

Using Note-Taking Appliances for Student to Student Collaboration

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Abstract - Student collaboration is important in courses that utilize project-based learning. We describe how we tried to enhance this collaboration by using electronic note-taking appliances along with the NotePals system. NotePals is a note-sharing system that captures and provides access to handwritten notes and documents of interest to a workgroup. Notes can be shared with other group members by synchronizing with a shared note repository that can be viewed using desktop-based web browsers. Students will only be able to take advantage of shared notes when note-taking devices are inexpensive and pervasive. Consequently, we have developed note-taking applications that run on inexpensive personal digital assistants (PDAs) and other ink-based capture devices. This paper gives an overview of the NotePals system and describes the early usage of the system for note taking by students.

Introduction

The last decade has seen repeated calls from industry for an educational system that produces graduates with basic business skills [6, 13]. In particular, businesses prefer workers who have strong interpersonal skills, especially with respect to collaboration and teamwork [5, 14]. One way we have approached this challenge is to make group-based project work a larger component of the courses we teach.

Communication of ideas and experiences is an important task performed by members of collaborating groups. Poor teamwork is often a result of miscommunication and a lack of shared understanding. We have been developing an electronic tool called NotePals [4] that helps to alleviate some of these communication problems and thus enables groups to collaborate more easily. NotePals gives group members more direct access to their colleagues' ideas and experiences by allowing them to view each other's notes.

The NotePals system is composed of note-taking software running on pen-based devices, a web-accessible note repository, and a set of web-based note "browsers" that allow users to access the note repository. NotePals operates by capturing group members' notes and some of the context in which those notes were written, such as the author, the topic, and the time the note was created. The notes are then uploaded to the shared repository that all group members can

access through the note browsers. These browsers allow group members to retrieve all notes taken in a given context or to access notes through other related documents.

For example, students can view their notes side-by-side with the presentation slides that a teacher was showing when the notes were taken. Students can also benefit by viewing the notes of their teammates at the same time to check for details they may have missed on their own or to get a different perspective on what was said in class. Students who have used NotePals reported that these were two of the important benefits of sharing notes using NotePals.

Outside of the classroom, notes can capture the outcome of project meetings. If one person in the meeting creates an important diagram in his personal notes, all group members have easy access to that information. This information can be retrieved by browsing for the desired page in the group-accessible notes taken by the author of the diagram.

Note taking is a natural activity that many people engage in to record their ideas and experiences. NotePals captures this activity with an informal ink-based user interface [7] that runs on PDAs and paper-based electronic tablets, which are inexpensive and very portable. Whereas untimely feedback from handwriting recognition systems encourages users to correct recognition errors, ink-based interfaces let users focus on taking notes.

This paper gives an overview of NotePals and shows how it has been used to share notes in classroom situations. We begin by reviewing the related work. Next, we describe the NotePals system, focusing on the note-taking interfaces and web-based note browsers in turn. Then, we relate early usage experiences that have shown the positive value of shared notes in the classroom. We finish with our conclusions and plans for future work in the classroom.

<i>Note-taking appliance</i>	Electronic device designed for one primary task – taking notes
<i>Electronic ink</i>	Handwriting and drawings that are captured digitally
<i>PDA</i>	Handheld computer
<i>CrossPad</i>	Paper-based electronic writing tablet (a note-taking appliance)
<i>Docking cradle</i>	Connects a PDA to a desktop PC

Table 1. Definitions

Related Work

Several researchers have discussed and evaluated the positive impacts of problem-based learning (PBL) on educational outcomes [11]. PBL often entails students working on projects together in teams. Others have attempted PBL using distance learning [10] and web technologies [8], but there has been little work implementing tools that support the current work practices of students or integrating information appliances into classrooms. Our work with NotePals supports the way students generally take notes – with pen and paper – and the way many teachers present their lectures – with presentation slides.

Other research has tried to enhance “natural interaction styles” in meetings. Tivoli allows users to manipulate handwritten text in structured ways on a large electronic whiteboard (the LiveBoard) [12]. Similarly, the Classroom 2000 (C2000) system [1] records classroom audio, presentation slides, and the professor’s LiveBoard notes, and provides ways to browse through them after class.

Electronic ink-based interfaces are better than conventional keyboard interfaces in meetings or classrooms, since typing is often considered disruptive, and is not well suited to the drawings and diagrams that often result in these environments. Therefore, we have also taken inspiration from research in informal, personal note-taking systems. Freestyle allows personal, handwritten notes and annotated documents to be shared using electronic mail [9]. These documents can then be read and manually arranged on the desktop computer of the recipient.

These informal, pen-based systems have been influential in our work. We have implemented many of these ideas, such as natural input and synchronization with other media, in cheaper, more portable systems. This is important for supporting educational settings. The NotePals project differs from the previous work by focussing on lightweight organization and sharing of freeform ink notes taken on inexpensive, portable, pen-based devices.

Note-taking Interfaces

We wanted the note-taking interface to run on a device that was as inexpensive as possible, usable in almost any environment, and capable of uploading notes to a central repository with little effort. These constraints are especially important in educational environments where there is little funding for purchasing equipment and building computing infrastructure. Since some users have trouble writing on today’s pen-based computers, we chose to use both a PDA-based solution and a paper-based solution. We present these different note-taking user interfaces in turn.



Figure 1. The 3Com Palm.

PDA User Interface

For the PDA-based solution we chose the 3Com Palm, a pen-based PDA that over two million people already use [15] and which currently sells for under \$200 (see Figure 1). The Palm has a simple mechanism for exchanging information with other computers. Placing the Palm in a docking cradle connected to a desktop PC and pressing the HotSync button causes the NotePals data exchange program to upload an individual’s notes to the group’s web repository. This platform enabled us to create a system that allows users to share notes with little effort.

The Palm’s size makes it easy to carry but difficult to draw on. As such, an ink-based interface is hard to design for the Palm’s two-inch square screen. A user’s hand can obstruct her view of words on the screen. Resolution is also a problem. Even if users can write very small, the 160×160 pixel resolution makes it hard to read.

The interface we created to deal with these problems is shown in Figure 2. Users write in their own handwriting directly in the box at the bottom of the screen (the “focus area”). Words drawn in the focus area appear on the page at the top of the screen (the “overview area”) inside the “focus cursor,” shrunk to 40% of their original size. Once the user has filled up the focus area with text, a quick right to left swipe of the pen moves the focus cursor forward, clearing space for the next word. This interface allows many words to fit on one page, despite the small screen. Contextual information, such as the author’s name and the time that the note was created, is recorded automatically.

Users can also control who has access to their notes. By default, notes are group accessible, but they can either be marked private so that only the author can view them, or they can be marked public, which makes the notes world readable. With this system, group members can take personal notes in any environment and make those notes available to their entire group, if they wish.

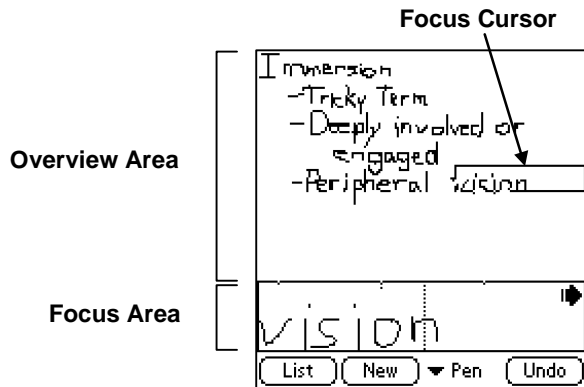


Figure 2. The NotePals Palm note-taking interface scales down text drawn in the Focus Area and places the result in the Overview Area.

Paper User Interface

For some users, the Palm is simply too small. Many users are also uncomfortable writing on the Palm’s glass screen. In response, we have explored more natural methods for entering notes. Many students use pen and paper for taking notes in classes. To take advantage of this, we have implemented support for the paper-based CrossPad [2]. This portable note-taking appliance uses a special ink-based pen and electronic tablet that digitizes ink as it is drawn on standard paper pads (see Figure 3).

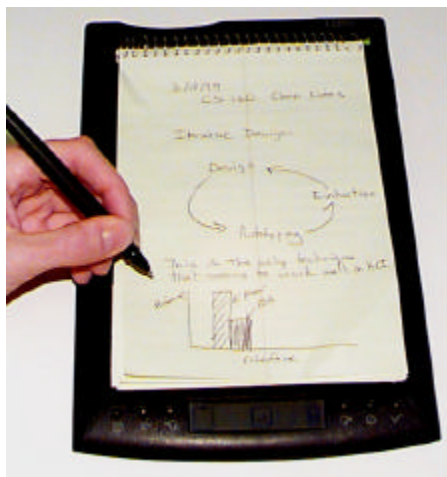


Figure 3. The paper-based CrossPad can also be used to take shared notes.

The CrossPad can be used just like the Palm client for taking notes. When users are ready to upload their notes, they attach the CrossPad to a serial cable connected to a desktop PC and select “Upload Ink” on the CrossPad. The system uploads each page of digitized notes to the shared note repository.

Uploading Notes

As notes are uploaded to the note repository, they are processed to make browsing easier. First, the stroke-based notes are converted to bitmaps. Next, the strokes are passed to a handwriting recognition engine, which returns an ASCII representation of each note. Finally, the system enters the note attributes and ASCII text into a database.

Note Browsing Interfaces

Shared notes are accessed through conventional web browsers. This makes notes viewable from many locations, such as from students’ home PCs, in computer labs, in classrooms, and in many meeting rooms. We have built three different task-specific note browsers. The first allows simple queries and access to notes, while the other two try to combine shared notes with other related documents. One is specific to the task of finding shared notes from on-line conference proceedings and the other to finding shared notes in the context of presentation slides. Of the latter two interfaces, we only describe the presentation slide interface here since it is most suited to browsing classroom notes.

Simple Notes Browser

When students wish to review notes, they point a web browser to the NotePals web repository. After entering their name and password, they can view a subset of notes by choosing from a list of note properties: project, author, date, type, or keyword (see Figure 4). Individual notes can also be viewed at full size by clicking on the thumbnails.

The ASCII output of the handwriting recognizer is used for filtering notes by keyword. This recognizer is not always accurate enough to provide a transcript, but it recognizes enough keywords to make searching for text faster than browsing through hard-to-read notes.

Presentation Notes Browser

Our group note-taking studies have shown that notes may be easier to manage if they are structured around a related, centralized document [3]. A set of presentation slides is one such type of document. The Presentation Notes Browser combines notes with presentation slides, making shared notes accessible from this related document.

To take advantage of this browser, presenters start their PowerPoint presentations with a program that logs when each slide is visible, and the audience takes notes with NotePals. After the lecture, the slides, the slide transition log, and personal notes are uploaded to the system. The browsing interface, shown in Figure 5, allows users to see the notes of up to five people synchronized with the presentation slides. When a user cycles through slides or notes, all other views are changed to keep them in sync. Using a unifying document, in this case the slides, reduces the complexity of numerous alternative threads of thought.

NotePals
Note Browser

landay
[Change Password](#) | [Log out](#)
[View as list](#)

Project: all:Courses:CS262 Fall98 [V]
Author: All [v]
Type: All [v]
Keyword: []

From: September [v] 5 [v] 1998 [v]
To: September [v] 9 [v] 1998 [v]

[Filter]

Sort by: Project, [Author](#), [Date](#), [Type](#)

Courses:CS262 Fall98	Courses:CS262 Fall98	Courses:CS262 Fall98
Note John Wilkes - Avoided - Low stress - operating in practice. Easy to add new storage may play with what stripe across all	Note Disked final - business case / viable Striping across all disks not all disks variable to larger stripes to greater writes disks have to be same cost/performance and not long running	Note Disks in single group have all be the same. - Get with faster chapter disk rotation - Growth all disks best case performance (processes) Solution: Use stripe groups Always add mirrored storage; Always add RAID 5 when necessary.
cbmorrey 1998/09/09 , 11:11:55	jasonh 1998/09/09 , 11:15:26	cbmorrey 1998/09/09 , 11:15:42

Figure 4. Web-based NotePals Note Browser showing students' class notes. Clicking on thumbnails shows notes at full-size

Review

- ✓ User-centered design (UCD) is different than traditional methodologies
 - * how does it differ from Waterfall?
 - * ?
- ✓ What are the advantages of UCD?
 - * ?
 - * leads to solving problems up front (cheaper)
- ✓ Know thy user & involve them in design

8. Review

Choose a Presentation: **Personality Types & Teams** [v]
 # of Note Windows: **4** [v]
 Note Size: **Small** [v]

Personality Types - why study? - know yourself - know the user (UCD) - not really necessary for UCD design - understand that performance differences	9/3/98 Project Ideas Avg: 88 Std Dev: 8.5 Waterfall - going back is expensive
Note taker: Allen [v]	Note taker: Marvin [v]
UCD - MORE THAN JUST CODE. PERSONALITY TYPES HELP KNOW USER Programs have personality People like Programs like them SYLLABUS TEAMS	Recognition over Recall! Waterfall model - flawed in that it is VERY EXPENSIVE to go back UCD - usability increases Personality Test Results? want to make sure that team not biased on the design of the project.
Note taker: Jonah [v]	Note taker: Tony [v]

Figure 5. A web interface for browsing presentation slides along with multiple users' notes.

Usage Experience

NotePals has been used extensively by our research group of about 10 people to take shared notes regularly. The group has used NotePals for 18 months and has taken over 3200 pages of notes in that period. The system has been used for personal notes, group notes, and classroom notes. Here we describe how students used NotePals to take course notes.

Undergraduate Usage

In the Fall semester of 1998, NotePals was used in an undergraduate course titled "User Interface Design, Prototyping, and Evaluation." This course is composed of thirty 90-minute lectures and a semester-long group project. It was chosen since it is group-oriented – 45% of a student's grade comes from work on a four-person team project. Each of the fifty students was provided with an IBM WorkPad (a relabeled Palm) for taking notes. Students could view lecture slides next to the notes taken by other members of their groups using the Presentation Notes Browser.

The students completed an anonymous survey at the end of the semester. Only a handful of students reported using NotePals. The main reason that students cited for not using it was that they found the online presentation slides to be complete. They saw no need to take additional notes, either on paper or on NotePals. Of the twelve students who said they did take notes, many felt that the WorkPad screen was too small, NotePals was too slow, or that paper was easier to deal with. Given the style of the lecturer's slides, this course may not be an ideal test-bed for this system.

The students may also have been put off by the prototype quality of the web interface for browsing presentation slides. It only operated on one type of web browser and was fairly unstable. In addition, the Palm client may be too hard for beginners to learn and thus the CrossPad client may be more appropriate in most situations where size is of less concern. We have seen users benefit by using NotePals for taking notes in graduate courses. We describe these positive experiences in the next section.

Graduate Usage

The observations in this section are a result of email interviews with three members of our research group (one of them a member of the NotePals project team) who found shared notes useful in their graduate operating systems course. The goal of the course is to teach students how to critically analyze research papers and how to recognize common themes in the literature. This course is extremely conducive to taking notes, since the instructor does not lecture from slides, and the classes are a combination of lecture and discussion. Much of the content of the course is contained in these class discussions. The instructor also writes and draws on the whiteboard frequently, so there is a lot of ephemeral material that is desirable to capture in notes.

These students say that there was more information presented in class than they could record alone and it was hard to determine which points were worth remembering. Each did his best to record the important points presented in class, but they relied on each other to improve their coverage of the topics. These students used NotePals so that they could benefit from each other's notes after lectures or when preparing for exams.

Right before the midterm, the three students met for their study session in a multimedia-enabled classroom so as to project on a screen large enough for three people to see easily. They displayed the NotePals Note Browser. Since the default display of the notes is in time order, they went through every class note sequentially and used it as a chronological summary of the semester.

These students found the NotePals study session to be productive and an effective way to study as a group. Many times during their discussion, the notes helped them recall information they had forgotten. Often the presentation of a particular note lead to discussion to clarify a particular concept, and sometimes this lead them to look at other information such as the papers themselves, the online paper summaries, or the instructor's published lecture notes.

There were quite a few diagrams in their notes (see Figure 6), mixed in with writing, so it would have been hard to take these notes with other computer-based tools. On the other hand, paper would have allowed them to easily take these notes, but it would have been harder to share the notes during the review session.

The students reported that knowing the context in which the notes would eventually be used (i.e., a group discussion) improved their notes. They took more thorough notes than they would have for purely personal notes because they used the notes to remind themselves about things to bring up during the discussion. They also reported expressing their thoughts more completely than they might have otherwise because they knew others would be using the notes. This was perceived to be beneficial. One student reported the difference in style was slight, but he felt it resulted in a significant improvement in the quality of the notes.

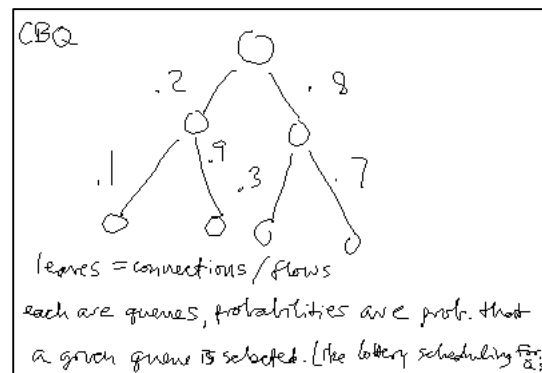


Figure 6. Examples of the notes taken by students in a graduate operating systems course.

The three students took a total of 390 pages of notes over the semester, fairly evenly spread among the three (158, 127, and 105 pages respectively). Although shared notes may be of higher quality, repetition of information is one perceived problem of such a system. These students reported that rather than this being an annoyance, it helped reinforce the important points from the class discussions and gave them confidence that they had understood and identified the important points. The note-browsing interface made it easy to skim past these duplicate notes.

These students found NotePals to be valuable in this class environment because they felt a strong need to recall as many important ideas as possible from class discussions. The students continued to use NotePals for the rest of the semester and reported it was helpful. In fact, the students also found it useful to refer to these notes after the semester ended for other research purposes. Having these notes online made this easier.

One of these students teamed up with another student this past Spring semester to use NotePals for taking notes in a graduate theory course. They used the CrossPad exclusively and will provide more feedback on the note-taking and uploading interface.

Summary of Classroom Usage Experience

The early usage of NotePals in classroom situations illustrated that the size and user interface of the Palm may still be inappropriate for novice users and a barrier to their use of the system. In contrast, the newer CrossPad client has been enthusiastically taken up by all those who have tried it, including other groups in our department. In addition, the NotePals system was found to be less valuable in situations where the students take few notes, such as in the user interface course. This indicates that although the presentation notes browser may have value, it is less important if the professor's slides are very complete. These observations are focussing our future investigations into the use of this tool in educational settings.

Conclusions and Future Work

NotePals is a lightweight note-sharing system that gives group members easy access to each other's experience through their personal notes. The system captures notes and related documents of interest to a group and provides a central repository for this information. Our usage experience has found the CrossPad client to be more intuitive for novices. In addition, we have found shared notes to be useful in courses where presentation slides are supplemented with significant oral information and where students already tend to share notes with classmates. In the future, we are looking at performing a more formal evaluation of NotePals in a law, business, medical, or biology course using the CrossPad client.

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