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► To cite this version:

Thomas Pietrzak, Sylvain Malacria, Éric Lecolinet. What do U-Note? An Augmented Note Taking System for the Classroom. Adjunct Proceedings of the ACM Conference on Ubiquitous Computing (UbiComp 2010), Papercomp Workshop, 2010, Copenhagen, Denmark. , 2010. hal-00671476

HAL Id: hal-00671476

<https://inria.hal.science/hal-00671476v1>

Submitted on 17 Feb 2012

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What do U-Note? An Augmented Note Taking System for the Classroom

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ABSTRACT

We present U-Note, a new system that helps children to study their lessons. It links a paper notebook and digital documents in order to reconstruct the context of the class. This system makes it possible for students to browse the teacher's documents at the state it was when he wrote the words he is currently reading. The student can also add information he found on internet. We first discuss the interviews we had with teachers, that led to the design of the system. Then we describe the system itself, which consists of a capture system, and a browsing application.

Author Keywords

Augmented classroom, digital pen, Digital lecturing environment, capture and access

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: User Interfaces—*User-centered design*

INTRODUCTION

As teachers become more fluent in digital media and the cost of laptops, beamers and recording tools keeps decreasing, teachers may have to orchestrate classes that rely on both physical and digital tools and media. As a consequence, experiments with digital teaching that used to be feasible only in universities, can now be experimented with a younger population, in any high-school setting.

In addition to oral explanations and writings on whiteboards, high school teachers we interviewed use presentations, videos, web pages and specialized applications. On the other hand, students still use pen and paper to write their notes. There are many reasons for that: pen and paper is cheap, easy to use and not distractive [5, 6]. Yet, when students review what they wrote during the class in their notebooks, the rich and interactive multimedia experience from the classroom is lost.

In this paper we present the initial stages of the design of U-Note, an application that aims at augmenting the students' paper notes by linking them with the documents used by the teacher in the class. We particularly focus on the granularity of the link between documents. For example our system allows to link a word in a notebook to a particular slide in a slide show. Students can also directly interact with digital documents and consult them along with the notes.

Our study began by interviewing secondary and high school teachers. This helped us to define our motivations and to focus on the real needs of users. After reviewing existing systems, we designed a new system called U-Note that provides features required according to our investigations.

INTERVIEWS WITH TEACHERS

In order to better understand how digital materials are used in classrooms nowadays, we visited a high school located in inner Paris. We interviewed three teachers with students ages, ranging from 11 to 21 years old: middle school (11-15), high school (15-18) and cram school (18-21). Each teacher was interviewed separately, for one hour. We focused on their use of paper and digital materials during 'normal' classes, practical classes, and outside of the classroom.

Uses of paper: we identified paper as the primary medium used by pupils for sharing, editing, and knowledge keeping.

Paper notes as a record: students used to write notes on notebooks in every class. In primary school they copy the lesson the teacher writes on the blackboard. In middle school the teacher dictates and write keywords on the blackboard. In high school students take notes upon the teacher's speech. However, teachers are also using modern multimedia equipment such as computers and beamers, but this is done more occasionally as a way to augment lectures with digital documents. These digital materials can be of different kinds, depending on the topic of the lesson: for instance videos for history or biology, or interactive demonstrations for Mathematics or Biology. Unfortunately, these materials are generally not available any longer after the class as they can hardly be printed out and distributed on paper by teachers. Alternatives consists in sending emails containing the multimedia resources, but this is not a widespread practice.

A striking finding of our study is that the main medium used for recording is still paper transcripts even when students do their work by using computers. For example, we could

observe a case where students had to perform some exercises on a spreadsheet, but would eventually have to report results and how they solved the problem on paper. An interesting point here is that not only paper makes it easier for the teacher to go through the students' work, but it also makes it possible for the teacher to annotate the students' work and write comments and advices.

Sharing: we also identified sharing ease as an important motivation for using paper in the classroom. Because paper is relatively inexpensive and copy facilitates already exists in high schools, paper documents can be reproduced quickly and distributed extensively. For instance, teachers frequently distribute printouts to complement the teaching-book.

Edition: the ease of combining heterogeneous paper materials together makes it a good candidate for editing and putting together final versions of documents. Students use their notebooks or binders to attach paper documents to their notes. We noticed that teachers often use text tools such as Word for editing text. But this text was often printed and merged with other paper resources copied from an external resource such as books, web pages, or hand-written notes, before being distributed to students or used as an help during the lecture.

Implications for design

we are currently running more interviews to assess our initial observations. In particular we are setting-up questionnaires for pupils and teachers to gather more information on the use of digital tools. Nevertheless, this preliminary work highlighted that paper is still the central medium for organizing information in the class. As said before paper notes do not currently hold any type of digital information. In the following section, we present the system we propose for augmenting paper notes with digital information. Then we will present existing annotation systems that makes it possible to conjointly use paper and digital documents.

U-NOTE

Our first investigations led us to design a system that allows to combine student's notes with teacher's documents. We centered our design around several principles:

- The navigation is centered around the student's notes: the notebook remains his main source of information.
- The link must be as specific and precise as possible: scholar documents are full of information, the student must be able to locate easily the piece of information he is searching for.
- The student must be able to browse the documents: students that misunderstood the lecture may want to freely read them again.

The U-Note system allows the student to reconstruct the context of the class. He can use his paper notebook to browse all the documents shown by the teacher, and add his own data, typically web links, comments or text excerpts that he col-

lected from the web. The system consists of two independent parts.

One part is used by the teacher. It records events occurring during the class. The other part is used by the student to access the documents. The student writes his course on dot-pattern paper with an ANOTO digital pen setup in batch mode. When he is at home he plugs the pen on the USB dock and the strokes are transmitted to the student application (figure 1) to be processed. This application downloads the history of the class from the teacher's server application. Timestamps of strokes and events allows to link them precisely. The student can also interact directly with his notebook with a digital pen in streaming mode. When he points on a stroke, he can access the documents shown by the teacher at this time. The same operation can be done in the student's application by clicking with the mouse.

The teacher's module

Nowadays teachers use multimedia files in their lectures, in particular in secondary school and high school. The purpose of this part of the system is to record the context of the class with high precision. It is composed of several programs and plugins.

We developed a Powerpoint extension that records information like presentations loads, unloads and slide changes. This plugin allows to know precisely which slide of which presentation was shown at a given time. The same functionality is offered for web pages by a Firefox extension. Finally teachers also use audio or video recordings in their lectures. We developed a multimedia player that records load, unload, play and pause actions on these files. All these extensions send events to a central server. This server generates a log file of the class, that is sent along with the documents to the student's application. Finally we also capture the teacher's oral explanations using an audio recorder software running on the teacher's PC. The program allows the teacher to stop the recording, typically when there is rampus in the class. Additionally the system can also take into account events generated by an interactive whiteboard, when available. The teacher's writings on the whiteboard is then made available to the student.

The student's module

The goal of the student's module of the system is to help studying lessons by reconstructing the context of the classroom. For instance when reading his notebook, the student may reach a part he did not understand. Clicking on the notebook in an appropriate way (described later), will make them possible to access all data related to this specific part of the course, *i.e.* (depending on what was actually recorded): the oral recording at this moment, the slide that was displayed at that time, the writing the teacher was making, etc.

Technology: in order to realize this we need a link between the handwritten notes and the events recorded by the teacher's module. Digital pens can not only be used for writing on paper, as usual pens but they are also able to store the handwritten strokes and to send them to a computer. Two

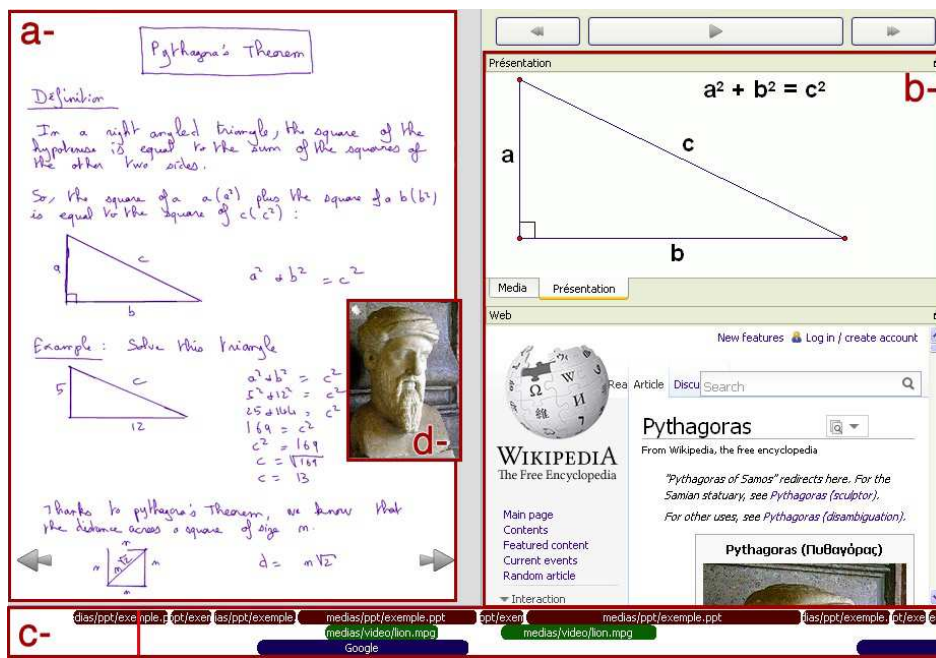


Figure 1. Screenshot of the student's application. a) notebook view. b) miniatures. c) timeline. d) post-it.

main kinds of technologies are currently available as described below.

Several models of digital pen rely on ultrasonic position detection (e.g. Epos¹ and Z-Pen²). The user must then clip an USB key on the top of the paper sheet, and use an electronic pen. Any kind of paper can be used as the device captures and stores every stroke relatively to the USB Key. However, the user has to re-clip the USB key every time he starts writing on a new page. This means that he cannot modify previously written pages. This strongly limits possibilities for interaction.

The ANOTO³ technology allows to digitize strokes in a more natural way. The counterpart is that specific paper must be used together with a dedicated pen. More specifically a dot pattern must be printed on the paper sheets. ANOTO pens offer one or two operating modes depending on the model. In streaming mode the strokes are directly sent through bluetooth and processed on the fly. In batch mode, strokes are recorded in an intern memory, and processed later when the pen is plugged on an USB dock. The important idea is that these strokes not only have a spatial value, but also a temporal value. The temporal value is absolute, so it can be used to link the teacher's events to the student's strokes. In our study we used a Nokia SU-1B model that allows both modes. The student uses the pen in batch mode in the class, and in streaming mode when he is back at home.

The notebook view: the main component is a view of the notebook (figure 1-a). It contains the strokes recorded with

¹<http://www.epos-ps.com>

²<http://www.danedigital.com/6-Zpen/>

³<http://www.anoto.com>

the digital pen. This view is useful in the situations when the student's notebook is not with reach. The student will probably prefer to read notes on his notebook otherwise, so that the view can be hidden on demand.

The miniatures: the part of the GUI display makes it possible to explore the teacher's documents while reading the notes. Four kinds of components can currently be displayed in this area (figure 1-b). The first component allows to view a miniature of a Powerpoint presentation. The user can browse the miniatures of a Powerpoint, and open the file in Powerpoint. The second one is a web view. The third one is a multimedia player, that can read audio and video files. The fourth one is a viewer for interactive whiteboard.

The timeline: the purpose of the timeline is to provide a visual link between the notebook and the digital documents (figure 1-c). Using the timeline, the user can explore the chronology of events that occurred during the class, and see which slides, webpages and videos were shown and when. The user can click on the items to open a miniature of the corresponding document in the same state than during the class. Pupils can also tap on their notebook with the ANOTO pen setup in streaming mode to open documents that were displayed when they wrote the word under the pen tip.

If the dynamic of the class is important, the student can replay the class from a given point. A red dot moves over the strokes to show what was written and when. The miniatures are updated to show the exact part of the documents shown at this time in the class.

Post-its: while doing his homework or studying his lessons, the student will sometimes search for additional informa-

tion on the Web. When he finds some useful information he might want to keep it and paste it into his digital notebook to make a link between the webpage and his lesson. We developed a tool that allows to cut pieces of a webpage and stick them in the digital notebook (figure 1-d).

The Web page capture is based on a Firefox extension. The user selects the piece of webpage with a drag selection. The collected information is sent to the student's module by a Firefox extension. The pieces appear in the student's module as post-it windows. The student can then stick them on one page of his notebook or trash some of them. The page is still active inside, and can be opened in a web browser.

RELATED WORK

Various systems have been proposed for allowing later access to captured live experiences. Ubiquitous Presenter [11] is a classroom presentation tool allowing an instructor to annotate slides with a tablet PC while he shows them and gives the lecture. Students can view the live presentation with narration and digital ink with non-Tablet PCs. The captured presentation can be saved to a Web server and later reviewed as a video by students online. Recap [4] enables the capture of the lecture, slides and teacher's annotations with a higher granularity than Ubiquitous Presenter. Students can access this capture after the class via any activeX enabled web browser. However, neither Ubiquitous Presenter nor Recap provide the capability to link teachers' multimedia datas with student's note, whatever they produced on paper on any type of device.

Classroom2000 [1], which later became eClass [2], is a classroom presentation tool allowing an instructor to annotate slides on an interactive whiteboard. It then links these annotations with a video and an audio recording of the class, and web links opened during the lecture. A longitudinal evaluation of this tool showed the usefulness of links between documents and audio recordings. It also underlined the fact that students take fewer notes when using this system. This is not surprising since the teacher provides his notes. The advantage of this is that students are more concentrated on the explanations. However taking notes has an important role in the memorization process [3] and they integrated a note taking system with pen-based video tablets [9]. Hence, unlike U-Note, these systems require specific equipment and are not adapted in secondary and high school where notebooks are still widely used.

In CoScribe [7], the teacher starts his lesson by giving printouts of his slides. Students are then able to directly create handwritten annotation on teacher's printouts with a specific pen. They also can structure and tag their annotations for a later retrieval. Finally, they can collaborate with other students by sharing their annotations. However, CoScribe uses the printouts as a central media and does not associate the teacher's materials with the notes in student's notebooks.

Finally, various works have been proposed to link digital documents and materials with physical notes taken in personal notebooks. Yeh *et al.* designed a notebook for field

biologists [12]. They associated handwritten notes with GPS coordinates and photos they could shot or samples they could find on the field. West *et al.* designed a similar system for scrapbooking [10]. Their system allows to combine handwritten notes with media documents such as photos, videos and sounds using explicit gestures. Finally, Tabard *et al.* proposed Prism [8], a hybrid notebook aggregating streams of digital resources (webpages, e-mails, etc.) with Biologists' notebooks. It long term deployment showed that from all the streams aggregated, users relied on one as their master reference (usually the paper notebook). These works and CoScribe are based on the ANOTO technology.

CONCLUSION

We presented a study about new technologies for classrooms. We began with an interview with secondary and high school teachers. It helped us to identify the usages and the needs. Paper appeared to be still widely used by students to take notes, while teachers use multimedia content in their lectures. The fact is that students have difficulties to link their notes with their teachers' materials. Hence, they cannot get all the advantages of digital contents when studying at home. We presented U-Note, a system that uses the student's notebook as a central media in order to go through captured lessons. It allows the student to access the teacher's materials at the exact state it was when he wrote his lesson.

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