Authoring and Sharing Annotation in Touch-based Mobile Devices

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Abstract

Electronic textbooks are offering functional advantages over classic paper textbooks. They provide various features like bookmark, annotation, and interactive contents. However, the growth of electronic textbooks has been slow. One of the main reasons is that usability of digital textbooks was often not evaluated carefully. For example, most students frequently highlight text and insert notes in the digital textbooks. Thus, annotating usability should be examined and designed for the reading system in education. The proposing interface was designed to support the students' annotating behavior and learner-centered education. The interface design was based on a requirement specification defined by expert consultation, data analysis and mental model. Therefore, we implement note-taking interface for digital textbooks according to the requirement. In this, paper, we present then the evaluation indicating that usability of our proposing interface in touch-based mobile devices satisfies users and reflect their needs.

Keywords: *Digital Textbooks, Note-taking, Mental Model, Data Analysis, Expert Consultation, Annotation*

1. Introduction

The digital textbook market has already grown largely, and widely applied to education field [1-2]. Especially, the usability of digital textbook has become more important with a numerous new touch-based devices.

In South Korea, the government initiated the pilot study to build and analyze the smart education infrastructure as shown in Figure 1. Digital textbooks on tablet computers have been used at certain schools since 2006 [3, 4]. According to the Korean government plan, the smart device and digital textbook will be distributed to elementary, middle and high schools by 2015.

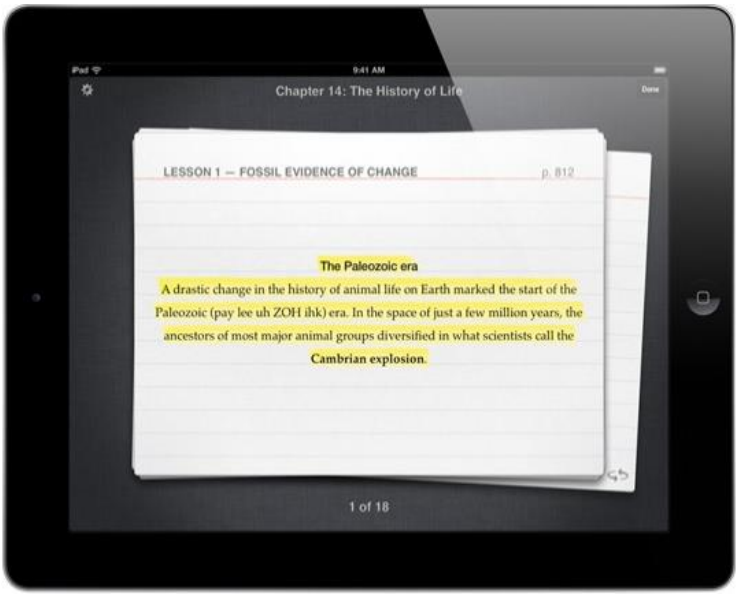
The use of digital textbook on the touch-based devices such as Amazon Kindle or iPad (Figure 2(a)) is more likely to replace paper-based reading rather than reading that was done on the desktop environment. Moreover, hardware manufacturer, such as KNO (Figure 2(b)), made an alliance with publishers to supply digital textbooks running on the various touch devices for college students over the country.

However, Amazon found that a considerable number of the users had quit using the Kindle DX for reading due to issues like its lack of support for note-taking and problems with looking up references, which was easier to do on the computer. In addition, the Kindle DX had negatively affected a study technique called cognitive mapping, which helps readers use

physical cues they have seen on the pages to remember where to find a specific section of text. Also, most of students used paper to take notes as they read [5].

Figure 1. Smart Education Infrastructure in Korea

Many researchers [6-8] believe the pen or sketch-like input metaphor makes the tablet computer more user friendly and easy to learn. The main reason is the usability of the tablet device because Ovsiannidov, *et al.*, [2] and Marshal [6] pointed that the usability effects on user experience and learning effect. Inappropriate design in usability may cause a negative cognitive process in learning, therefore it is very important in elementary school education [9-10]. According to researches, it is shown that the following two factors should be considered to enhance the usability of educational contents in touch-based device [11].



(a) iPad

(b) KNO

Figure 2. An Example of Touch-based Educational Content

First, a user requirements need to be analyzed to define the development goal and requirement specification. To do this, we used expert consultation, data analysis, and mental model approaches. Second, implementation of a prototype application based on the requirement specification is required. A usability test is also required to evaluate its effectiveness.

In this paper, we propose research design and implementation in Section 2 and evaluate it in Section 3. Then, we conclude in Section 4.

2. Related Works

In desktop environment, many Web annotation tools have been developed. With a Web annotation system, a user can add, modify or remove information from a Web resource without modifying the resource itself. The annotations can be thought of as a layer on top of the existing resource, and this annotation layer is usually visible to other users who share the same annotation system [12].

However, smart devices such as iPad or Galaxy Tab use touch-based input method, and this makes a big different usage from classic desktop Web annotation. Yet, not many studies on annotation field in touch device have been done, because the history of touch device is not long enough compared to the desktop system.

The most common book reader is iBooks, launched by Apple. It supports basic annotation features such as note, highlight and bookmark as shown in Figure 3. It also synchronize user bookmark in a book purchased by the same account between the apple devices. If a user need to select more or less of the text to highlight, a user can pinch to zoom as necessary. When a user taps and drags one of the small blue dots to change the selection, a small magnified excerpt of the text. It aids to choose the precise text selection. This process may require a user to a detailed manipulation leading to cognitive loads.

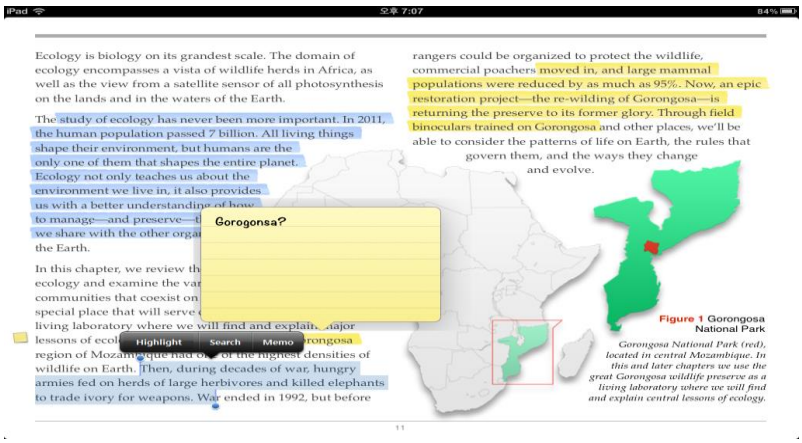


Figure 3. iBooks Annotation Example

iAnnotate is another commercial annotation tool developed by Branchfire, LLC. This PDF annotation tool allowing a user to annotate PDF documents on iPad as shown in Figure 4. It supports pen, highlighter, typewriter, stamps, note, underline, strikethrough, photo, voice recording, and date stamp functions.

Annotating method is similar to that of iBooks. In addition, it supports free hand-drawing to write text or drawing shapes by touch gesture. This tool is specifically designed to annotate on PDF document. However, most electronic textbooks are now follow HTML5 or ePub standard. Thus, annotation features should support web document standard for compatibility and reuse issue.

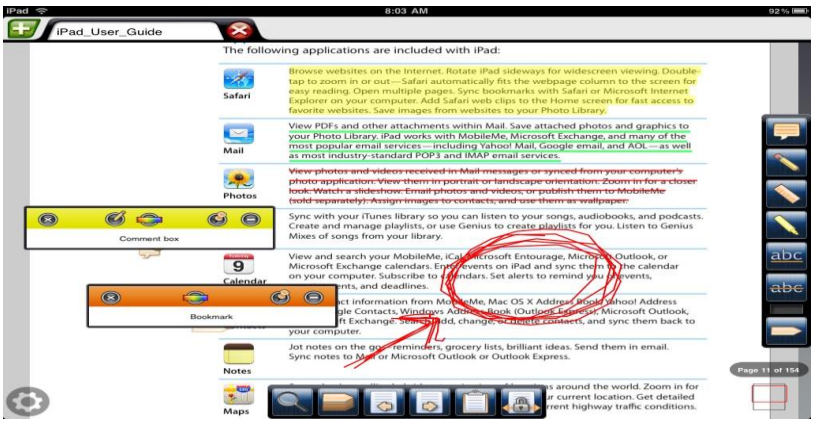


Figure 4. iAnnotate Interface

Most electronic book readers on tablet pc support various annotation features. However, the most important issue in creating annotation on touch device is usability of user interface. The interface should be properly designed by requirement analysis and observing user behavior. Therefore, we propose user interface for creating annotation at the following section.

3. Design and Implementation

To prepare the research design, requirement analysis consisting of expert consultation, data analysis, and mental model approaches was conducted.

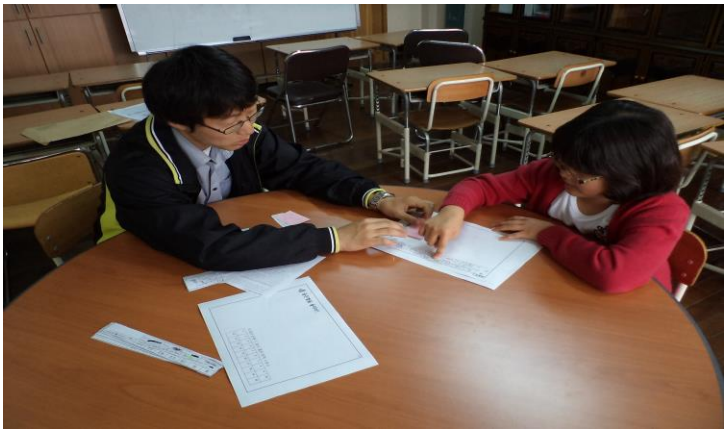
3.1. Requirement Analysis

For expert consultation, 5 elementary school teachers participated in this analysis. 4 teachers have an experience with teaching a class using digital textbook and the other is currently studying mobile e-learning system at graduate school. Therefore, all of them have a profound knowledge about the smart devices and e-learning system. According to their experience, they suggested the necessary features in note-taking interface as shown in Table 1.

For data analysis, related papers and common note-taking software such as Microsoft OneNote, UPAD, Penultimate and other applications currently using in elementary school in Korea were analyzed.

For mental model, we observed student's behavior such as the way that the student creates and organizes the note as shown in Figure 5. For this observation, we used behavior, behavior-stack, and metal space process. We firstly construct the behavior stack, the collection of similar actions form extracted primitive actions such as 'writing text' or 'drawing a shape'. For example, 'adding annotation' stack contains a pile of actions such as 'writing text', 'using a highlight pen', and 'drawing an underline'. Then, the stacks are categorized based on the functional similarity and each category is called metal space. In this research, we found 103 actions, 42 stacks, and 6 mental spaces.

(a) Paper Prototype



(b) Observing Student's Behavior

Figure 5. Observing Student's Behavior by Paper-Prototype

We present only major requirements as shown in Table 1 due to the space limitation. We did not implement the relatively less important applications such as color of pen or icon on our prototype yet since they are more related to decoration. They will be included in the future version.

Table 1. Requirement Specification

Requirement	Type	Applied	Requirement	Type	Applied
Post-it Style	E/M	○	Highlight pen	D/M	○
Note Sharing	E/D/M	○	Category	D	○
Bookmarking	E/D/M	○	Sorting	D	○
Text Typing	E/D	○	Searching	D	○
Handwriting	E/D/M	○	Arrows	M	
Notebook	D/M	○	BBS	E	
Note Resizing	D	○	Colorful Icons	M	
Note Rotating	D/M	○	Colorful Pen	M	
Note Moving	D/M	○	Correcting Pen	E	
Note Deleting	D/M	○	Shapes	M	
Multi-Pages	D/M	○	Text balloon	M	
Freeform Area	E/M	○	Auto-Saving	D	

E : Expert Consultation, M : Mental Model, D : Data Analysis

4. System Implementation

Base on the specification, we designed and implemented a note-taking interface for tablet PC (*i.e.*, iPad). Detailed function and structure of the application are described in [13]. In this paper, we focus on the design process and the evaluation.

4.1. Note-Taking Interface

We implemented the proposing interface on iPad which has the biggest portion in the global tablet market. The basic function of interface is to create and read a note by touch gestures. The interface also has a proposed touch correction module to help a user creating annotation in an easy and accurate way.

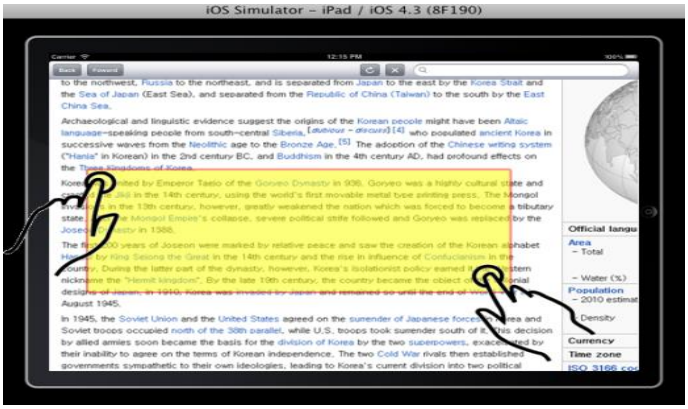
The interface provides several gesture commands for inserting an annotation. A user can move a finger to select a desired region until a target is highlighted. This input gesture is mainly used for inserting an annotation on a simple object such as an image, video, or a paragraph of text shown in Figure 6.

(a) Initial Input by User

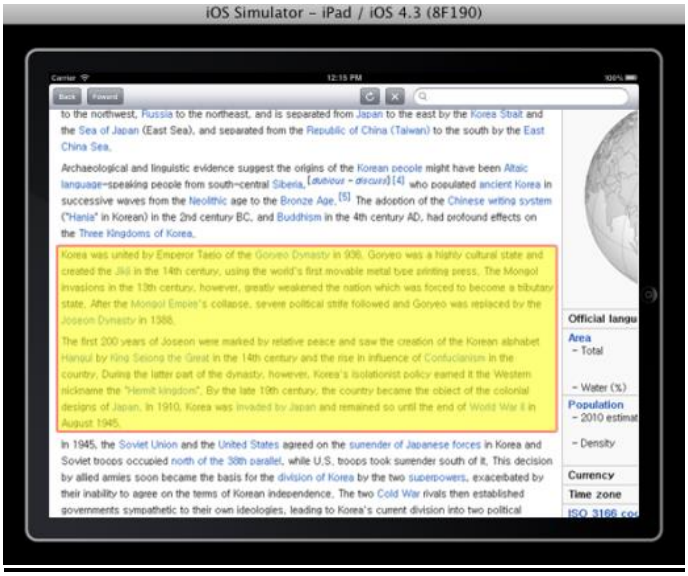
(b) Corrected Area

Figure 6. Selecting Object on a Website

User can also select multiple objects by moving two fingers for resizing the selection area. User can select not only a part of paragraph, but also multiple paragraphs. For the better usability, our correction process will select whole paragraph when the selected text size is larger than a certain threshold size of paragraph.



(a) Drawing an Area Over Two Paragraphs



(b) The Area is matched to Two Paragraphs

Figure 7. Selecting Text by the Second Type of Touch Gesture

Figure 7(a) shows the text area selected by a user and selected area exceeds 90% of two paragraphs. Then, the correction module expands the region to select two paragraphs as shown in Figure 7(b). The module assumes that the user intends to refer the whole two paragraphs, but is not be able to select them exactly due to the inaccurate input type of touch interface.

After finalizing the area, an empty slot will be appeared on the right side of the screen. A user can drag and drop the selected object into the slot to store it in the note collection as shown in Figure 8.

Figure 8. Note Collecting Interface

4.2. Organizing and Sharing a Notebook

The proposing application has another view called a notebook canvas where a user can create a personal notebook by inserting notes from the collection. The collected notes are listed as thumbnails on the left side of the screen ordered by date or source web URL. A user can drag and drop the thumbnail on the empty canvas, and also insert a blank note as a new note. It also provides basic touch gestures to manipulate a note clip such as translation, rescaling, and rotation as shown in Figure 9.

When a user stores a created notebook on the cloud server, it can be accessible at any location. In addition, a notebook can be shared to other group members for their information. Touching the 'publish' button on the top of the screen sets one of notebooks open to the public. Thus, other group members can read public notebooks and import them into their workspace as well.

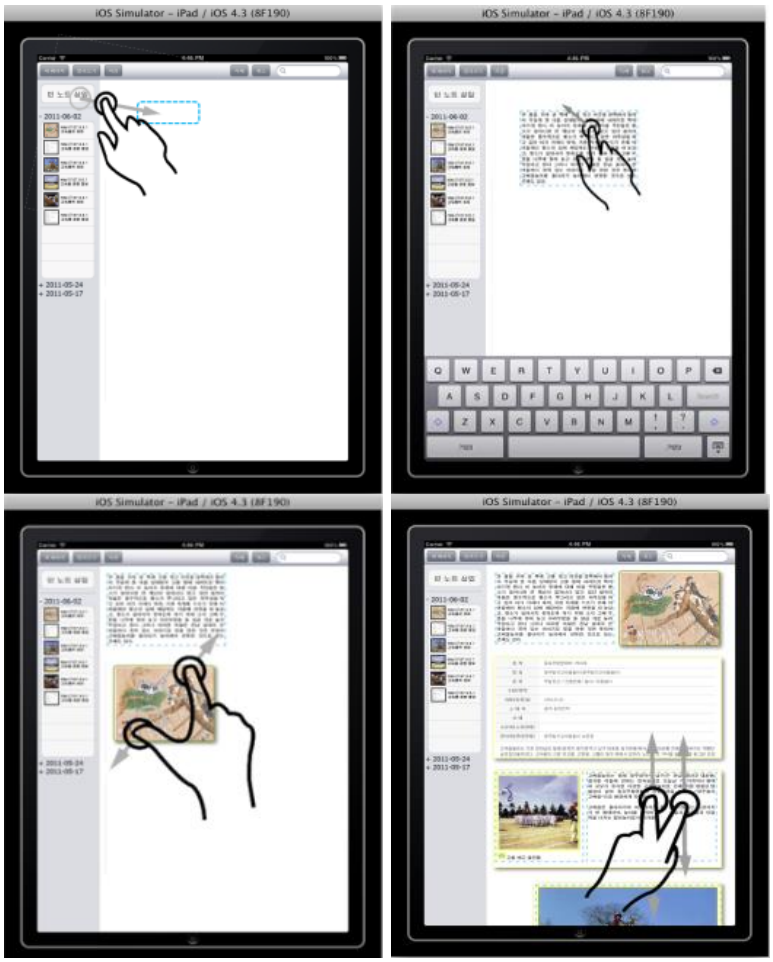


Figure 9. Notebook Editing Interface

In educational institutes, it is shown that many students tend to refer a well-noted notebook of a top student or a teacher. They also often tend to discuss about their notes. These educational behaviors are the motivation of this interface.

5. Evaluation

In this test, interface A represents the proposed application, and B represents the Microsoft OneNote for iPad application. Both the proposing and a comparative interface are explained for 30 minutes to 40 elementary students (*i.e.*, 21 male and 19 female, the 6th grade student) as evaluators. We have them familiar with the interface before the test. Hypothesis testing is listed as follows:

H1 : Interface A will take less time to complete the tasks than B
H2 : Interface A will improve student's knowledge more than B.
H3 : Interface A will show higher system usability scale than B.

The interface B is evaluated using quantitative and qualitative methods. Both the proposing and a comparative interface are explained for 30 minutes to 40elementary students (*i.e.*, 21 male and 19 female) as evaluators. We have them familiar with the interface before the test. The participants were divided into experimental group (*i.e.*, EG) and control groups (*i.e.*, CG). EG used the interface A and CG used B.

5.1. Experiment Design

Table 2 shows the design of experiment. A pre-test was given to measure the participant's basic knowledge of the employing material in experiment. Then, the designed tasks, post-test, and questionnaires were given.

Table 2. Design of Experiment

Group	Pre-test	Interface A	Interface B	Post-test	SUS
EG	P_1	X_1		P_2	S_1
CG	P_1		X_2	P_2	S_1

P_1: Pre-test, P_2 : Post-test
X_1, X_2 : Task completion time of interface A and B respectively
S_1 : System usability scale

5.2. Methods for Measuring Task

As described in Section 3.1, four methods were designed for measuring task. The basic knowledge of the given material was measured by the pre-test. Second, we defined the tasks to measure the completion time. The following 4 tasks were given to the each group.

T_1: Reading a whole material only with page flipping
T_2: Annotating and taking a note on the material by using the functionality of given application
T_3: Making a notebook by using the collected notes from T_2
T_4: Sharing the notebook with group members. Participants can freely make a comment on other's notebook

Third method measures the improved knowledge after completion of T_1 through T_4 by the post-test. In post-test, participants were asked to solve it by the same methods used in pre-test.

Finally, system usability scale [17] was employed to measure the degree of user efforts and resource usages for the successful job completion and user satisfaction.

5.3. Evaluation Result

EG and CG scored average of 4.13 and 4.19, standard deviation of 0.18 and 0.40 respectively as shown in Table 3. We can see that the difference of test results between EG and CG is not significant (p = .44). This ensures that those two groups have a similar level of basic knowledge on the material.

Table 3. A Comparison between the Pre-Test of Two Groups

	N	Avg.	SD	t	p
EG	20	4.13	0.18	-.803	.441
CG	20	4.19	0.40		

After the pre-test, we evaluate the time needed to complete the given tasks. The entire outcome of two groups is shown in Table 4. Paired-t test was used to analyze the result. CG takes more time to complete the tasks from T_2 to T_4(p=.000, .004, .033 respectively). T_1 showed no significant difference. This means that reading the whole material took the same time in the both application.

Table 4. Time Cost for the Given Tasks

Task	*Group*	*N*	*Average(min.)*	*SD*	t	*p*
T_1	EG	20	8.54	0.85	-.30	0.765
	CG	20	8.62	0.81		
T_2	EG	20	13.80	1.94	-6.34	0.000
	CG	20	18.63	2.79		
T_3	EG	20	13.60	2.36	-3.03	0.004
	CG	20	15.64	1.84		
T_4	EG	20	8.50	1.53	-2.20	0.033
	CG	20	9.56	1.48		

One hour is given for each group to study the assigned material. As shown in Table 5, the score of experimental group is higher than that of control group. Significant difference is found(p = .009).

Table 5. A Comparison between the Post-Test of Two Groups

	N	Avg.	SD	df	t	p
EG	20	86.01	7.16	21.50	1.023	.009
CG	20	72.24	18.98	13.78		

We can see that use of the proposed notebook application on a touch device have on positive effect on the problem solving skills.

Finally, the questionnaires were given to measure system usability scale. The average of EG and CG were 87.6 and 76.5 respectively. The significant difference was found between two groups(p=.02). Interface A generally received higher satisfactory scores than B.

The feedback of the participants after above studies indicates that the interface A was more intuitive and easier to use, especially in note-taking and sharing functions. The interface B receives a positive feedback for the categorizing tab function that helps categorize the notes easily.

6. Conclusion

In this paper, we designed and implemented an annotation interface for electronic textbook and evaluated its efficiency. We aimed a low-cost and accurate user interface. As the proposed interface required less touch inputs than the basic selection interface provided OS, it cost less time and effort. The interface was simpler and more intuitive to work with than the basic interface. Moreover, the annotating and sharing note functionality improved student's knowledge.

One of limitations is that it was implemented for iPad tablets only. We are currently developing the system for other mobile operating system such as Android. Therefore, we will enable students to access their annotation on any mobile device and anywhere by using cloud server.

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