# NiCEBook – Supporting Natural Note Taking

**Peter Brandl, Christoph Richter, Michael Haller**
Media Interaction Lab
Upper Austria University of Applied Sciences
mi-lab@fh-hagenberg.at

## ABSTRACT

In this paper, we present NiCEBook, a paper notebook that supports taking, structuring and reusing notes. Through a study of note-taking habits, we observed that different strategies are used to organize and share notes. Based on these observations, we developed a design for a notebook that combines different approaches to better support these activities. The details of our design were informed by an additional online survey. We emphasize the need to examine the characteristics of taking notes with paper notebooks in order to develop a digital system that resembles the quality of traditional writing. With NiCEBook, we present a solution that combines the flexibility and simplicity of taking notes on paper with the benefits of a digital representation. We demonstrate the capabilities of our system through customized views, searching and sharing functionality.

## Author Keywords

Paper Interface, Digital Notebook, Digital Pen, Note-Taking, Structuring, Tagging

## ACM Classification Keywords

H.5.2: User Interfaces - Input devices and strategies, User-centered design

## General Terms

Design, Performance

## INTRODUCTION

Despite the fact that note taking is a common activity throughout all fields of knowledge work, it constitutes, upon closer examination, a very intricate practice. In particular, the physical tools that are used for taking notes play a decisive role. Usually, notes are written on individual sheets of paper that are often assembled in the form of notebooks. Any given notebook may include a variety of different notes, such as short notes, sketches or meeting logs. The information that is collected in a notebook

therefore includes different types, e.g. temporary, long-term, confidential, private or public notes. Just as diverse as the content that is stored in notebooks is the motivation for taking notes. They support the transfer of knowledge to paper for memorization, facilitate thinking on paper or enable the sharing of information with others.

Understanding the physical interaction with notebooks helps human-computer interaction developers to apply this knowledge to creating tools that support note-taking activities. Previous research has shown that paper can be used as an interface for digital systems in various forms. This encompasses the annotation of electronic documents [6][27], creating rich documents from paper [17][31] and structuring information [7][28]. However, to support note taking in its entirety, a profound exploration of the activity itself is necessary. Thus, an enhanced note-taking solution must be carefully designed in order to preserve the quality of a paper notebook.
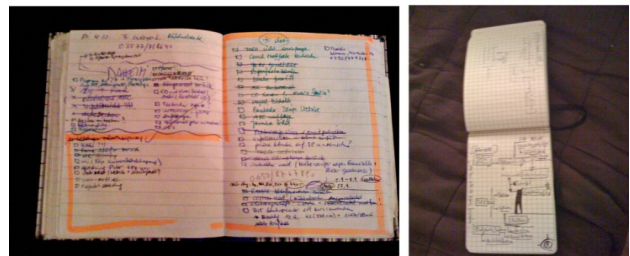


**Figure 1: Samples of notebooks with different form factors show various types of content and structuring strategies.**

In this paper, we explore some characteristics of note taking with paper notebooks that affect the design of combined paper and digital solutions. We then present an observation of note-taking habits and the related tools. Based on the results and the surveyed shortcomings of current practices, we discuss the interesting situation that a number of enhanced note-taking solutions are available but practically not used. To address this issue, we propose NiCEBook, a novel paper notebook that provides the benefits of a digital note-taking system. The design considerations for NiCEBook are based on an online survey with a focus on the actual user requirements. Our NiCEBook prototype demonstrates new solutions for organizing notes while maintaining the flexibility and simplicity of note taking on paper. The resulting structured notes are accessible through an application that offers different views on the notebook.

Moreover, it supports a basic interface for digitally sharing notes. Finally, we evaluate the usability of the NiCEBook design compared to a commercial product.

## RELATED WORK

Two main areas of related work influenced the development of NiCEBook: previous projects that aimed at bridging the paper-computer gap through digitizing notes and studies about paper use and note-taking practices.

### Digitizing Notes

Previous work has shown that several approaches can be chosen for digitizing notes. One possibility is to take notes in a digital system which supersedes the need for digitizing from paper [8][23][25][30]. Microsoft OneNote [9], for example, allows for digital note-taking that grants some of the expressive freedom pen and paper notes offer. The disadvantage of such systems is the dependence on a computer for the task of taking notes. In most cases, tablet computers with stylus input are used to substitute the analogue pen and paper combination. However, those systems cannot compete with the natural affordances of paper for taking notes.

Alternative solutions that take advantage of real paper have to deal with the problem of digitizing notes. One possible solution is to place a tracking tablet beneath the paper for detecting the pen through the paper. Mackay's A-Book [19], for example, uses a WACOM tablet for that reason with a paper overlay to enable sketching with real ink. DigiMemo [10] is a commercial solution that builds upon the same idea. A similar concept is used for clip-on systems like the PC Notes Taker [14]. The main disadvantage of these solutions is the inflexibility of handling multiple pages. The user has to manually keep track of the page numbers because the tablet cannot distinguish between the overlaid paper pages.

Anoto [11] addresses this issue by encoding the page number directly into the paper. This provides a powerful solution for digitizing notes across several pages and even several notebooks. Multiple research projects already explored this technology to bridge the gap between paper and the digital world. Paper Augmented Digital Documents (PADDs) [6], for example, automatically manage the correspondence between paper and digital copies. Based on this system, PapierCraft [17] demonstrates the tagging of notes where the user can select any specific region in a printout or notebook page and issue a tag command using a pigtail gesture. In contrast to NiCEBook, PapierCraft is mainly designed for working with existing documents instead of freeform notes. Therefore, tagging and managing tagged information is a component of PapierCraft, but it is not designed to support the expressive capabilities of natural note-taking as NiCEBook does. Other projects that build on Anoto technology include PaperPoint [27] that allows annotating digital presentation slides by using their printouts as proxies and PaperProof [29], a proof-editing application based on a correspondence between the digital version and a paper printout. ButterflyNet [31] uses Anoto for a mobile capture system that integrates paper notes with digital photographs captured during field research. Similar to NiCEBook, ButterflyNet visualizes notes in a digital browser. However, ButterflyNet does not provide the structuring and tagging functionality of NiCEBook, since its main focus is on combining notes and photos.

### Paper Practice and Note-Taking Studies

Sellen and Harper investigated the role of paper in different work environments in order to answer the question why paper is still used although technologies have been developed with the goal to replace it [26]. They report that the digital alternatives were not mature enough in terms of creating, collaboratively editing and generally reading notes to replace paper. Although these insights come from a decade ago, not much has changed as we are still dealing with paper in our daily work environments. One reason for using paper instead of digital applications has been explored in air-traffic control [4]. There paper is still preferred because it facilitates highly specialized cognitive and social processes.

The roles of paper notebooks and note-taking practices have been studied by Wilcox et al. [30]. Based on the results of their observation, they designed a digital notebook application with additional audio recording capabilities. They stress the need to make a new system for note taking as easy to use as paper. Due to the lack of available digital pen and paper solutions at the time of their study, they used tablet PCs for capturing notes.

However, it is still a challenge for developers to reproduce or even exceed the simplicity of taking notes on paper with a digital system. It is not a matter of insufficient technical possibilities, but rather the high expectation a system has to meet when it is compared to the quality and convenience of taking notes on paper. A closer investigation of this topic helps to better understand the design space and derive requirements for an enhanced note-taking system.

## NOTE TAKING AND PAPER NOTEBOOKS

In the following, we briefly sketch some characteristics of note taking with paper notebooks we consider especially relevant. Following Wilcox et al. [30], our focus is on note taking as a general form of personal knowledge management not restricted to a particular application domain or usage scenario. In contrast to notes made on single sheets of paper, sticky notes, or whiteboard, notebooks usually provide a series of entries created over an extended period of time. Notebooks therefore have a more complex structure and history than single notes requiring strategies for organization and retrieval of information. Furthermore, while other types of paper-based artifacts such as the design sketches investigated by Cook and Bailey [3] or the flight strips used in air-traffic control [4] are created for collaborative use, most notebooks are kept by a single person only, making it a quite personal artifact. Even though the owner of a notebook might decide to share parts of the contents, the notebook itself is rarely passed over to someone else entirely.

Due to their format, paper notebooks can be used for quite different purposes including memos, meeting minutes, sketches, calculations or mnemonics, for example. Providing little restrictions to the contents or organization of the notes taken, personal notebooks are very flexible and can be used for different purposes simultaneously. For example, contact information and literature references might appear next to a memo or a design sketch might be annotated with notes about the next steps to be carried out. In this sense, notebooks provide instruments for multiple types of mediation in that they allow users to articulate, record and reflect on ideas as well as to organize their own working process [1]. As a consequence, the information recorded in a notebook is usually not restricted to a certain subject or project but often feeds into multiple lines of action. Even a single note might be relevant for different activities and purposes. McAlpine et al. [21] support this observation through their comprehensive survey about the content of engineers' logbooks.

While notebooks can be used for documentation purposes to support memory and reflection [18], they are often also used to record information for future usage [22]. Such information might include such diverse things as an interesting idea picked from a presentation attended, a promising pointer to some literature, contact information for a possible collaborator or a brief sketch of an idea for the next project. As argued by Kidd [16], this kind of not yet processed information is likely to provide an essential driver for productive knowledge work, but as the future role of the information is partly unknown, it often cannot be properly named or classified by the note taker. Therefore the note taker might decide that the information is potentially important and jot it down but does not know when and where it will become relevant.

## USER NOTEBOOK FIELD STUDY

In order to explore the role of note taking and notebooks as enabling tools, we conducted a field study about note-taking habits. Twelve people were interviewed about their experiences with notebooks. Three were female and nine were male, with a diverse professional background including professors, sociologists, designers and manager. We based our study on the approach taken by Lin et al. for their micronote investigation [18]. Data collection included semi-structured interviews, contextual interviews based on participants' notebooks, as well as an artifact analysis of existing note taking devices. Guiding questions for the semi-structured interview have been derived from HP Lab's survey on note taking practices [15]. In the semi-structured interview, participants were asked about the kind of notes they take, their structuring methods within the notebook and their habits of reviewing and further using previously made notes. Answers were recorded by the interviewer by taking notes. Each of the interviews lasted 30 minutes. Second, we examined a typical notebook used by this person. For this part, we specifically asked about note taking details that we found in the notebook. The results

were recorded in form of notes by the interviewer and sample photos of the notebook. These interviews lasted another 30 minutes. Finally, we collected information about additional devices that are used to overcome restrictions of traditional notebooks and suggestions for improvements of current notebooks.

Our results are in tune with the findings reported by Wilcox et al. [30], but highlight additional aspects particularly concerning the role of paper for taking notes and the systems for structuring and reusing of notes.

### Quality of Paper

The affordances of paper have been explored by Sellen and Harper [26]. In our interviews, many of these qualities were mentioned as criterion for using traditional paper for taking notes instead of digital devices such as laptops or PDAs. The most frequent arguments for paper were the light weight, easy annotation, powerless usage and the social acceptance especially during meetings. Moreover, the designers in our interviews valued paper for encouraging creativity, a quality that was also reported from Cook and Bailey's [3] study about designers' use of paper.

### Structuring Notes

Structuring is a common task to keep notes organized. We found that structures generally appeared in two spatial dimensions: in detail when notes were organized on a single page or through the whole notebook by using separate pages for different topics. All interviews revealed that structuring strategies are applied, although different methods were used. For organizing notes on a page, 67% of our participants regularly used demarcations such as horizontal lines while 58% used different pen colors. Depending on the size of the notebook and the content of the notes, 75% occasionally organized different subjects side-by-side and 25% even spanned notes over two pages.

All people used to start new pages for important topics, obviously to have enough space for notes but also to prevent others from seeing confidential information that might be visible on previous pages. However, this introduced a problem since notes to the same topic were taken at successive meetings over a period of time. This created notes that were scattered across several pages, although they belonged to the same subject. In order to link related subjects and for later retrieval of information, 67% of our participants categorized their notes with a topic/date. Other strategies we found included the use of different colors for different topics (16%) and symbols to mark associations (16%). It is important to note that the symbols were explicitly used to link content over several pages in a notebook. This extends the insights from related studies that only deal with marks and colors for highlighting notes [15][18]. The only comparable strategy was found by Marshall in context of hypertext annotations [20]. She describes the use of colors and symbols for reorganizing sections in a printed book. Re-arranging pages was used by one person, although this was not a typical solution since bound notebooks normally prevent the removal of pages.

One person used a part of the page to summarize important notes in this area. For that reason, a dedicated part at the bottom of the page was reserved on each new page. After finishing taking notes on the page, he duplicated important information in this area. Khan describes a similar method called summary boxes where important notes are separately listed [15].

### Marking Notes
In addition to linking notes across pages in the notebook, all persons used strategies to mark notes as specific items. For example, 83% highlighted contact details for fast retrieval or later transcription to a digital device. Other common categories for tagging notes were *ToDo*, *Date* or *Deadline* and *Memo*. This result is supported by the information types that were observed by Bernstein et al. [2]. Although they investigated information scraps instead of notebooks, they found that ToDo notes are most common, followed by Contacts and Dates.

We observed different methods for marking notes, but all persons consistently used their approved system through the whole notebook. Among others, the most common methods included color marks with highlighters or colored ink (58%), circling or framing regions (66%), numbering items in a list style (75%), adding checkboxes to notes for *ToDo's* (33%) and special symbols as a code for categories (50%). According strategies for structuring and highlighting notes can be found in related studies [15][20]. Four participants tagged whole pages for fast access. The most common methods that were used for tagging included dog-ears and paper-clips. Moreover, we observed two different approaches to mark notes: either they marked notes immediately after writing them, or they had a pass over a finished page to mark notes. Generally, a combination of both methods was used.

### Re-using Notes
The collected notes were commonly used for archiving and documentation reasons. Especially in meetings, notes from previous sessions were reused. In order to access specific notes, 67% of our participants marked sections in the notebook with a date and meeting subject combination. The dates allowed to chronologically search for specific notes. McAlpine [21] also discovered that browsing through pages in combination with the approximate date of entry is the most common method (61%) to locate notes in a notebook. A slightly lower percentage of users regularly dating their notes (54%) is reported by Khan [15]. One person used a smart phone to additionally store condensed notes. For later retrieval, the notes in the notebook and the digital notes were classified with a consistent tag. We observed that 92% of the interviewed persons regularly transfer important notes to digital applications after the meetings. Depending on the kind of notes, the most common applications were timetables, contact and task managers and word processing tools for creating protocols. Lin et al. [18] also describe the strategy of transferring notes from paper to digital applications. They moreover discuss the constraints why the information is not directly captured with a digital device.

### Sharing Notes
Notebooks that are used for meetings generally contain notes that are taken during the meetings and notes that are taken offline. Both kinds of notes exist uniquely in the author's notebook. However, we observed the frequent necessity to share and exchange notes between several people. With traditional notebooks, this requires to copy or extract pages from one notebook and insert them in another. These workarounds were used by three (25%) of the interviewed persons in order to share notes with others. In addition to photocopies, digital photos and written duplicates of notes, two people used to share their whole notebook. Depending on the relevance of the notes for the person, the according notebook was chosen. If the notes were important for them, they would let others write in their notebook or vice versa. However, this approach still restricts the notes to a single notebook and moreover affects the notebook owner's privacy. Another way of sharing notes is to rewrite them as reported in [15].

## EXISTING COMMERCIAL PRODUCTS
The information gathered from the interviews shows that traditional notebooks are chosen for their support of simple note taking but foster the development of workarounds due to their shortcomings. Thus, a system that allows digitizing and structuring notes could improve efficient note taking. However, our experience with already available solutions shows that they are hardly used. To explore the reasons therefore, we now review these systems given the previously mentioned insights about note-taking habits and related work.

Among existing solutions for digitizing notes, Anoto's pen and paper technology is currently the most mature solution. There exist a few products that use this functionality in combination with notebooks and specialized features that can be triggered directly on paper. Logitech developed the *ioTags* [12] that can be used with Anoto notebooks. *ioTags* allow invoking actions on parts of notes on a page by writing a pre-defined prefix to the notes. The tags consist of a chosen letter with a circle around it defining the action and a straight line from the circle to the end of the text part on the left hand side that marks the note included in the action. The general concept of the *ioTags* fits well to note-taking practices since it allows performing the structuring actions after writing and thus does not complicate the task of taking notes. Ngoc [22] gives a good summary of *ioTag's* pros and cons in his thesis. The tags support multiple commands on one page or note part. The used commands are moreover visible on the page and therefore support traceability of issued actions in the notebook. However, the visibility/traceability comes at the cost of using extra space on the page that could be used for notes otherwise. Moreover, multiple tags on a page quickly confuse the readability of notes. Additionally, the user has to remember the *ioTag* prefix and what header it takes.

An alternative that addresses these problems is specialized paper design. It relies on a fixed layout of the page that prevents wrong command assignments and the need of remembering tag structures. For example, a page that supports sending notes as email would consist of a subject, receiver and content area and a send button. Since the layout defines the function, such solutions generally provide a variety of different designs like Oxford's EasyBooks [13] to cater to different needs. The advantages include the immediate visibility of available commands and the simplicity of one-tick actions. Moreover, it is visible through the marked checkboxes which commands have been used. On the downside, the fixed page layout is forcing instantly structuring of notes since the input must fit the predefined areas of the page. This is contradictory to note-taking habits that, by their very nature, result in diverse and unpredictable content. Therefore, specialized page designs can only be useful in very specific cases. For example, a meeting protocol that is based on a fixed structure could benefit from a predefined page layout. For general note taking, specialized page designs are too restrictive.

With LiveScribe, a recent product using the Anoto technology offers interesting additional functionalities. An embedded microphone allows recording audio synchronized to taking notes. This idea has already been proposed a decade ago with Dynomite [30], a note-taking solution with simultaneous audio recording. Dynomite used a tablet PC for writing, while LiveScribe can take advantage of writing on real paper. Nevertheless, the added value of capturing auxiliary audio information affects the task of taking notes. Without structuring the notes already during recording, the navigation through the audio material is complicated afterwards. Like with the specialized page layout, this hinders efficient and simple note taking resulting in a contradiction to the basic function of a notebook. Unfortunately, the audio quality of LiveScribe is only satisfying if the additional ear-plugs are used (they support stereo recording). However, it is socially unacceptable to wear ear-plugs during a meeting. In contrast, for taking notes during a lecture or a presentation, the LiveScribe in combination with ear-plugs is a good solution.

## NOTEBOOK DESIGN

Based on the experiences with available Anoto solutions and the results from our user observation, we present the prototype NiCEBook that combines note taking with enhanced structuring and sharing functionality. A key design consideration is to preserve the quality and simplicity of writing in a paper notebook. This means to avoid restrictions that complicate the core task of taking notes. The enhanced structuring functionality should be accessible on demand, but taking notes should not depend on it. To support structuring activities, our notebook allows tagging notes in different ways. The tags can be assigned either directly while taking notes or afterwards. Therefore,

we support both types of structuring that we observed in our interviews. In addition to the digital collection of tagged notes, the tags are also visible in the real notebook. This allows retrieving a fast overview of assigned tags on a page. Moreover, dog-ears can be used to mark entire pages in the notebook.

A related approach for tagging and structuring notes has been proposed by Steimle et al. [28]. In contrast to our solution, they used additional adhesive stickers as bookmarks and applied them to single sheets of paper. Their prototype aimed at collaboratively bookmarking educational documents instead of structuring notes in a notebook. Heiner et al. [7] demonstrated the use of a paper notebook in combination with a digital system with their PaperPDA prototype. They describe some techniques for manipulating and tagging information in the notebook through paper widgets called StickerLinks. In contrast to our system, the synchronization with the application is based on scanning the pages. Moreover, they used specialized page layouts since their focus was on a PDA-like functionality of the notebook. A different approach is pursued by XLibris [25], a digital annotating system for active reading. It supports structuring of a digital document by marking sections through highlighting, underlining, circling, or margin annotations.

### Paper Notebook and Digital Representation

Our proposed design aims at improving the management of notes within a notebook. This includes the support of structuring activities while taking notes as well as later retrieving, reusing and sharing tasks. For this purpose, we designed a novel notebook that allows to structure notes immediately along with a corresponding digital notebook representation for extended functionality. In the paper notebook, notes are written in a traditional way with ink on paper. This ensures that writing is familiar for the user (no handling with computers is necessary) while the notes are digitized in the background. For capturing the notes, we use Anoto technology. All pages have the Anoto dot pattern as background and special additional control elements in the border region.
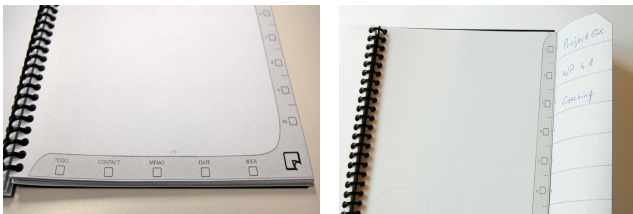
### Categories

Notes can be assigned to a general category such as *ToDo*, *Contact* or *Date*. These categories are pre-defined. The reason for using pre-defined categories is based on related research which proved that a key factor for the convergence of tags is the suggestion of frequent options [5]. For the design of our notebook, we collected the most common categories that are already used in notebooks. We did an online survey that was sent to professionals and students from the local university. The results were evaluated separately to see if the note-taking habits differ between the two groups. We collected 44 professional answers and 232 student answers. The results in Figure 2 show that *ToDo* is the most common category, followed by *Date* and *Memo*.
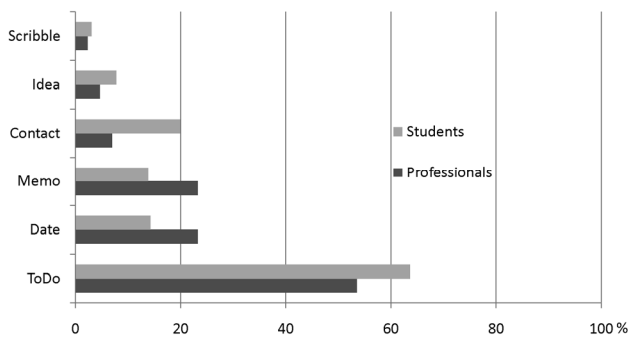
**Figure 2: Categories that are used by professionals and students for structuring notes.**

Based on the results of our survey, we used the categories *ToDo*, *Contact*, *Memo*, *Date* and *Idea* in our notebook design. The category items are placed at the bottom of each page (cf. Figure 3 (*left*)).



**Figure 3: The NiCEBook design. Five checkboxes at the bottom of each page allow tagging notes with categories (*left*). An extendable sidebar offers space for defining topics (*right*).**

To assign a category to a note, the user selects the appropriate checkbox and then defines the area on the page that should be included (cf. Figure 4).
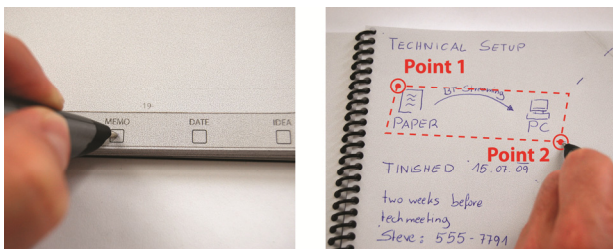


**Figure 4: Categories are assigned by ticking the according checkbox (*left*), followed by the selection of two corners of the region (*right*).**

When ticking a checkbox, the pen is shortly vibrating as a feedback to signal that the action has been recognized. Since one requirement for our notebook design was to minimize the interference of traces that are created by actions other than writing on a page, the following selection can be done by simply marking two corners of the bounding rectangle with a point. However, it is also possible to use more visible marks if desired. For example, one could draw the corners of the selection rectangle for marking the two points of a note instead of just two simple points. This allows the user to visually highlight categorized regions. Moreover, the checkboxes at the bottom/side of the page

can be checked with visible marks so that each page shows the assigned categories. This helps to gain a fast overview of the categories assigned on a page when browsing through the notebook. We note that the degree of visible tagging information can be defined by the user; this provides the maximum flexibility, ranging from invisible to clearly visible marks on the page.

### Topics

In addition to pre-defined categories, notes can be classified under a topic. Topics are user defined terms like project titles or work packages. Since the topics are created by the user on demand, we designed empty text areas where the user can create new topics. Unlike the pre-defined categories that exist on each page, topics are placed on a unique expandable page (cf. Figure 3 (*right*)). The corresponding checkboxes for the topics again exist on each page.
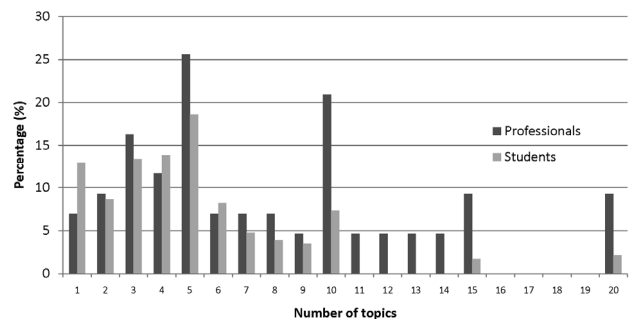


**Figure 5: The number of entries from our online survey concerning the amount of topics that are used in a notebook.**

The number of possible topics that can be defined were again derived from the results of our online survey. We asked for the amount of different topics that were usually managed in a notebook. Figure 5 shows that the most frequently amount of topics used in a notebook ranges between 1 and 10. Based on that result, we decided to offer 10 topics in the notebook that can be defined by the user in our notebook. In order to create a topic, the title is written in an empty textbox of the expandable sidebar. The checkbox that is horizontally aligned with the topic on each notebook page then refers to this topic. Selections are performed like with the categories by selecting the specific topic and defining the region with two corner points on the page.

### Dog-Ears

The results of our initial observation revealed that sometimes whole pages were be tagged. Our notebook design supports page-wise tagging through dog-ears. Dog-ears are commonly used for marking pages in books. As Rosner et al. [24] describe, the practice of physically dog-earing pages is used for keeping track of ideas or even pointing to particular words on a page. The advantage of dog-ears is the simplicity of creating and removing them without the need of any additional tools.

Moreover, dog-ears assist the searching for pages since the physical modification of the dog-eared corner provides haptic feedback when browsing through the pages of the notebook.



(a)  (b)  (c)
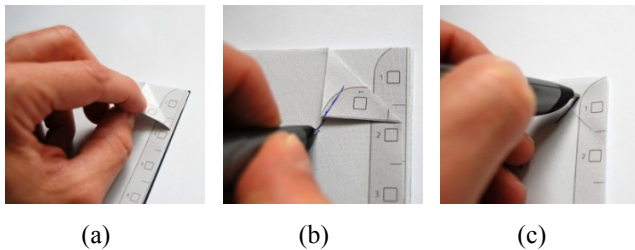
**Figure 6: Creating a dog-ear by folding the page's corner (a). Registering the dog-ear (b) and deleting a dog-ear by unfolding and cancelling (c).**

To create a dog-ear in our notebook, the corner of a page is folded like depicted in Figure 6 (a). The digital registration of the dog-ear is done by stroking over the folded dog-ear. The two different page IDs that are captured during the dragging action over the dog-ear allow to identify the page that should be tagged. For removing an existing dog-ear, the corner is unfolded again and the digital dog-ear is removed by stroking over the folded edge.

**DIGITAL NOTEBOOK APPLICATION**
Our physical notebook is synchronized with a digital representation that offers additional functionalities. For the digitalization, notes that are taken in the real notebook are stored in the Anoto pen's internal memory. This allows using the notebook in a traditional way without the need to connect to a digital application. For example, notes can be taken while traveling or on the way to a meeting. The notes are stored on the pen until the user explicitly transfers them to the application. This happens through clicking on the transfer icon that exists at the bottom corner of each page. A single click transfers the pen's entire storage to the application. We developed the digital notebook in C# using WPF for the visualization. The connection between the Anoto pen and the application is handled via Bluetooth using the OBEX file transfer protocol.

The functions we developed for the notebook application implement the requirement to reuse notes. The results from our online survey show that 98% of the professionals and 87% of the students are reusing notes from their notebooks. The lower percentage of students might be caused by the fact that a considerable amount of notes is related to courses during a term. These notes are only partially reused after the exams, eventually for follow-up courses or projects.

Since all notes are digitally available through our system, we can offer different methods for accessing and reusing notes. The basic approach is to flip through all pages and search for notes. This method resembles the analogue searching in the real notebook. In addition, the digital notebook can be shown using different views, thus a note can be searched in a specific view. An explicit search

function allows searching for keywords in the digitized notes. Finally, we developed a basic interface that allows transferring notes to external applications so that they can be reused in different programs.

**Notebook Views**
One of the main advantages of a digital notebook is the possibility to provide different views on the content. For example, with conventional book bound notebooks it is impossible to spread out the pages to gain a fast overview. With the digital notes however, all pages can be easily shown simultaneously. Moreover, features like zooming into pages make use of the digital capabilities. Our current prototype application provides four different views including an overview of all pages, a category based view, a selection of all dog-eared pages and a view of a single note from the notebook.

*Page Overview*
The overview shows all pages that contain notes in spread visualization with a zoom slider that allows adjusting the level of detail. If notes on a page are tagged with categories or topics, these are shown on top of each page. As Figure 7 depicts, tagged notes are additionally highlighted with different colors for each category once the view is zoomed to a certain detail level.
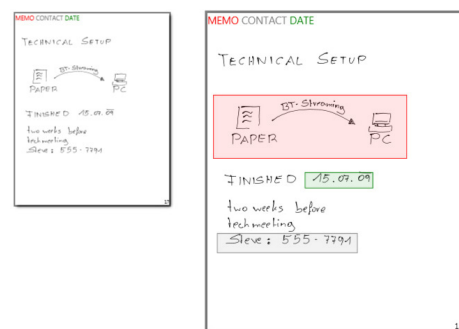


**Figure 7: Depending on the zoom level, tags are either shown in list style on top of the page only (*left*), or with additional feedback showing the tagged areas (*right*).**

*Category/Topic View*
In the category/topic view, notes are collected according to their tags. This filter shows an accumulation of notes considering a specific tag. Like with the physical notebook, the five categories (*ToDo, Contact, Memo, Date, Idea*) can be selected at the bottom of the screen. All topics that have been created in the notebook are shown on the right sidebar. Since topics are user defined, they are represented as buttons with the topic's name in handwritten style. It is possible to define sub-categories or topics within tagged notes. Hence the user has the maximum flexibility for tagging notes without the difficulty to keep a structure during note taking in mind. For example, it frequently happens that a contact, deadline or to-do is jotted down somewhere in the middle of a longer note. In Figure 8, a note is tagged as *ToDo* but it also belongs to a larger note that is tagged as a *Memo*.

**Figure 8: Parts of already tagged notes can be tagged again with a different category or topic. This allows assigning notes to multiple tags.**

*Dog-Ear View*

The dog-ear visualization summarizes all pages that are tagged with a folded corner (cf. Figure 9). Dog-ear marked pages are also labeled in the page overview with a digital dog-ear.



**Figure 9: Digital dog-ears mark pages that have been dog-eared in the notebook.**

The cancellation of physical dog-ears in the notebook consequently deletes the digital dog-ears. Therefore, the related page is removed from the dog-ear view collection and the folded-corner is erased in the page overview.

**Searching Notes**

During synchronization, all notes are analyzed by an OCR library. In the current implementation, we use Microsoft's .NET *InkAnalyzer*. To search for a word, the application offers a text field for entering the search term. The search function browses through all stored words in the notebook and returns the pages that contain the search term. Additionally, the recognized notes are highlighted on the pages. A similar approach can be found in InkSeine [8], although they only support digital note taking instead of a combined paper and digital solution that NiCEBook offers.

**Transferring Notes**

We implemented a simple interface for transferring notes to other applications. By dragging a whole page (in the page overview visualization) or a single note (in category, topic or single note view), a copy is created that can be dropped into applications. For example, notes can be included in an email. As an alternative to the Drag&Drop exchange, we support copying notes to the clipboard. The decision to convert notes to images as exchange format is based on the feedback we collected in our initial user observation and the results from our online survey. Overall, 63% of the professionals and 50% of the students stated that they would regularly transfer notes from their notebook to digital applications. However, the range of applications they use

for managing their notes is broad. We found a preference for the Microsoft Office palette (including Outlook, Word, Excel and OneNote) but a much larger number of different proprietary online tools such as Wiki systems and shared timetables as well as graphic suites (Photoshop, InDesign, Illustrator). These results suggest that it is difficult to offer a solution that satisfies the requirements of the average user. For that reason, we decided to provide a general interface that does not restrict the transfer of notes to a specific application.

**EVALUATION**

In order evaluate the usability of the NiCEBook design, a first user study has been carried out. The study focused on the categorization and selection of notes including the impact of the tagging mechanism on the note-taking process. In particular the study aimed to answer the following questions:

1. How does the tagging mechanism of the NiCEBook perform?
2. Does the tagging mechanism alter or hamper the note-taking process?

In order to identify adequate benchmarks, we compared the NiCEBook with the commercially available *ioTags*. In comparison to the *ioTags,* we assumed that:

a) the NiCEBook would perform better than *ioTags* regarding the correct recognition of the categories selected as well as the selection of the note text or image,
b) the tagging mechanism supported by the NiCEBook would be judged at least as easy to use as *ioTags,*
c) the tagging mechanism supported by the NiCEBook would be judged as more natural and less disruptive than the *ioTags*.

**Method**

Twelve participants, recruited from the local university, took part in this study. There were two females and ten males between the age of 22 and 35 (M=27.5, SD=4.0). Three participants had never worked with an Anoto pen before.
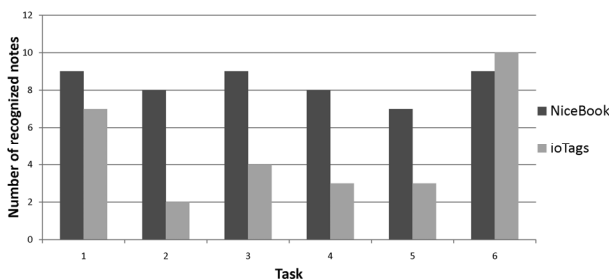
With both techniques (NiCEBook and *ioTags*), participants were asked to carry out six successive note-taking tasks. The technique/task assignments were counterbalanced. The tasks included the creation of a *Shopping* list, a *ToDo* list, a *Sketch*, and a *Calendar* entry as well as the subsequent addition of a *ToDo* item to the existing list, and the addition of a *Memo* to the *Sketch*. The tasks were chosen based on the analysis of notebook entries in the study on user notebooks reported in the beginning of the paper as well as the categories provided by the NiCEBook and the *ioTags*. Tasks with subsequent additions to existing notes were introduced to simulate successive note-taking behavior. Participants were briefly introduced to the two notebook systems ahead of each treatment and spent about 15 minutes on each treatment condition.

Data collection included observation of participants during the note-taking exercise, analysis of the notes taken (visual inspection and test whether the notes are correctly recognized by the corresponding software) as well as interviews with participants after each treatment. Interviews focused on participants overall impression as well as ratings of the ease of use of the tagging mechanisms and their confidence in the correct recognition of the category chosen and the proper selection of the corresponding text or image.

**Results**

In order to assess the performance of the NiCEBook tagging mechanism, we compared error rates with those of the *ioTags*. Besides the selection of the correct tag in the notebook, we distinguished between the software recognizing the correct category and the correct selection of the corresponding text or image. Regarding the latter, we counted a selection as incorrect if words or lines were partially or totally cropped. With both techniques, all participants tagged all notes in the notebook correctly throughout all tasks. In case of the NiCEBook, on average 5.0 (SD=1.41) out of 6 tags have been recognized correctly and on average 4.17 (SD=2.29) out of 6 notes have been selected correctly. With *ioTags*, on average 4.0 (SD=1.21) out of 6 tags have been recognized correctly and on average 2.42 (SD=1.62) out of 6 notes have been selected correctly. In both cases the differences in error rates are significant and in favor of the NiCEBook (*t(11)=2.10, p <0.05* and *t(11)=2.47, p<0.05*, respectively). Figure 10 depicts the number of correctly recognized notes for each task. Analysis on task level revealed that the selection of notes with the *ioTags* was particularly error-prone in cases where multiple items in a list had to be tagged or where notes were more complex as in the case of an annotated sketch. In these cases only 30% of the selections were made correctly with the *ioTags*.



**Figure 10: With the NiCEBook, a significantly larger number of notes from each user per task were correctly recognized than with the *ioTags*.**

All in all, participants assessed both techniques as easy to use. While all participants rated both the selection of a category and the selection of the corresponding note as 'easy' or 'very easy' with the NiCEBook, 11 out of 12 participants rated the selection of a category with the *ioTags* as 'easy' or 'very easy' and 10 participants assigned the same rating to the selection of the corresponding notes. Statistical analysis revealed no significant difference

between the ratings. Despite the overall positive ratings, 75% of the participants reported that the overall tagging procedure with *ioTags* was more difficult than using the NiCEBook. The main reasons purported by the participants were the need to reserve sufficient space for the tags as well as problems in making additions to an already existing note with the *ioTags*. Figure 11 depicts these differences of structuring notes with both systems.



**Figure 11: Page examples from the user study. The notes were structured on a single NiCEBook page (*left*) and on two *ioTags* pages (*right*).**

To assess whether the tagging mechanism has an impact on the overall note-taking process, we analyzed the data obtained from the interviews as well as the filled in notebooks itself. The main drawback regarding the *ioTags* is the need to organize notes in one column per page as otherwise the tagging mechanism does not work properly. In line with this restriction, seven participants complaint about the fact that they could not use the available space efficiently and/or flexibly. In contrast, the fact that the NiCEBook does not provide an indication of the category a note has been assigned to has only been mentioned as a possible drawback by one participant. While the latter finding might be due to the task assignments provided, which did not ask participants to search their notes for a particular type of note, it might also be due to the fact that many users add headings to their notes independently of the tagging. In fact we found that five out of twelve participants added headings to their note spontaneously even though it has not been asked for in the assignment.

**CONCLUSION & FUTURE WORK**

With the NiCEBook, we have shown a prototype paper notebook that combines the analogue quality of note-taking on paper with the digital capabilities of structuring and reusing notes. It supports organizing notes through multiple tagging options, including marking of whole pages with dog-ears. Our design is based on an initial observation about note-taking habits and an online survey for further refining specific parameters.

In order to evaluate the usability of the NiCEBook design, we carried out a first user study where we compared it with the commercially available *ioTags*. The results provide evidence that the selection technique used in NiCEBook outperforms *ioTags* in terms of error-proneness. Moreover, the flexibility of taking notes and tagging with invisible or

visible tags in NiCEBook was positively accepted. However, our study did not investigate searching for tagged notes in the notebook. But we could already observe strategies of additionally marking tagged regions with headings, although our participants had to manage only six different notes. Based on this observation, it would be interesting to further explore this behavior.

Moreover, for a system that should be really used for daily knowledge work activities, the error-rate of recognizing selected notes is still too high. Thus, we aim at improving the feedback capabilities of our system. Furthermore, we plan to extend the interface to other applications and to develop a web-based version in order to generalize the access to the digital notebook. After implementing these features, we are looking forward to deploy the NiCEBook to a larger number of people and investigate the applicability of our solution. This will lead us a step further towards the efficient management of notes in an environment that relies on the coexistence paper and digital information.

## REFERENCES

1. Bèguin, R. and Rabardel, P. 2000. Designing for instrument-mediated activity. Scandinavian Journal of *Information Systems, 12*. p. 173-190.

2. Bernstein, M., Van Kleek, M., Karger, D.R., and schraefel, mc. Information Scraps: How and Why Information Eludes Our Personal Information Management Tools. ACM Transactions on Information Systems (TOIS). 2008.

3. Cook, D. J. and Bailey, B. P. 2005. Designers' use of paper and the implications for informal tools. *OZCHI '05*. p. 1-10.

4. Gladwell, M. 2002. The Social Life of Paper. *The New Yorker*. p. 92-96.

5. Golder, S. A., and Huberman, B. A. The structure of collaborative tagging systems. Tech. rep., HP Labs, 2005.

6. Guimbretière, F. 2003. Paper augmented digital documents. *UIST '03*. p. 51-60.

7. Heiner, J. M., Hudson, S. E., and Tanaka, K. 1999. Linking and messaging from real paper in the Paper PDA. *UIST '99*. p. 179-186.

8. Hinckley, K., Zhao, S., Sarin, R., Baudisch, P., Cutrell, E., Shilman, M., Tan, D., InkSeine: In Situ Search for Active Note Taking. *CHI '07*. p. 251-260.

9. http://office.microsoft.com/onenote

10. http://www.acecad.com.tw/

11. http://www.anoto.com

12. http://www.logitech.com/index.cfm/66/452&cl=us,en

13. http://www.oxfordeasybook.com/uk/

14. http://www.pc-notetaker.com/

15. Khan, F. 1993. A Survey of Note-Taking Practices. HPL-93-107.

16. Kidd, A. 1994. The marks are on the knowledge worker. *CHI '94*. p. 186-191.

17. Liao, C., Guimbretière, F., Hinckley, K., and Hollan, J. 2008. Papiercraft: A gesture-based command system for interactive paper. *ACM Trans. Comput.-Hum. Interact. 14*, p. 1-27.

18. Lin, M., Lutters, W. G. and Kim, T. S. Understanding the Micronote Lifecycle: Improving Mobile Support for Informal Note Taking. *CHI '04*. p. 687-694.

19. Mackay, W. E. 2003. The missing link: integrating paper and electronic documents. *IHM '03*. p. 1-8.

20. Marshall, C. 1998. Toward an ecology of hypertext annotation. *Hypertext '98*. pp. 40-49.

21. McAlpine, H., Hicks, B. J., Huet, G. and Culley, S. J. An investigation into the use and content of the engineer's logbook. Design Studies, 27 (2006), pp. 481–504.

22. Ngoc Phan Hong Nguyen. 2006. Note Taking and Sharing with Digital Pen and Paper, Norwegian University of Science and Technology, Master Thesis. 2006.

23. Olsen, D. R., Taufer, T., and Fails, J. A. 2004. ScreenCrayons: annotating anything. *UIST '04*. p. 165-174.

24. Rosner, D. K., Oehlberg, L., and Ryokai, K. 2008. Studying paper use to inform the design of personal and portable technology. *CHI '08*. p. 3405-3410.

25. Schilit, B.N., Golovchinsky, R., Price, M.N. 1998, Beyond Paper: Supporting Active Reading with Free Form Digital Ink Annotations. *CHI '98*. p. 249 - 256.

26. Sellen, A. J. and R. H. R. Harper, The Myth of the Paperless Office. 2003. 1st ed: MIT Press. pp. 242.

27. Signer, B. and Norrie, M. C. 2007. PaperPoint: a paper-based presentation and interactive paper prototyping tool. *TEI '07*. p. 57-64.

28. Steimle, J., Brdiczka, O., and Mühlhäuser, M. 2008. Digital paper bookmarks: collaborative structuring, indexing and tagging of paper documents. *CHI '08*. p. 2895-2900.

29. Weibel, N., Ispas, A., Signer, B., and Norrie, M. C. 2008. Paperproof: a paper-digital proof-editing system. *CHI '08*. p. 2349-2354.

30. Wilcox, L.D., B.N. Schilit, and N.N. Sawhney. Dynomite: A Dynamically Organized Ink and Audio Notebook. *CHI' 97*. p. 186-193.

31. Yeh, R., Liao, C., Klemmer, S., Guimbretière, F., Lee, B., Kakaradov, B., Stamberger, J., and Paepcke, A. 2006. ButterflyNet: A Mobile Capture and Access System for Field Biology Research. *CHI '06*. p. 571-580.