important to ascertain how the devices influence the quality of the notes taken and their impact on learning. Finally, we conducted a small case study to get a glimpse of how students reacted to and adapted to an electronic note-taking system in an authentic setting. This portion of our study looks at usage over a longer term

(in this case, a semester) and helps put the results into perspective. The online survey, the observational study and the case study served as the basis for our requirement recommendations presented at the end of the paper.

2 Previous work

Note taking in the classroom, the task supported by the electronic systems discussed in this paper, has been studied for many years. The activity done by the students involves note taking while attending class lectures, usually followed by note reviewing or studying for some form of test or assignment. There have been many studies that evaluate the impact on learning that different types of note taking behavior produce. For example, one research question is whether having a full set of notes from the professor helps or hinders learning. A concern commonly expressed in the literature and in many academic discussions is whether having all the notes from the professor makes lectures obsolete (e.g. by indirectly minimizing the impact of student absences). Another common research question is whether actually taking the notes improves learning, presumably by improving the encoding and storage of the notes in the student's memory. An article by Mark Grabe (2005) presents one study in this area and nicely discusses many of the issues explored in this area of research.

A number of different approaches have been taken to support and enhance the task of note taking using electronic systems. One such effort is E-notes (Wirth 2003), 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 or benefits. That is not necessarily bad as this approach may provide some additional support without also adding many distractions.

Another note-taking system is eClass, formally known as the Classroom 2000 project (Abowd et al. 1997; Brotherton and Abowd 2004). One portion of that system, StuPad (Truong and Abowd 1999; Truong et al. 1999), 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 requires an extensive infrastructure in the classroom that limits the places where it can be deployed.

NoteLook (Chiu et al. 1999) 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 and ink stroke 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.

Live Classroom (2005) is a commercial system similar to NoteLook, although it is oriented specifically towards a classroom environment. (This program was reviewed when it was called Silicon Chalk v.3.5 in late 2005 and will be referred to as such.)

Video and audio, from the lecture's screen, are streamed to each participant's computer where the notes are then added. It did not then support ink-based notes but endorsed only typing-based input. While the system supported a number of useful features, it was not extremely easy to use. Managing the various windows was challenging and the interface was cluttered. The system focused on supporting the total classroom experience by providing for pop quizzes, surveys, feedback from the students, and so on. This made the program feel bloated and hard to manage. This is quite possibly an example where introduction of the technology in the classroom will change the student task considerably.

NotePals (Davis et al. 1998, 1999) 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 originally designed for the classroom and focuses mainly on sharing notes as a meeting support tool. 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 (Spoerri 2002) 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 (Anderson et al. 2004a, 2007) is of a similar vein. The system uses a Tablet PC to allow the lecturer to add notes and scribbles to the presentation as it progresses. It also supports integration of student devices that may be used for note taking.

Ward and Tatsukawa (2003) describe some of the qualities of lecture notes and some of the features that note-taking systems should possess to account for these qualities and to support students in this activity. Some of the qualities identified include the personal nature of the notes (i.e. the notes are written for the student's use, not someone else), the short fragments of text, the combination of text and graphics, the two-dimensional layout of elements about the page, and constraints for the production of notes, such as time and available area. From this, they determined that a note-taking system should allow for multiple methods of input (pen, keyboard, mouse, etc.) with little need to switch between them and should support the entering of text swiftly and in any location. Their system, NoteTaker, is an attempt to meet these requirements.

Other works provide insights into the use and the lifecycle of notes (Lin et al. 2004) and into the design of software agents that use context to help find and deliver the right information at the right time (Hong and Landay 2001).

Most of these systems address new functionality and activities that can be supported in the classroom. 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. Instead most of them focus on applying

information technology (IT) to classroom situations without a deep understanding of how this technology is needed or where a different application of IT principles might have a bigger impact. This is a major deficiency.

3 Note taking task

In this section we present a brief description of the student task of note taking in the classroom. This description is based on the functionality described in the literature for note taking systems, our personal experience on note taking, and our intuition about the domain.

Note taking systems should support the abstract tasks of entering notes, managing notes, and accessing note contents. The notes are often entered in the classroom, while listening to a lecture. In some cases, some form of supplemental material is available while taking notes. This occurs in the form of the slides for a class presentation, or an outline of the material presented. The notes are at times edited, expanded, or reorganized to improve their usefulness. The ultimate goal of taking notes in the classroom is to improve the learning, although some might say that it is to get an A in the exam. To this end, the notes are often used as a study aid for tests or as a reference for doing homework or other class projects. When a student is absent or cannot take notes due to some physical disability, then the notes are often shared. These are typically shared by making a copy of the notes.

Based on this description, we define three abstract tasks that an electronic note-taking system should support. Table 1 below shows the three stages: note creation, note management, and note use. The systems reported in the literature by far support stage 1, note creation. Very few systems provide support for note management or note use, other than providing some generic search and browse mechanism.

Technology makes some of these abstract tasks easier, while complicating others. For example, the added benefit of having the notes electronically makes it easier to share notes, edit, and organize notes, which are troublesome on paper. However, the actual task of taking the notes, we believe, is still easiest with paper. The added benefit of having the notes electronically does not necessarily compensate with the added difficulty of taking the notes. Although digital is intuitively better, we have already seen in "post-its" (Lin et al. 2004) that the added benefit of digital media sometimes is not sufficient to make the user switch. Therefore, merits and demerits of each newly introduced use by note-taking tools should be carefully considered.

Table 1 Tasks in note taking

Abstract task	Description
Note creation	The task of writing notes while in class or while taking notes from a source. It also includes getting copies of notes from a peer.
Note management	Editing and organizing the notes.
Note use	Using the notes to study for an exam or as reference while working on an assignment

To better understand how people use electronic note-taking devices, how it changes the task, and what needs to be or does not need to be supported, we should evaluate them in a more realistic environment. A controlled lab setting, while useful, cannot produce the same kinds of results. Now that the Tablet PC is a commodity item, this type of naturalistic evaluation is possible. Our work here is but one step in the process. Much more work will need to be done to determine what else should be supported, changed, or removed.

4 Research method

We set out to study how note taking takes place in the classroom and to identify how electronic note taking systems can support this activity. We conducted a three part study. The first was an online survey of students to ascertain their current practices, their opinions on how note taking is done in the classroom and their attitudes towards electronic note-taking systems. This helped us enumerate potential elements that should be or not be supported and it provided a basis for the other studies. The second part of our study was an observation of students' behavior in a classroom lecture followed by a short quiz on the material presented. While this occurred in a partially controlled environment, the setting was realistic enough to allow us to compare the devices in light of the previously identified elements and to refine those elements as needed. The third part was a high-level analysis of the notes taken by a few students on a Tablet PC for their classes. This case study provided a look at longer-term, authentic uses of note-taking devices. From this we can gauge how students' notes change by using the systems. This also allows us to put our previously identified elements into a proper context so we can see what is a continual problem, what will be adapted to, and what should be supported. The following sections present the research method and the results found.

5 Survey results

Thirty-five computer science (CS) graduate students and human-computer interaction (HCI) researchers were surveyed about their note taking methods and preferences. Participants were recruited via announcement on student and HCI mailing lists. Participation was voluntary. With most participants being in CS, we can speculate this subject group has higher acceptance rates for new technologies (early adopters) and is inherently curious for exploring new gadgets. All participants were affiliated with the university; however, we did not explicitly collect any additional demographic data from the participations in this survey.

The survey consisted of a total of thirteen questions that covered current note taking practices, on paper and on the computer, the preferred method of input, review habits, the references that are useful for context, and the use of electronic systems. We used multiple choice, multiple answer, and essay questions. The complete survey can be found in the appendix. The survey was conducted during the Fall of 2004 using http://survey.vt.edu, a locally developed online survey system used widely at Virginia Tech.

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.

5.1 Current practice

When asked about their current note taking practices, almost all of the respondents stated that they take notes in class. Of this group, 55% agreed (or strongly 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 much overlap between the groups. It can be assumed that those who answered both that they write down most of what is *written* and that they only write down the *important parts* think that everything said by the professor is important.

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 of what is said. These two were also negatively correlated, but at a much weaker level (−0.23).

5.2 Current practice with 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 and decrease the attention paid to class-related activities.

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 practices 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. 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 may multiply. This is not to say that the use of computers and the Internet in the classroom cannot have a multitude of benefits. It

is very easy to imagine situations where they would be immensely helpful. However, the very same technology that allows students to find additional information through Google or to interact with their peers in group learning activities also allows them to watch music videos and chat with friends instead of attending to the class. The technology provides opportunities and one must be careful to see both the positives and the negatives associated with it.

5.3 Writing versus typing

Three fourths 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 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 (1986) 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, Live Classroom (2005), partially provides 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.

5.4 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.

5.5 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% and 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 [exactly] _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.

5.6 Context references

Most people 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 (Chiu et al. 1999; Live Classroom 2005; Truong and Abowd 1999). Since there is a fair amount of complexity incurred by integrating these things into the classroom, this may not be the best approach as many people may not want them or use them. Live Classroom (2005) 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 (Wirth 2003), 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 (Davis et al. 1999), 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.

5.7 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 paper 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 (Anderson et al. 2004a; Chiu et al. 1999; Davis et al. 1999; Truong and Abowd 1999) as it seems to be more natural to more people. Souvenir (Spoerri 2002) went further to support both writing and typing, which provides an arguably better interface. Only Live Classroom (2005) does not support ink-based interactions, which seems to be a major shortcoming.

5.8 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.

5.9 Survey conclusions

From the survey, we found that note taking appears to be a very personalized task. What is written down, how it is written down, and how it was accessed later varied from student to student. The desired contextual material also varied from student to student. Everyone wanted copies of the lecture slides. 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 students in our survey 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 affect 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 and so we investigated them through the following observational study.

6 Note taking observational study

6.1 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 min) and were asked to take notes. The lecture material covered the topic 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 on the part of the participants and was likely to be unfamiliar to them. 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 in the study. Five students 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. Table 2 below shows the distribution of participants across the different conditions.

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.

6.2 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 20 s. The majors were equally diverse and covered Computer Science, several Engineering disciplines, Chemistry, Statistics, Media Studies, Nursing, and Interior Design. Two were female. The table below contains a summary of the demographics for the observational study. Some participants did not answer some of the questions, so the numbers provided do not add up as expected (Table 3).

6.3 Results for the pen and paper condition

The five students using pen and paper 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. All of the sets of notes used underlining or

Table 2 Conditions on observational study

	Pen and paper	**Tablet PC**		**PDA**	
		Given lecture slides	Given lecture slides	Free form ink	Graffiti
Total participants = 13	5	2	2	2	2

Table 3 Demographics for observational study

Participants	Ages	Major			Year					Gender	
		CS	Engr	Other	1st	2nd	3rd	4th	5th+	Male	Female
13	19–34	1	4	4	1	4	0	1	3	11	2

braces for grouping information or showing divisions. Arrows were commonly used for showing references or for indicating increases and decreases.

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.

6.4 Results for the PDA condition

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 Fig. 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

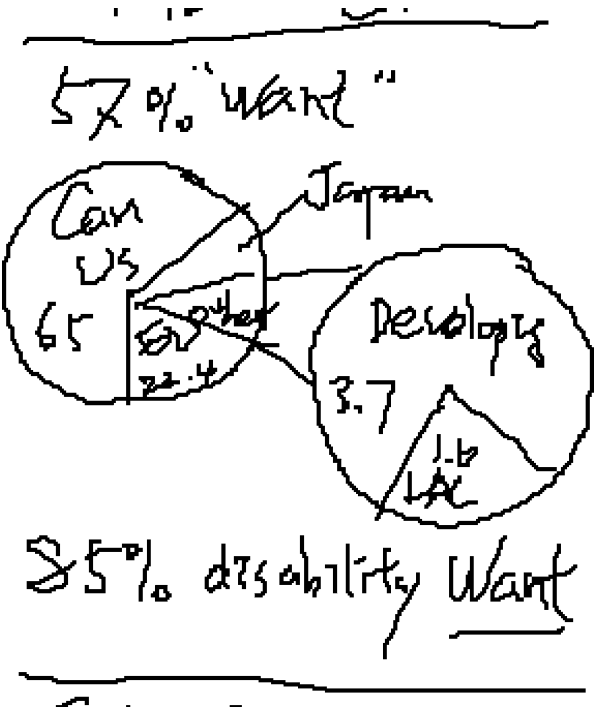

Fig. 1 Note from the PDA with freeform ink notes

paper and pen, while shorter and 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 was found in the work on NotePals (Davis et al. 1999). 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.

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 which 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.

6.5 Results for Tablet PC condition

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 (Fig. 2).

The fourth participant's notes were in stark contrast to the others in the group. 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 affect 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

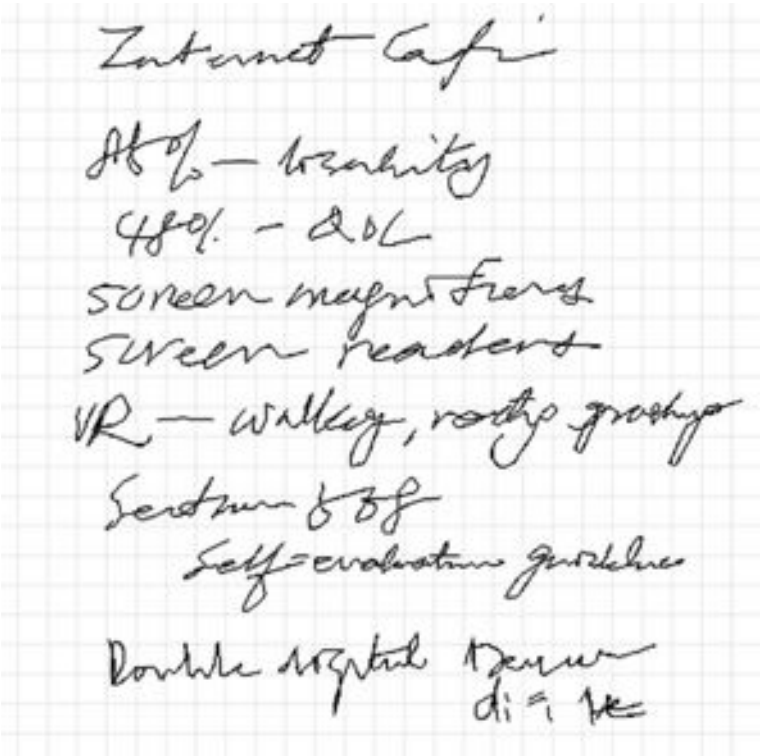

Fig. 2 Notes from the tablet PC

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 performed 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.

6.6 Observational study conclusions

From the observational study, we found that, like the survey, speed was a key factor in the process of note creation. Everyone wanted to take notes faster. The input method and hardware limitations seemed to be parts of this issue. There were indications that the participants thought that typing would have been faster, or that if they did not have to scroll so much, they could have gotten more done. The size of the display was also a constraint that works into this problem and limited the amount they could see and where they could work.

Overall, the reactions to the devices appeared to be very personalized and there was a wide range experiences. Some people adapted to their use very quickly. Others may have to acclimatize themselves to it over an extended period of time. It did not appear that the electronic devices were good substitutes for paper and pen for everyone during the note creation stage.

7 Case study of students' electronic lecture notes

7.1 Experimental design

To gain further insight into the how students were using electronic devices for note taking, we collected lecture notes from a small number of students who were using OneNote or Windows Journal in the classroom. Near the end of the Fall 2006 semester, undergraduate students who were taking notes electronically were asked to email a copy of their notes to us and answer a few demographic questions. All the notes we collected were taken on Tablet PCs. While it would have been interesting to analyze real classroom notes taken on a PDA, we did not observe anyone in our classes using a PDA for this purpose and the results from the previous study seemed to indicate that the PDA is not very well suited for this particular type of note taking. Our goal was to get a glimpse at some of the patterns that emerged from actual use over the course of a semester. For this case study, we gathered and analyzed three sets of notes. Each of these sets of notes was, presumably, an entire semester's worth of electronic notes. (The students may have taken some notes on paper.) While these sets do not span all of the possible variations of electronic note taking, they are representative of the students taking notes in our classes.

Once we had gathered the notes, we inspected them looking for the features one would expect from a set of notes (i.e. did they look like notes taken on paper?), for changes in the notes over time, and for the use of functionality supported by the digital medium. To help guide our efforts, we based part of our analysis on the properties of lecture notes described by Ward and Tatsukawa (2003). Specifically, some of the things we looked for included, but were not limited to:

- Layout/structure
- Completeness (was it all the notes for the semester?)
- Audience (personal/group)
- Importation of external objects (slides, worksheets, video, audio, etc.)
- Use of color, electronic markings, or other tool supported features

7.2 Demographics

All the participants were freshmen (i.e., first-year undergraduates) males; two were Computer Science majors and one was a Materials Science and Engineering major. While this is neither a large nor a diverse group, it does provide some insight into the process and helped us generate some ideas about the note taking task. The notes covered introductory courses in Chemistry, Engineering, and Computer Science and

sometimes included problem sets. Two sets of notes were taking in OneNote and the third was done with Windows Journal (Table 4).

7.3 Analysis

In this section, we examine some the attributes of the electronic notes we collected. Many features were similar to those found in paper notes. In fact, many of the features that are now possible or are well supported by the electronic nature of the notes (i.e., sharing, import of external objects, etc.) were little used or were missing all together. However, there were some interesting differences that appeared.

Layout/structure The notes of the three students in the study shared a common organization. They all organized their notes by class and day. In this case, this meant the each day's notes were contained in its own page (or file for Windows Journal). Homework tended to be separate from notes taken in lecture.

The formatting resembled notes taken on paper. The markings were typically short sentences or fragments and were arranged about the page, in the margins, and across lines. Diagrams and symbols were placed along side the text. These included struck-out lines, arrows, and hand-drawn tables. One student's work appeared almost exactly as if they had been done on paper. The other two, for various reasons (like completeness) had some noticeable differences. This parallels what we found in our observational study. Overall, it seems that students can successfully transfer to an electronic format, but they may have some difficulty in doing so (Fig. 3).

Completeness The completeness of the notes varied greatly. One student's notes spanned the entire semester and seemed to cover the lecture material well. The other two had notes that were much spottier and covered roughly a third of the semester. The timestamps for the notes were spread out unevenly across this period of time. If these students took notes on the other days, they must have been done on paper. It is also important to mention that some of these two students' notes were very short with as little as a couple of lines and that the amount of notes tended to decrease over time. These differences may be accounted for by normal variations in note-taking style, but like in our pervious experiment, they are a possible concern. If the

Table 4 Case study demographics

	Gender	Age	Major	Year	Handedness	Classes
1	Male	18	Materials Science and Engineering	Freshman (1st)	Left	Chemistry General Engineering
2	Male	18	Computer Science	Freshman (1st)	Right	Chemistry Computer Science Vector Geometry
3	Male	18	Computer Science	Freshman (1st)	Right	General Engineering Computer Science

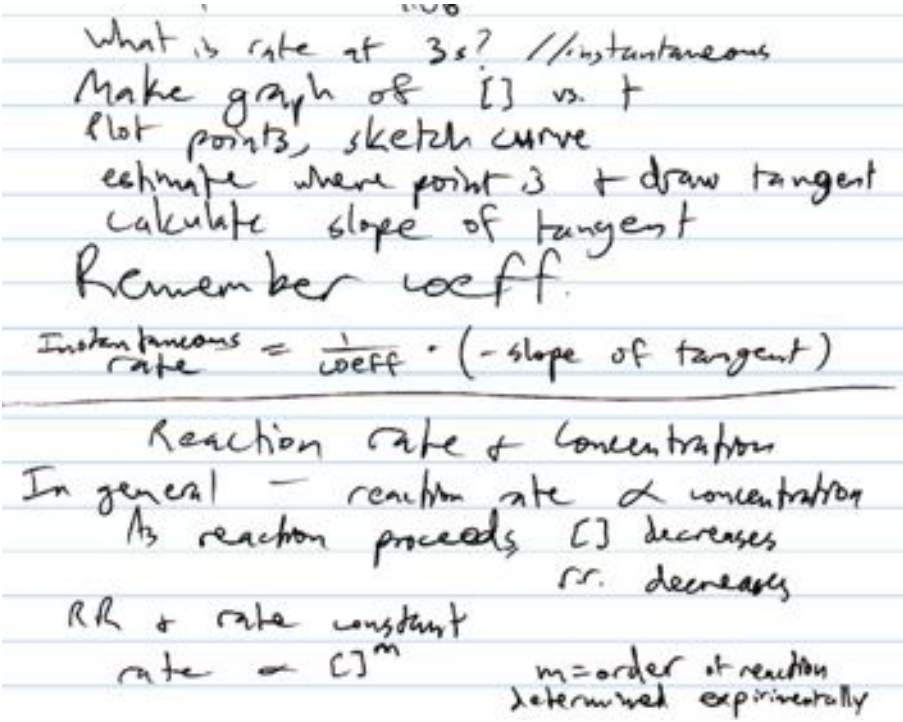

Fig. 3 Note layout

change to an electronic medium discourages note taking, then the student may be less actively engaged in the learning process. This is something that needs to be examined more closely.

Audience For most of the time, the notes appeared to be specifically for the writer. This corresponds with the attributes of classroom notes as put forth by Ward and Tatsukawa (2003). There were, however, a couple of examples where they were group oriented. In one case, the notes contained a group progress sheet with a couple of notes in the margin. In another, one student received feedback from some of his peers (perhaps during an in-class activity). In this case, it does not seem that the information was shared electronically, but rather that the tablet was passed around and students added comments.

Importing external objects Two of the students added external objects, such as worksheets and lecture slides, to their notes. The student using Windows Journal did not. These external objects received fairly little annotation once added to the notes. One student, who included a couple of lectures worth of lecture slides, only wrote on a few of them. The slides contained some attention marks and short notes. The total amount of notes seems to be significantly less than what he normally produced. He also imported group progress sheets into OneNote. These appeared to have been filled in elsewhere and added in their complete form.

The other student imported diagrams and tables for homework problems and did some mark up on them. He did not seem to import anything for the notes he took during class. This may be because the material was not available to him before class or he may not have found them useful.

Color, markings, and other features All of the students used different pen colors or highlighters to emphasize important information within their notes. More interestingly, they used color more heavily at the very beginning of the semester and then rapidly stopped or almost stopped using it. Student 3 was the only one to continue to use color throughout the entire semester and, after the first couple of weeks, he was only using the highlighter to mark the answers to homework problems (which, presumably, were done outside of class). This seems to be similar to the results found by Anderson et al. (2004b) in their work with lecturers using Presenter. They found that, during lecture, instructors did not often change pen colors to highlight important points and they surmised that this was due to the extra effort involved. The same appears reasonable for the note-taking task as well (Fig. 4).

Aside from the use of color, we did not find much evidence indicating that other features were used. There were no note flags or use of handwriting recognition (i.e. explicitly changing their writing to text, not the passive recognition OneNote performs to allow for searching) and there was only one instance of text typed directly onto the page. The students may not have found these features useful or may not have known they were there. While they may be very useful in other situations or for other students, they did not seem necessary for this particular group. As mentioned earlier, this is a task in which speed is important and additional effort, no matter how small, will be likely be avoided.

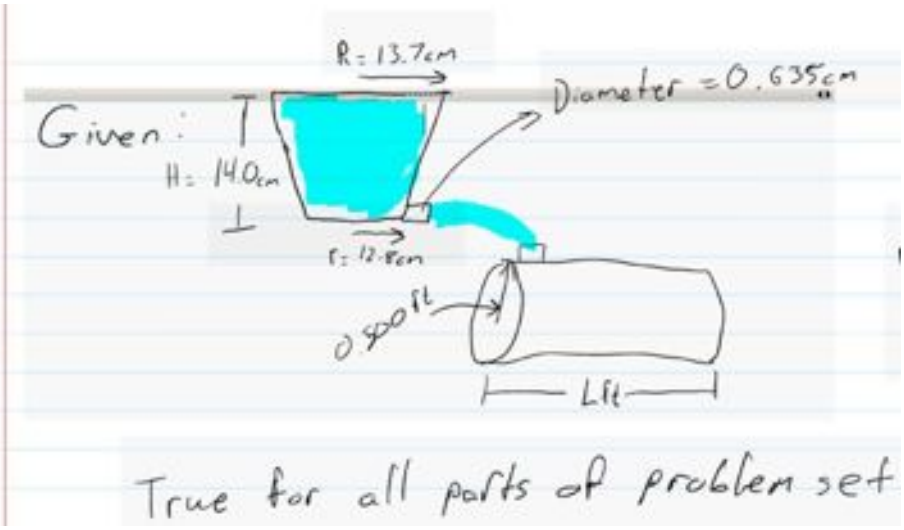

Fig. 4 Use of color in notes

7.4 Case study conclusions

From the case study, we found that the students either adapted to the use of the device quickly or they tended to stop using it. As mentioned, the amount of notes for one of the students held fairly constant over the course of the semester but decreased for the other two students. It is reasonable to assume that if user does not see any real benefit from the device then their use of it will drop off once the initial excitement has worn off. While there are many other factors that could be involved, this may be the cause for the decrease in the notes. Although we did not attempt to measure the students' perceptions of how fast they could enter their notes on their devices, it seems reasonable from our other results, that the input speed could be a part of the problem. Again, like we found in the previous studies, the reaction to the device seems to be very personalized and affects the decision to use the device.

We did note a low use of the features that the electronic medium provides. This is not only for the note creation stage, but for the others as well. There appeared to be little or no effort spent on reorganizing, making changes to, or marking sections during the maintenance and use stages. This brings into question how well these stages are being supported at all.

8 Discussion

The goal of this work was to gain knowledge about how students approach note-taking in order to assess the impact of technology on the task and to develop requirements for electronic note taking systems. More formal studies are needed to understand the effect that note-taking systems have on learning. In this section we present our observations about the task of note-taking in the classroom based on our studies.

Note creation The single most important factor for creating notes was the speed with which students could create them. From our survey we learned that independent of the devices, people complained that their interface was slow to use and that they would like to speed up the process. Curiously, what the students considered fast varied. To some fast meant typing and to others it meant writing in paper. Making an interface for note taking faster 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. The hardware form factor may also impose limitations. For instance, with the clamshell models, it is difficult to write on the screen when it is in a "laptop" mode. Rotating the screen to put it in a "slate" mode makes it easier to write on but completely hides the keyboard. It can be problematic to fluidly move back and forth between both methods of input. There are similar problems with the models that have detachable keyboards.

Input method In spite of the advances made with handwriting recognition, pen input is still considered an 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. The effect of this is seen in the larger and worse handwriting on both devices. Some of the newer Tablet PC's hardware does a much better job emulating the abilities of pen and paper for this function. Nevertheless, the users try to compensate where the technology fails. The result is that the use of the electronic pen does seem to have an effect on the amount and the quality of notes taken. Those participants, who seemed to have the most difficulties with the interface, appeared to have the most incomplete notes. These changes, in turn, may affect the learning process.

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 functionality.

Note management Notes tend to have a "life" of their own. To do lists often show more than just the things to do, they also shows the status of things being done—cross out text shows a completed item; text with extra annotations shows progress made but not completed. In some respect, lecture notes seem to be similar. Students like to see the notes, and the changes made to the notes. Showing the changes themselves is important as it helps the student understand the process of how they have arrived at the current set of notes. Electronic systems tend to ignore this feature. Features similar to MS Word's editing functionality might be appropriate, where notes taken in the classroom are shown in one color and notes added later are shown in a different color as an overlay.

Note use Notes are, of course, used in studying, but they can also be shared between people. The use of note sharing for the students we interviewed seems to be mostly to overcome "holes" in their notes. The sharing of notes is done mostly at the macro level—photocopy of full page. It is not clear how students would use of benefit of sharing notes that have been transcribed. An interesting use of note sharing is when students take notes for others. For example, at Virginia Tech, the Office of the Dean of Students coordinates with professors so that a note taker is identified to help students who cannot take notes for themselves due to a physical disability. Are the notes taken for someone else different from the notes taken for one's own use? Answering this question will help us understand if students would take notes differently if they knew ahead of time of the sharing capabilities of the note-taking systems.

Process vs. end-product From our studies we learned that the process of creating notes seem to be important as the notes themselves (end-product). This finding is in agreement with results previously reported in the literature. However, many systems being developed today look to extend the amount of automatic capture of the notes; i.e. they seem to remove the user from the note-taking activity. Systems such as Live Classroom (2005) and some of the work done in eClass (Abowd et al. 1997; Brotherton and Abowd 2004) both provide to some extent automatic note taking support. We must question the impact that this extra technology will have on learning.

Nevertheless, there appears to be some valid uses for automatic capture of notes. Students with disabilities, for one, would benefit from this feature. Second, distance education might also have valid uses. Finally, there is some evidence that shows that in some circumstances professor provided notes are useful (Grabe 2005).

In summary, we believe that providing the notes is not sufficient. The student needs to be engaged in some process whereby s/he needs to look at the notes and review them before they study for the exam. The comments from the survey seem to echo this opinion.

9 Conclusions

Over the years, there has been continuous improvement on handwriting recognition. Today we appear to be at the verge of having reliable recognizers that work well for everyone. Thus it is no surprise that we find ourselves evaluating where we can use this technology. Classroom note-taking is one such example where the technology could be effectively used. But good enough handwriting recognition is not sufficient. Note-taking systems need to go beyond this and provide support (and perhaps improve) the whole note-taking and note-using process.

In closing, we take a step back and try a different view, a view similar to that of Lin et al. (2004) 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. Even simple and seemingly innocuous features (such as copy and paste) may have detrimental effects (Bauer and Koedinger 2006). 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 (1986) 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 (Wirth 2003) 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.

Appendix: Survey

Class note taking survey

1. Please rate these based on your experience in a class.

- I write down most of what a teacher writes on the board.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down most of what a teacher says.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down only what I think important among a teacher says.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down only what I think important among a teacher writes.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I take no notes.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- Other, please explain.

2. If you use a computer (desktop—in labs—, laptop or notebook) in the class, please answer the following question. Otherwise, please move to the next question. Please rate these based on your experience in a class.

- I write down most of what a teacher writes on the board.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down most of what a teacher says.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down only what I think important among a teacher says.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I write down only what I think important among a teacher writes.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- I take no notes.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- Other, please explain.
- How do you enter the graphical contents such as diagrams on your computer?

3. Is it convenient to bring a notebook computer to class?

- Yes
- No
- If no, are you willing to bring other alternatives, such as a tablet pc or a handheld, if they were available?

4. Do you think that internet access in the classroom is important during a class?

5. Do you prefer typing on the computer over writing on paper for taking notes in class?

- If you prefer typing, why?
- If you prefer writing, why?

6. Have you ever borrowed notes from your classmates?

- Yes
- No

If yes, did you...

- photocopy the notes? Yes / No
- transcribe them all? Yes / No
- partially transcribe them? Yes / No
- borrow a PAPER set of notes Yes / No
- borrow an ELECTRONIC set of notes (i.e. your classmate has the notes online and just emailed them to you)? Yes / No
- other:

7. When do you see your class notes which you have taken?

8. How do you normally look through your notes?

- Sequentially
- Jump to specific parts

9. Is it easy to find specific pieces of information when you review your notes?

- Yes
- No
- If no, what kind of problems do you have?

10. Does taking notes help you understand the material? Yes No

11. Please rate these based on your experience reviewing your notes.

- Having the lecture slides as references is/would be useful to me.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- Having an audio recording of the lecture is/would be useful to me.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- Having a video recording of the lecture is/would be useful to me.

  Strongly Agree Agree Neutral Disagree Strongly Disagree

- Having other students' notes available to me is/would be useful to me.

Strongly Agree Agree Neutral Disagree Strongly Disagree

12. Please rate these based on your experience taking your notes.

- I commonly use URLs or emails addresses in my notes to denote things to look up or people to contact for more information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- I often add information from outside sources (papers, web sites, etc.) to my lecture notes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- I often add information learned from my homework to my lecture notes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking, I think typing is a NATURAL way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking, I think typing is an EFFICIENT way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking, I think writing with a pen is a NATURAL way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking, I think writing with a pen is an EFFICIENT way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking with a pen, I think writing using a gesture recognizing language, such as Graffiti, to be a NATURAL way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking with a pen, I think writing using a gesture recognizing language, such as Graffiti, to be an EFFICIENT way for me to record the information.

Strongly Agree Agree Neutral Disagree Strongly Disagree

- While note taking with a pen, I want to be able to create free form drawings, such as circles, arrows, etc., to enhance my notes.

Strongly Agree Agree Neutral Disagree Strongly Disagree

13. Have you ever used an electronic note taking system?

- Yes
- No
- If so, why did you try it? If not, why not?

If you are not currently using one, what leads you to not use an electronic note taking system? Mark all that apply.

- Price of hardware
- Ease of use
- Ease of input
- Availability
- Naturalness
- Lack of Features

References

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