

A Study of User Interface Design for Note-taking Behavior in

Classes

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Abstract

With technological advancement, the number of using laptop computers by students in schools has become larger and larger. According to several different studies, they reflect that using laptops in classes has positive and negative influence on learning respectively. Besides, due to the positive influence of note-taking behavior on the understanding of subjects and the memory, the computer-assisted note-taking tools have been developed increasingly. However, the problem of using laptops for non-class purposes in classes is still serious that it probably resulted from the unsatisfying interface design of those computer-assisted note-taking tools. Thus, this study aims at (1) exploring human needs, (2) providing generalizable design guidelines, and (3) proposing initial design concepts.

The research methods of this study consist of the diary study, interviews, grounded theory, and prototyping. The research result of this study are eight core issues: limitation of interaction between each student in classes, purposes of reviewing notes, related note-taking tools, note-taking methods, reading of notes, incentives of note-taking, and note management. Moreover, five design guidelines as accelerating the speed of note-taking, providing the function of note editing, effective note management, accelerating the speed of note searching, and enhancing the memory for notes were presented so as to propose several initial interface design concepts. In conclusion, this study hopes to fulfill users' needs through the design guidelines and concepts. But when designing the interface of auxiliary learning tools, sometimes convenient technological functions would influence learning negatively. Hence, this problem should be taken into consideration in order to promote usability.

Keywords: interaction design, note-taking, diary study, interviews, grounded theory

1. INTRODUCTION

1.1 Background

With technological advancement, laptop computer gradually meets user needs in several parts like price, equipment, weight, and appearance. And according to the Moore's Law, it predicted that the number of components in integrated circuits had doubled every year along with the efficiency increase and price decrease. So it is obvious to see the difference between the early and present laptop computers. Because technology has been making great progress, it makes laptop computer more portable and price friendlier.

Although the aspect of hardware has become better and better, it still cannot bring the efficiency into full play without the internet. According the global competitiveness reports from 2008 to 2012, the ranks of Taiwan about the internet access in schools are 14, 13, 8, and 13 respectively (Schwab 2008; Schwab 2009; Schwab 2010; Schwab 2011). It is obvious that it will be more common and easy to access the internet in schools. Thus, with the support of advanced computers and pervasive network, the number of using laptop computers by students in schools has become larger and larger.

The growing numbers of students have used their laptop computers that it looks like the normal things, but actually it has produced several problems and issues deserved to discuss. For instance, a study showed a negative finding about using the laptops in class (Sovern 2011). There were more than half the students used their laptops for non-class purposes more than half the time. So a question was raised that it is how much they learned from class. But equally, there was a positive research finding that most of the students claimed that laptops were useful in supporting the academic experience in class. If it can integrate meaningful laptop activities into the classroom, the frequency of beneficial laptop behaviors will increase (Kay and Lauricella 2011).

1.2 Motivation

In traditional paper-based learning, taking notes is able to promote the learning efficiency because it should extract the key points from abundant information as quickly as possible. Furthermore, annotating the important content by different kinds of marks is helpful to comprehension (Marshall 1997). These note-taking behaviors plays a very important role in learning, and there were also verified that they have positive influence on learning for students (Piolat, Olive et al. 2005).

With the advancement of technology and growing pervasion ratio of laptop computers, a study has claimed that the incentives to take notes by means of the laptops are the characteristic of easy modification, clearer note-taking pages, and convenient store of notes and teaching materials concurrently (Steimle, Gurevych et al. 2007). In the aspect of e-learning, the growing assistant tools have been developed to help take notes and annotate such as Livenotes, Dykow, eMargo, AOF, and u-Annotate (Steimle, Gurevych et al. 2007).

Using laptop computers in class has become more common, and the related assistant learning software has been developed continually as well. But using laptops for non-class purposes is still serious. To assume that one of the possible reasons why students did not use laptops to assist learning was probably resulted from the unsatisfying interface design.

1.3 Objective

In order to understand users' real needs so as to promote satisfaction of users in using the interactive interface, the objective of this study was threefold in the following:

1. Adopting different kinds of research method to explore people's requirement.
2. Providing generalizable interface design guidelines of assisting learning tool in class.
3. Applying the software to establish low-fidelity prototypes for demonstrating initial design concepts.

1.4 Process

Figure 1 illustrates the research process of this study. At first according to the research background and motivation to find out and concretize research questions. Then searching for the related papers to increase understanding of this research, and giving comments on them or adopting their research results to support this study through literature review and discussion. With the identified research questions and literature review, research framework would be established such as the study object, method, and procedure for user requirement investigation. The users' data would be collected and analyzed by the qualitative research methods. Those results of research findings would be used for the design guideline establishment to propose initial design concepts in order to solve the research questions. Finally, in addition to the conclusions of the research findings and results, it has discussed the limitations, future research, and implications of this study.

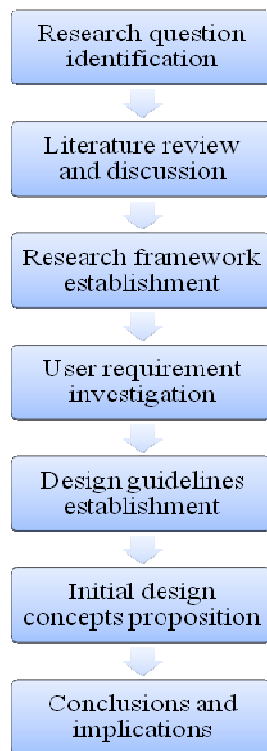


Figure 1. The research process of this study.

2. RELATED WORK

This section is an attempt to supplement the findings of these earlier studies and related knowledge of note-taking and interaction design.

2.1 Note-taking

2.1.1 The effects of note-taking strategies on learning

There are some researches relative to note-taking reveal that it has positive effects on the student's cognitive learning because it's helpful to the delayed retention (Titsworth and Scott 2001). In addition, note-taking has other benefits such as facilitating further study and constructing structure of the subject (Isaacs 1994).

With respect to the note-taking behavior, it is commonly divided into its process function and product function that the former is the act of note-taking, and the latter is the review of note-taking. And a research conclusion has described that the both process and production functions are beneficial (Kiewra and A. 1985), that is, reviewing notes can lead to better performance than not reviewing notes. Besides, according to the phenomenon of memory decline, it shows that we would forget something learned almost more than half as time goes by only after an hour (Ebbinghaus 1885). So the review of notes is beneficial for recalling the memory for what we have learned in classes.

There are several researches about the note-taking form and content had discovered that taking notes by the matrix form and reviewing expert notes both have positive effect on the student's learning performance. But a problem still exist that the expert notes will not be produced automatically. Maybe we can think about how to make our own notes more complete for reviewing such as collaborative note-taking or note sharing.

2.1.2 Cognitive process

Although there are a lot of researches about the note-taking format and effect on the learning have been conducted, the number of research about the cognitive effort during note-taking is still relatively less. In a study of cognitive effort during note taking, it discovered that the behavior of note taking is not just simple information condensation that it actually consists of three steps of comprehension, selection, and production (Piolat, Olive et al. 2005). So getting deeply into the cognitive process of note taking to design a satisfyingly assistant note-taking tool is essential

2.1.3 Note-taking-related computer-aided learning tools

When the computer technology has become more mature, a number of studies have investigated and designed the auxiliary learning tools based on the computer technology. For example, software of Livenotes was proposed originally in 2000 that it has been still improved and studied (Kam, Wang et al. 2005). There are two important design concepts in Livenotes which are the cooperative and augmented note-taking. NiCEBook is another example of the auxiliary learning tool that it seems like a traditional notebook but with the ability of transferring the content into digital format (Brandl, Richter et al. 2010). In addition, it provides several functions such as classification, editing, organization, and so on.

Although there are many auxiliary note-taking tools have been developed to help take notes in classes, fewer studies focus on the problem that seldom people would review their notes after note-taking. A study proposed a concept of peripheral display of digital handwritten notes that it can help recall the memory by skimming the title or date on the notes

which were displayed automatically on the screen (Hsieh, Wood et al. 2006). Notably, the research result of the study indicates that it is good for low-distraction reminding and unanticipated idea generation.

2.2 Interaction design

2.2.1 Development process in different fields

In the book of Interaction Design (Preece, Rogers et al. 2007), the authors have collected several models from different domains such as the human-computer interaction and software engineering that they are the waterfall development model, spiral development model, rapid application development model, star lifecycle model, and ISO 13407 human-centered design lifecycle model. The first three models belong to the domain of software engineering, and the last two models are arisen from the field of human-computer interaction.

According to the above-mentioned five development models, basically there are not constant titles and quantity of steps or activities in models. But through the progress of different system development cycle models in different domains, it can be observed that there are some common points and trends existing among these models, which can be specified by three main features and four basic activities of interaction design. The three main features are:

1. Focus of the users,
2. Specific usability guidelines
3. Iteration

When researchers are conducting a project, they have to need more people involved for user study by the techniques such as observation, interview, survey, ethnography, focus group, and so on. In addition to understanding the requirements of users, applying the existing usability guidelines in a project is also a feasible way to keep away from the mistakes made by early research. The last feature also plays a key role in interaction design that it is in order to reduce the time of development and risk of requirement changing. Iterative process can provide researchers with the chances of getting the feedback from users to make refinement as quickly as possible. The four basic activities are:

1. Identifying needs and establishing requirements for the user experience
2. Developing alternative designs that meet those requirements
3. Building interactive versions of the designs
4. Evaluating what is being built throughout the process and the user experience it offers

At the beginning of a project, due to the ultimate goal of creating a product capable of satisfying users, we have to know who the target users are and what favors can give to help those users. The result of this activity would be the foundation for subsequent activities. When the needs and requirements have been established, the alternative design ideas can be proposed for meeting the requirements, which can be divided into two sub-activities: conceptual design and physical design. The conceptual design describes what the product should do, what it should look like and how it should behave. The physical design considers the detail of the product including the colors, sounds, and images to use, menu design, and icon design (Preece, Rogers et al. 2007). Because the final product is aimed to interact with users, with the design ideas, we can establish a version of the designs for identifying problems in the early stage of design. The version of the designs does not need to be as real as possible,

which is often built on the format of low-fidelity or high-fidelity prototypes. After the rough version of the design was created, there are several usability guidelines and measures available for evaluating the usability and acceptability of the product or design. Notably, these four basic activities are not conducted only one time. They can be done for several times according to the budget of a project in order to make the design more satisfying.

2.2.2 Research methods

According to the previous section of introducing several models in the fields of software engineering and human-computer interaction, there are five basic activities can be generally sorted out that they are data collection, data analysis, design solution, prototyping, and usability evaluation. In each activity, there are various methods and tools can be determined according to which is suitable for your project and then picked out to utilize. But some techniques can exist in different activities at the same time. For example, the techniques of survey, interview, and observation can also be used along with the usability evaluation. Those commonly used research methods in each activity were collected in Table 1.

Table 1. The commonly used research methods in each activity.

Activity Technique	Data collection	Data analysis	Design solution	prototyping	Usability evaluation
1	Survey	Ground theory	Persona	Low-fidelity	Focus group
2	Diary	Content analysis	Scenario	High-fidelity	Heuristic evaluation
3	Interview	Affinity diagram			Cognitive walkthrough
4	Observation				Usability testing
5	Ethnography				

2.2.3 Application and modification of research methods

There are many literatures in the field of HCI had not only applied above-mentioned research methods in their studies, but also made some modifications to them for efficiency.

In a research relevant with the ethnography research method (Millen 2000), the author has proposed an improved method called the rapid ethnography because the traditional ethnography needs a great deal of time to collect and analyze data that it cannot follow the same pace with the production development cycles. There are three key ideas in this method:

First, to narrow the focus of the field research appropriately before entering the field. Zoom in on the important activities. Use key informants such as community guides or luminal group members.

Second, to use multiple interactive observation techniques to increase the likelihood of discovering exceptional and useful user behavior.

Third, to use collaborative and computerized iterative data analyze methods.

The author in this case modified and adjusted the traditional ethnography due to the constraints of the time. Also in an ethnographic study aimed at building an understanding of Automatic Teller Machine adoption in Mumbai, India (Angelia, Athavankarb et al. 2004), the affinity diagram rather than the more complex grounded theory was used to analyze the data. According to this trend, the research methods used in the field of HCI would be more flexible and adjustable that companies may develop their own research methods to conquer the challenge of time.

3. METHODOLOGY

3.1 Research design

3.1.1 Research process and methods

In chapter 2, there are five system development models in the domains of software engineering and human-computer interaction, in which some common points and trends have been found out that the three characteristics and four basic activities can be the foundation of the process in the interaction design. By means of the common points and trends among those models, the research process in this study would be drawn up based on these characteristics and activities to achieve the goal of user satisfaction.

The research process of this study consists of four phases that they are Look, Ask, Learn, and Try. In the first phase, the goal of researchers is to observe what people are doing in the real context rather than lab-based environment. Through the phase of look, a rough understanding of people behavior could be evolved to help researchers verify what they have seen and get deeper insights in the next phase of ask. After all the data that may be quantitative and qualitative were collected, they would be analyzed in the phase of learn. Moreover, the analysis result could be helpful to the creation of design guidelines that would be applied to the prototype establishment of interface for demonstrating the initial design concepts in the last phase of try. The Figure 2 shows the research process of this study which involves different research methods and outputs for each phase.

In the phase of Look, the combined feedback and elicitation diary method asked participants to make a diary recording when specific events occur and was used as prompts to encourage users to expand the explanation during an interview at a later time that it is able to shorten the gap between the time of events occurrence and recall of that events for the participants (Lazar, Feng et al. 2010). By means of the previous defined events that should be recorded when it occurs, the participants can record useful data for the researchers to conduct further interviews.

In the phase of Ask, the interview technique was employed to ask the users more in-depth questions about the events occurred in the phase of Look.

In the phase of Learn, the qualitative data analysis was conducted by the method of the grounded theory to find out the interesting patterns or problems occurred during note taking in classes. And with the finding from the analysis, the design guidelines would be created to help design more useful interface.

In the phase of Try, the low-fidelity was used to assist researchers in quickly making abstract ideas more concrete to find out potential problems and verify whether an idea is truly feasible through showing the prototypes interacted by the users.

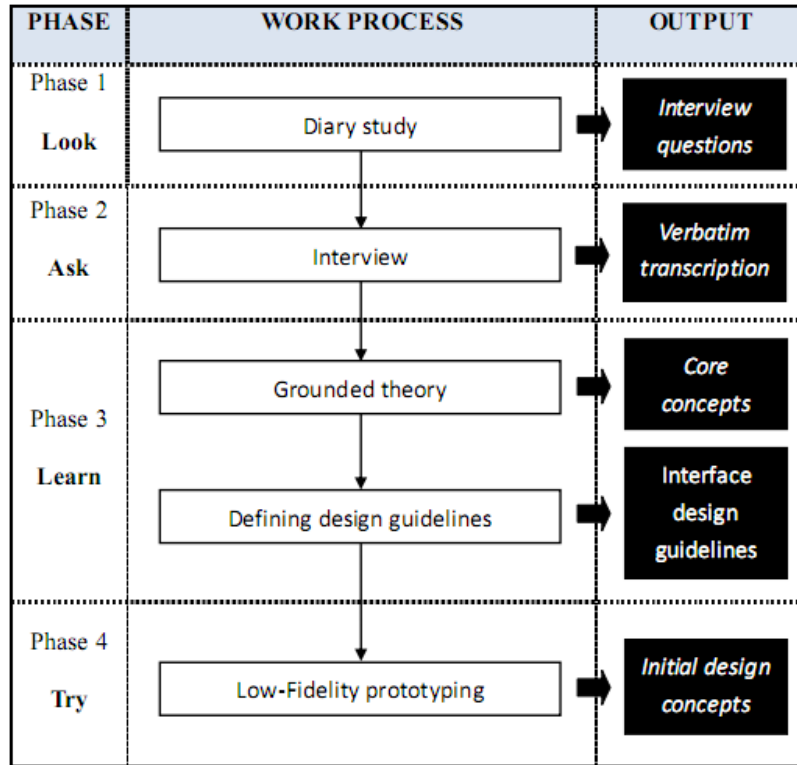


Figure 2. The research process and methods used in this study.

3.2 Study objects

3.2.1 Source of study objects

Because qualitative study focuses more on the user's experience sharing in comparison with quantitative study, we narrowed down the range of participants to the student from the department of Information Management in the National Yunlin University of Science and Technology. And the purposive sampling and snowball sampling methods would be used to recruit someone else who is used to take notes in classes recommended by the existing participants.

3.2.2 Quantity of study objects

The quantity of sample is usually determined by what the problem you want to solve, and when the problem is narrower or the tasks and environments performed and existed in by the samples are more consistent, the quantity of sample can be less (蕭淑玲, 黃宣龍 et al. 2009). According to the above suggestion and the situation of this study that the environment is limited in the classroom and there is only one researcher, five study objects would be involved in the phase of Look and Ask.

3.3 Implementation procedure

When the participants have been identified, they would be informed by the e-mail or cell-phone number to come to discuss about the informed consent face to face and then decide

whether they are willing to participate in the formal study or not. If they sign the informed consent, the schedule of the diary and interview will be arranged.

With those participants who are willing to go on to the formal study, they would be provided with a table of the diary that they need to fill out the form according to what we need them to record. Besides, when they attend a different course, they have to use new diary table to record the data relevant to this course. As all the diaries are finished, they will be collected for further observation by the researcher to discover the interesting phenomena that would be helpful to the question establishment in the next phase of Ask.

When all users' diaries had been filled out after one week, those data that contain written words and photos would be analyzed respectively. The written words would be analyzed by means of the grounded theory to find out the common phenomena of each diary based on four aspects of teaching methods, note-taking tools, note-taking ways, and other assistant learning methods. The photos would be analyzed by inspecting for the interesting phenomena on the basis of note-taking tools and methods. With all the organized phenomena, they would be the source of interview question. When interviewing with participants, they would be asked about the reason and purpose constantly based on those phenomena and their responses to my question. During interviewing with all participants, the dialogue would be recorded and then transferred to the verbatim transcription for data analysis in the next section.

When the verbatim transcription was derived from the interviews, it would be analyzed according to the grounded theory to explore something new and develop theory. There are three main stages that the open coding in first stage was to analyze the text and identify any interesting phenomena, the axial coding in the second stage was collection of similar codes to identify and form concepts, and the selective coding in the third stage was to identify the potential correlations between each concept. When all the correlations had been identified according to the verbatim transcription, the core issues would be created through collection of similar propositions.

Because the core issues can stand for the important and critical problems or phenomena occurred during the note-taking behavior in class, in order to solve these problems or provide more effective solutions for note-taking in class, we tried to define some design guidelines based on those core issues for the next section to propose initial interface design concepts.

On the premise that the technology of tablet pc is mature enough at present, it was decided to be used as the basic platform for the interface design. And the interface design concepts were be demonstrated in the format of low-fidelity prototypes by the software of Axure RP.

4. RESEARCH RESULT

The following sections are the research result derived based on the diary study and grounded theory. The research result was transferred into design guidelines and creating initial interface concepts displayed by low-fidelity prototypes.

4.1 Core issues

After analyzing the row data from the diary study and interviews by the grounded theory, there are eight core issues found from each combination of different propositions can represent the critical problems or phenomena about note-taking behavior in class. The core issues were explained in detail as the following:

1. Limitation of interaction between each student in classes

It reflects that if students miss taking some notes of important information in classes, they will borrow notes to refer from classmates or directly ask them that it will result in distraction with the result of missing more information. Therefore, most of students incline to borrow notes from classmates or ask them out of classes instead of in classes.

2. Purposes of reviewing notes

It indicates that the purposes of reviewing notes by students basically consist of (1) helping do exercises, (2) helping answer questions from teachers or classmates, (3) helping recall or comprehend the teaching content they forget or don't understand. Because the memory retention will decline as time goes by, reviewing notes is helpful to recall or associate the memory they forgot in those above-mentioned situations.

3. Related note-taking tools

It reflects that the related note-taking tools such as the stationery (pencil, whiteout, correction tape, eraser, white paper, filler paper, and notebook) and electronic products (camera and video camera) are used basically result from the reason that the writing speed can hardly keep pace with the speech speed, which leads to the problems about writing wrong words or missing more information. Therefore, they use the pencil and eraser instead of pen and whiteout to reduce the time consuming problem on using the correction tool while the eraser and correction tape still have the shortage of difficult control of clean range. In addition, students use the camera to quickly record abundant or complex information, or even watch the course videos for supplementing the missing information of notes. Besides, the kind of single paper such as filler papers is good for expanding the content of notes and management. Although the baselines on papers will interfere with reading when taking notes by drawing, they are still good for note editing when taking notes by writing primarily.

4. Note-taking methods

It reveals that the low writing speed will influence the note-taking methods used in classes such as simple symbols (line, arrow, asterisk, parenthesis, triangle, question mark, frame, English alphabet, Arabic numeral), drawing, different colors, and written words (transcription and condensation) which are not only capable for speeding up note-taking, but also able to assist note editing such as distinguishing different notes, sequencing, and classifying so as to make key points of notes clear and easy to read and comprehend.

5. Reading of notes

It indicates that it is easy to forget the meaning of notes when reviewing them because the memory retention will decline as time goes by. If the frequency of reviewing notes is too low to stimulate memory timely, or when the date of reviewing notes is far from the date of taking notes, it will be easier to forget the meaning of notes.

6. Note searching

It reflects that when reviewing notes, students usually search for specific information rather than reading complete notes. So the method of searching notes by turning every page will waste a lot of time.

7. Incentives of note-taking

It shows that there are several situations will prompt students to take notes. For instance, the teaching content will be the source of test, when they feel interested or confused, or teacher has told that something is very important.

8. Note management

It reveals that when students write down a title such as chapter or date on the paper and stack them in the sequence of chapters and sections, or put them with the same teaching materials together that would be more convenient and quicker to search for what you need while reviewing notes.

4.2 Design guidelines

The core issues represent the important problems or phenomena about note-taking behavior in classes, which can be adopted to be the foundation of establishing design guidelines for improving the usability and user experience of products like the auxiliary learning equipment or software. There were five design guidelines proposed as the following:

1. Accelerating the speed of note-taking

From the core issue 1, 3, and 4, they reflect that the main purpose of using simple note-taking methods, borrowing notes from classmates in or out of classes, and using additional assistant tools is to make students able to keep pace with the speech speed when taking notes. Therefore, the critical factor is to speed up the note-taking.

2. Providing the function of notes editing

From the core issue 2, 3, and 4, they indicate that the simple note-taking methods and baselines on papers will affect the note editing and reading. In addition, students would review their notes to assist in recalling or associating with the forgotten memory in some situations. Therefore, the function of note editing is essential for assisting in comprehending the meaning more quickly when reviewing notes.

3. Effective note management

From the core issue 8, it shows that the methods of classifying and storing notes such as writing down a title on papers, putting the papers of notes with handouts or textbooks together, and using different kinds of folder are good for the note searching when reviewing notes because the speed of searching out the notes you need would become faster. Therefore, effective classifying and storing abundant notes are very critical.

4. Accelerating the speed of note searching

From the core issue 6, it indicates that when reviewing notes, students usually search for specific information rather than reading complete notes. If searching notes by turning every page will waste a lot of time. Thus, it should reduce the time-consuming searching for notes.

5. Enhancing the memory for notes

From the core issue 5, it reveals that it is easy to forget what you learned or the meaning of notes when reviewing them because the memory retention will decline as time goes by. It should to stimulate our memory timely so as to promote the value of note-taking behavior.

4.3 Initial design concepts

Nowadays, the tablet computer such as the iPad designed by Apple incorporation is very popular that it is the dominant trend in electronic products. Thus, our research has proposed several initial design concepts based on the aforesaid design guidelines and established the low-fidelity prototypes based on the platform of tablet computer to demonstrate. The following is one of the initial design concepts based on the design guideline 5.

Design guideline 5: Enhancing the memory for notes

There is a problem that the memory retention will decline as time goes by. Besides, seldom people will review their notes again after taking notes. Hsieh, Wood, & Sellen (2006) proposed a concept that automatically displaying the notes on the computer screen for people to intentionally or unintentionally watch can promote the creativity. Therefore, Figure 3 shows the interface that it can automatically display the notes in order of the date. The frequency of occurrence for notes will depend on the date of note-taking. The older the notes are, the more frequently they appear. If you suddenly have an idea or need to stop to think, tapping the screen can immediately stop displaying.

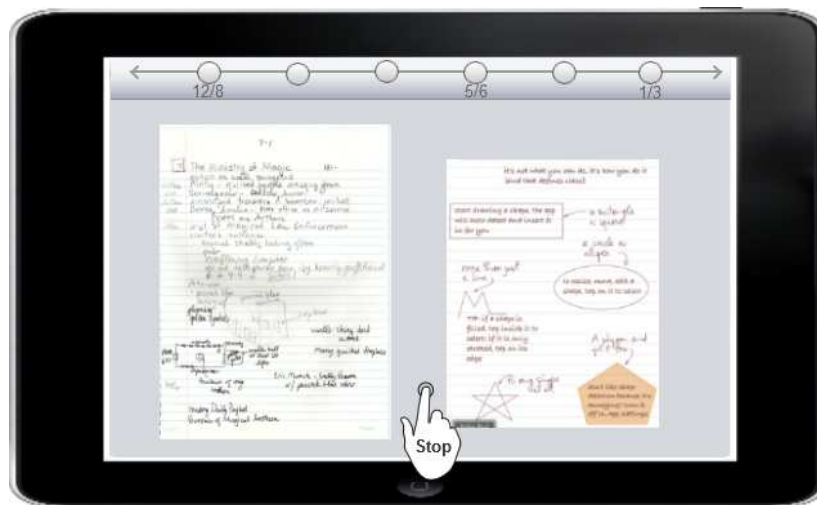


Figure 3. The initial design concept of note displaying.

CONCLUSIONS

5.1 Conclusions

Based on the interaction design process, we start from the original requirement identification by means of the dairy study, interviews, and grounded theory to explore the phenomena and problems about note-taking behavior in classes. And there are eight core issues explored which are the limitation of interaction between each student in classes, purposes of reviewing notes, related note-taking tools, note-taking methods, reading of notes, note searching, incentives of note-taking, and note management respectively. Then in order to improve the experience for the users by making interfaces more useful and satisfying, there are five design guidelines established rest on the core issues for application developers to follow. In this study, we also try to propose several initial design concepts based on those design guidelines for developing interfaces of assistant learning application in classes. However, a previous study related to the note-taking claims that even a convenience-oriented

functionality of technology such as the copy-paste would have a negative influence on users because users perhaps reduce attention to detail or not actively generate own notes when using copy-paste functionality (Bauer and Koedinger 2006). So it complements this study for the caution that it should be careful when designing interfaces. Although a design concept seems very convenient, it would have an exactly opposite effect.

5.2 Implications

In addition to the study of interface design discussed previously, according to the core issues of the purposes of reviewing notes and incentive of note-taking, they reflect that there are several situations will prompt student to take notes such as the teaching content will be source of test, when they feel interested or confused, or the teacher has told that it's very important. So how to inspire them to take notes will be the first and critical problem for solving before creating a well-designed application. Similarly, a finding of previous study claims that if it can integrate meaningful laptop activities into the classroom, the frequency of beneficial laptop behaviors will increase (Kay and Lauricella 2011). Thus, inspiring students to take notes is very important that it can enhance the real efficiency of designing assistant learning applications.

5.3 Limitation

The limitation concerns the less number of participants because more participants need more time and human resources to collect and analyze users' data.

5.4 Future research

The future research of this study is as follows:

1. Perhaps future research could expand the initial design concepts of this study to the evaluation stage in the interaction design process. That is, to design more complete and interactive prototypes to evaluate the usability of them.
2. With the design guidelines of this study, they can also be applied to other different technologies such as the virtual reality and augmented reality.

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