The Effects of Touch Input Modes and Navigation Bar Styles on the Usability of an Ecology Education System

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Abstract: Many organizations had employed interactive media systems to facilitate ecology education in natural science museum or through websites based on touch screen technologies. Since the mapping issue between input modes and digital contents is very important, the objective of this research is to study the effects of touch input modes and navigation bar styles on the usability of an ecology education system. In this research, three types of navigation menu, i.e., global fisheye menu, local fisheye menu, and tabbed menu were constructed for comparison. In addition, two touch modes for the backward shortcut button from the detailed page to the main menu were constructed. In the experiment, participants carried out typical tasks to locate assigned pages for searching information. Video recording were employed to keep track of the behaviors. After that, the participant was asked to complete system component usability and overall workload questionnaire. The result revealed that tabbed menu with long touch was superior in usability.

Key words: User Interface Design, Touch Screen, Navigation Bar, Ecology Education Media

1. Introduction

Many organizations had employed interactive media systems to facilitate ecology education in natural science museum or through websites. The information architecture of such an ecology education system is always complicated, with a large amount of information located in many pages within different hierarchy. With the advent of touch screen technologies, more and more touch devices had been installed, either for large screen or mobile devices. Since the mapping issue between input modes and digital contents is very important, the objective of this research is to study the effects of touch input modes and navigation bar styles on the usability of an ecology education system. In this research, the literature relevant to different navigation styles and touch input modes were discussed. Based on the results of literature review, three types of navigation menu and two input modes were chosen to construct the experimental education systems for comparison. Detailed results were presented in the following sections.

2. Literature Review

2.1 Navigation Menu Design

It was recognized that the style of a navigation menu played an important role in an information system, especially in the case with huge amount of information distributed in the same level of a hierarchy. A good navigation style can definitely help user find information easily. In order to provide the solution for the case that many menu items should appear at the same level, some literature had proposed two different approaches, i.e., fisheye view menu [3] and tabbed menu [12]. They are discussed in the following sections.

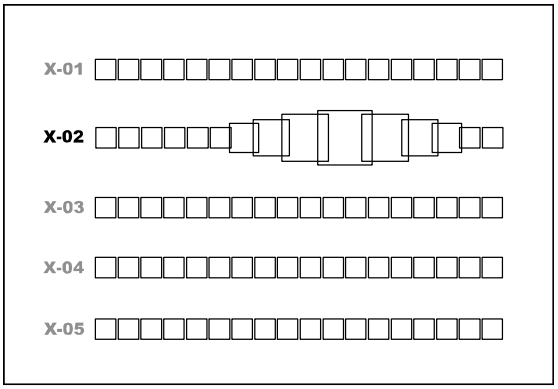

Figure 1. Fisheye Menu

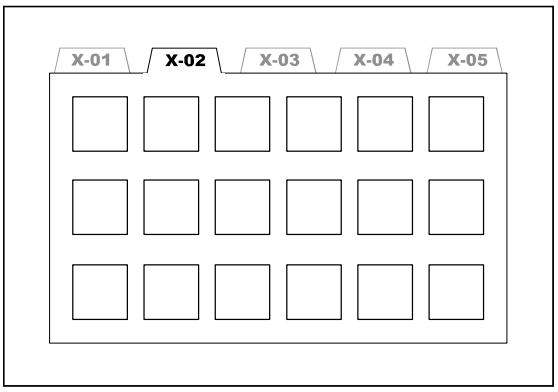

Figure 2. Tabbed Menu

2.1.1 Fisheye Navigation Menu

As if a magnifier and a camera fish-eye lens, "Fisheye" views on a page of a traditional book, is a logical and intuitive ways to finding information, especially, reading small letters from a lot of context in a thick book. "Fisheye" can show places nearby in detail while still showing the whole picture (Figure 1). It provides local detailed finding of interactions by assigning focal points and magnifying the working area with peripheral awareness by showing their position and actions in a global context. Fisheye navigation provides convenience to navigate information from global contexts and local details in a same time. It is useful for the computer display of large information structures [3][5]. Compared with Zoom and Panning Techniques, researchers found fisheye view was faster and effective navigation interface on small screens [6]. In addition, fisheye systems had been shown to perform well in a number of contexts for navigating networks [10]. Some companies even developed fisheye UI widgets for web application (http://demos.dojotoolkit.org/demos/). Although fisheye navigation styles had been proved to be useful for large information structure on desktop screens, no evidence had shown that it would be superior on a large touch screen.

2.1.2 Tabbed Navigation Menu

Drawn from the idea of the "folder tab" used in paper file cabinets, tabbed panels are useful and fast in searching information (Figure 2). In addition, an important purpose of using tabbed panels for navigation controls is to save space [8]. It was reported that Amazon.com was the first major e-commerce web site to use tabs as a primary navigation mechanism. Since then, tabs as navigation have become widely popular [9]. Base on empirical studies, Burrell and Sodan [1] reported that users preferred tabbed style compared with top and left navigation bars. Although tabbed navigation styles had been proved to be useful in browsing web on desktop

computers with the mouse as the input device, no evidence had shown that it would be superior on a large touch screen.

2.2 Touch Input

Touch technology provides a more intuitive and the most natural of all input devices for interacting with digital contents [7]. Since 1990's, a great deal of interactive multi-media touch screen kiosks had been built for public information system, they provided self-use services at transportation counter, bank's ATM system and information announce at public service centers. Through direct touching graphic elements, touch input was more compelling than mice and pointing devices. Nowadays multi-touch input system provides benefits for multi-user working with digital contents, touch input not only controls on desktop screen but also working on different size screen and tabletop player. Direct-touch interaction on tabletop displays provided several benefits over traditional desktop displays [13]. Similar to the mice control function, single finger touch input had different control modes: single touch, double touch and long touch, depending on different depress timing and acting interval speed [2]. Running on the Diamond Touch, multiuser, touch-tabletop surface, some researchers had developed a personal digital historian system that facilitated story sharing around the table. When the user performs a long touch (by holding down the touch for 0.5 second) on an image, a contextual menu with eight items pops up that allows users to easily request more pictures that are similar along any of the who, what, when, or where dimensions [11]. In a research project, a virtual touch screen was developed to offer similar actions like those of a mouse. A touch can be interpreted as a click, a "double-touch" (touching the wall twice within a short time period) as a double-click [4].

2.3 Summary of Literature Review

Although a great deal of research had studied the usability of different navigation menus for desktop computers with regular screen size and mouse inputs, the study of menus for large touch screen was not enough. As more and more public information kiosks use touch screen, the study of the interaction between touch input modes and navigation styles deserved much attention. Therefore, the objective of this research was to study the effects of touch input modes and navigation bar styles on the usability of an ecology education system.

3. Experiment Design

3.1 Three Types of Navigation Menu

The experiment media had the introductory contents of Taiwan natural species and employed the 2-level information architecture with a natural atmosphere and situational music. To the right was a diagram with vertically-arranged text that indicated the altitude. In addition, a horizontal navigation menu with animal or plant images appeared for each altitude at the first level. By touching on the menu, text contents displayed the information including the animal's name, scientific name, characteristics, habitual behaviors and habitat at the second level. The user could touch on the speaker icon to listen to the animal's sound, or the camera icon to play a video. Based on literature review, several experimental navigation bar styles at the first level were constructed. The fully expanded style was the basic one, in which all menu items among different categories were of the same size and spread on the screen. In addition to this style, three more styles were developed for comparative experiments, i.e., global fisheye, local fisheye, and tabbed. For global fisheye, the menu set of selected

categories was larger than neighbor sets. The size of menu for unselected categories decreased gradually based on the distance from the selected categ ories, i.e. th e farther the unselected category, the s maller the menu size (Figure 3). For local fisheye, all menu items were of the same size except the ones near the focal point of touch. That is, the size of menu items in each category increased twice as the finger rollover on them and decreased to the regular size as th e finger leave the menu (Figure 4). In the tabbed style, only the items of selected category would show up at one time (Figure 5). User needed to touch the category buttons at the right hand size to trigger the tabbed panels with menu items. In each panel, menu items were of the same size.

All three conditions had equal numbers of menu items and shared the content in pages at the l owest level with detailed description for a sp ecific animal or plant. Backward buttons were provided for the user to trav el from these pages back to the fully expanded page (Figure 6).

Figure 3. Global Fisheye Menu

Figure 4. Local Fisheye Menu

Figure 5. Tabbed Menu

3.2 Two Touch Modes of the Backward Shortcut Button

In order to navigate among different levels of pages, single touch was used to travel from the fully expanded menu to the experiment menu and from the experiment menu to detailed information page, or reversely. In addition, double touch or long touch was used for backward shortcut button for users to jump from each level back to the fully expanded level at any time. The double touch mode is similar to the double click of a mouse. These touch modes were tested to interact with the navigation menu. The Illustration layouts of different menu styles and corresponding touching modes were presented in the following diagram (Figure 6).

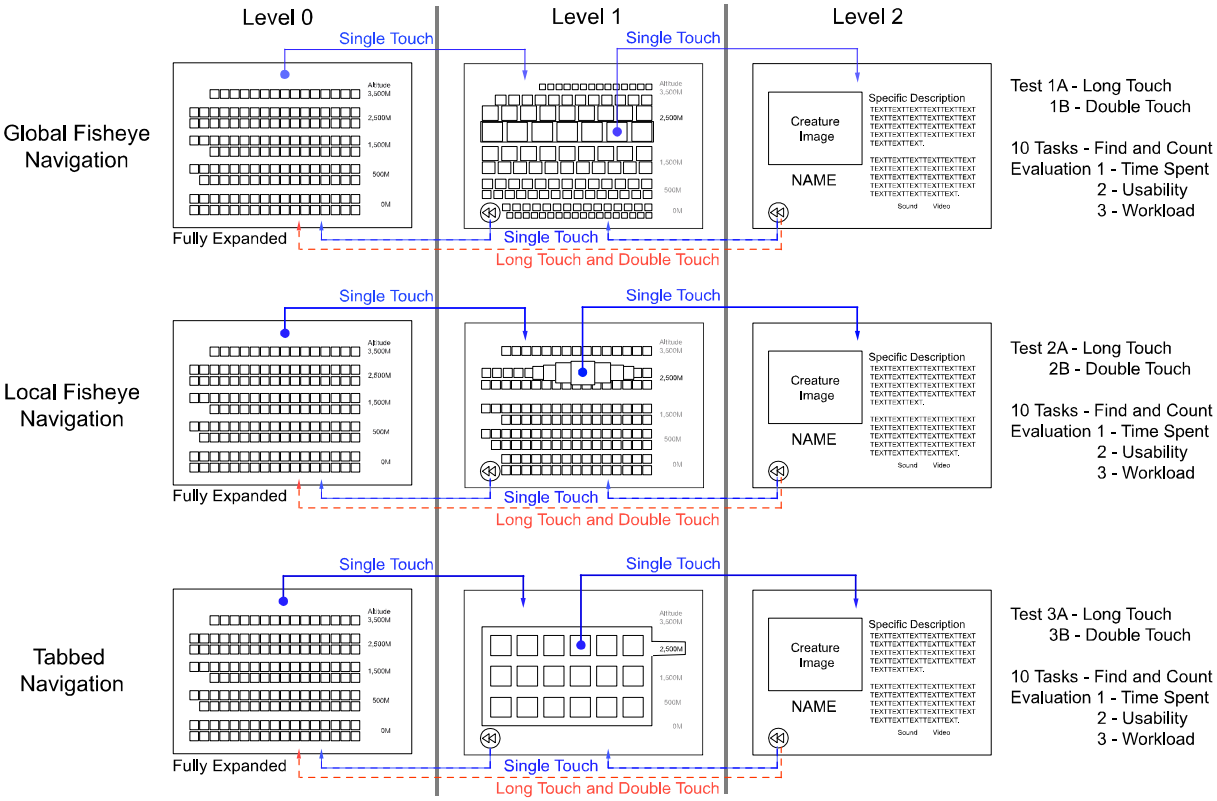

Figure 6. The Experiment of Long Touch versus Double Touch for the Backward Button

3.3 Equipments and Procedures of the Experiment

Since three types of navigation menu and two types of touch modes for the backward button were considered in the experiments, this research employed a 3 x 2 factorial design. The three levels of navigation menus were global fisheye, local fish eye, and tabbed. The two levels of touch modes were double touch and long touch. Therefore, six sets of experiment pages were constructed. The media contents were constructed based on Adobe Flash and Director and tested on a HP xw4600 workstation with a 32-inch touch screen. The touch screen employed the optical sensor technology developed by Xiroku Inc. and mounted on a BenQ 32" LCD TV with 1366x768 resolution. In the experiment, thirty participants, 11 female and 19 male with average age 24.3, carried out typical tasks to locate assigned pages for searching or comparing information. They were divided into six groups, each group had five participants. They were asked to complete the same set of tasks to locate the information relative to different species at different altitudes. During experiments, Camtasia Studio pro 4.0 was used for video recording in order to keep track of the behaviors of participants. After that, the participant was asked to complete system component usability rating and overall rating questionnaire. The system component usability rating included six items relevant to menu and touch. They are ease of identifying menu items, ease of navigation, ease of quick overview, ease of distinguishing categories, ease of touch for selection, and ease of touch for backward. The overall rating included six measures modified from NASA Task Load Index. They were presented in positive expression, i.e., good guidance, less physical workload, less time pressure, less effort in learning, satisfaction in performance, and less frustration. The participant evaluated the system based on their agreement on these measures using a 7-point Likert scale. High grading value represented positive response with respect to the performance measure. These data were analyzed using statistic methods, such as two-way ANOVA.

4. Results and Discussions

4.1 Task Completion Time

There were no significant differences in task completion time for the main effects of two factors. However, there is an interaction between two factors. Detailed analysis showed that global fish eye with double touch for backward button turned out to be the worst combination. The participants reported that global fisheye menu hampered the search tasks due to different size in menu items. In addition, they got confused in using single touch for forward traveling and double touch for backward traveling. The combined effects of complicated visual presentation of menu items and different numbers of touch actions made navigation difficult.

Table 1. The Mean and Standard Deviation of Task Completion Time (Measured in Seconds)

Touch Mode	Navigation Menu		
	Global Fisheye	Local Fisheye	Tabbed
Double Touch	570.4 (43.5)	380.6 (58.0)	397.8 (12.6)
Long Touch	473.4 (94.3)	345.2 (77.8)	426.8 (86.4)

4.2 Ratings for the Usability of System Components

The results of ratings , based on 7-point Likert scale, for the usability of system components were presented in Table 2. Although there were no significant differences in the first five measures for main effects and interaction, there was a significant difference in the ease of touch for backward interaction. Detailed analysis revealed that tabbed menu with long touch was the best combination, while tabbed menu with double touch was the worst combination. The reason was when people were familiar with single touch for manipulating tabbed menu, it become inconsistent in the number of touch while applying double touch on the backward button. In addition, from the comments provided by the participants, tabbed menu had better boundary of each category compared to those of global fisheye and local fisheye. Base on the responses from participants, the authors studied the reasons to explain why long touch input mode was better than double touch mode. If the system did not respond immediately after touch, participants started to worry about the sensitivity of the system. In such a case, their first reaction was to touch harder and longer, therefore, increasing the time and area of touch. On the contrary, if the participants applied double touch, they tended to touch lightly and quickly. If the speed and pattern of touch did not match the conditions preset in the system, the failure rate of detection would increase dramatically. Even some participants did try to adjust their double touch actions by changing either the speed or the force, matching the exact pattern were still more difficult than pressing and waiting for response.

Table 2. The Mean and Standard Deviation of Ratings for the Usability of System Components

Metrics	Combination of Navigation Menu and Touch Mode					
	Global Fisheye and Double Touch	Global Fisheye and Long Touch	Local Fisheye and Double Touch	Local Fisheye and Long Touch	Tabbed and Double Touch	Tabbed and Long Touch
Ease of Identifying Menu Items	4.8 (1.8)	3.6 (1.8)	3.4 (1.8)	3.6 (2.3)	4.6 (1.5)	4.6 (2.1)
Ease of Navigation	4.8 (2.2)	4.2 (2.2)	5.0 (1.9)	4.0 (1.9)	5.6 (0.9)	4.4 (2.3)
Ease of Quick Overview	4.4 (1.7)	2.8 (1.3)	3.0 (1.3)	2.8 (2.2)	4.2 (0.8)	4.0 (2.0)
Ease of Distinguishing Categories	3.4 (1.5)	3.4 (1.1)	4.8 (1.9)	3.6 (1.3)	5.2 (1.5)	4.8 (2.2)
Ease of Touch for Selection	4.4 (1.5)	3.2 (1.3)	4.0 (1.6)	3.2 (1.3)	2.4 (0.9)	3.6 (1.7)
Ease of Touch for Backward	4.6 (2.2)	5.2 (0.8)	5.0 (1.9)	4.4 (1.5)	2.8 (0.8)	5.6 (0.5)

4.3 Workload Ratings

The results of workload ratings, based on 7-point Likert scale, were presented in Table 3. There were significant differences in physical workload for the main effects of navigation menu. Local fisheye required less physical workload compared to other types of menu while searching for information. There were two reasons. For global fisheye, the selected category corresponding to a specific altitude had a larger menu than other categories. In order to have a better overview of the entire species with respect to different altitudes, user tended to switched

back and forth among different altitudes, thus increasing the frequencies of touch operations. Similarly, since the tabbed menu allowed the user to see only one category at a time, the user tended to switch among categories frequently in order to locate the entry menu of a specific species. For local fisheye, the user can benefit from the rollover function to enlarge local menu. There was no need to switch among different categories. In addition, local fisheye had the benefits of facilitating eye-hand coordination if the participants would like to search on a specific menu bar.

Table 3. The Mean and Standard Deviation of Workload Ratings

Metrics	Combination of Navigation Menu and Touch Mode					
	Global Fisheye and Double Touch	Global Fisheye and Long Touch	Local Fisheye and Double Touch	Local Fisheye and Long Touch	Tabbed and Double Touch	Tabbed and Long Touch
Good Guidance	5.0 (1.2)	4.6 (0.9)	4.4 (1.8)	4.8 (1.3)	3.4 (1.9)	5.2 (0.8)
Less Physical Workload	4.4 (1.8)	4.2 (1.3)	5.8 (1.1)	4.8 (1.3)	3.2 (1.1)	4.0 (1.4)
Less Time Pressure	5.8 (1.6)	4.0 (1.6)	5.2 (1.5)	4.8 (1.3)	2.8 (1.3)	4.2 (1.9)
Less Effort in Learning	5.6 (0.9)	4.6 (0.9)	5.4 (1.1)	6.0 (0.7)	4.4 (1.1)	5.0 (1.2)
Satisfaction in Performance	4.2 (1.3)	3.6 (1.3)	4.0 (1.4)	4.4 (1.7)	3.6 (0.9)	4.0 (1.2)
Less Frustration	4.6 (1.3)	4.0 (1.6)	5.6 (1.3)	4.6 (1.3)	3.0 (1.0)	4.4 (1.1)

4.4 Comments for Navigation Menu from Participants

In addition to task complete time and subjective evaluation, the author also collected the comments provided by participants about the advantages and disadvantages for different styles of navigation menu. In navigation menu, there were some advantages of good overview for selected category in global fisheye, good searching style for rollover operation of fingers in local fisheye navigation, and big menu items and clear boundaries of different categories in tabbed navigation menu. However, for fisheye menus, no matter local or global, they suffered from the disadvantages of size change in menu items.

Although tabbed navigation style was inconvenient for overview across different categories, the boundaries of different categories were clear. Since only one set of menu items were displayed at each time of changing categories, the menu items were generally big. Thus facilitating search in the same set. If the users did not have time pressure in searching items across different categories, they preferred tabbed navigation.

Table 4. Comments for Navigation Menu

Comments	Navigation Menu		
	Global Fisheye	Local Fisheye	Tabbed
Advantages	Good overview for selected category	Rollover function were good for searching on the menu bar	Boundaries of different categories were clear; Menu items are big
Disadvantages	Menu items were cluttered due to different sizes	Menu items were too small; Change in size caused the position change of menu items; Boundaries of different categories were not clear;	No overview across different categories

5. Conclusion and Recommendation

5.1 Conclusion

For navigation menu, global fisheye was not appropriate due to unequal size of neighbor menu items. Although fisheye menu required less physical workload, the cluster screen and dynamic change in the size of menu items hampered the visual search task. Tabbed menu had better boundary of each category compared to those of global fisheye and local fisheye. In addition, although long touch was not always better than double touch while applying on the backward shortcut button, tabbed menu with long touch was significantly better than with double touch. The reason was when people were familiar with single touch for manipulating tabbed menu, it become inconsistent in the number of touch while applying double touch on the backward button. Therefore, consistency in the size of menu items and consistency in the style of controls is important for a navigation bar with large structure.

5.2 Recommendation for Further Research

This research focused on the effects of navigation menu and touch modes on the usability of an ecology education system. In the experiment, the touch screen was mounted on a 32-inch LCD TV and installed vertically on a table, similar to the setup of a regular screen on desktop. It was reported that participants felt tired to keep their fingers touching on the screen. Further research could study the effect of placing the touch screen horizontally or with an incline angle. In addition, in the experiments, the appearance of backward buttons adopted the symbol commonly used in media playing systems. If the users are not familiar with the system, it is difficult for them to recognize the function. Therefore, graphic design of forward or backward buttons, including the size, the shape and the text, may affect the affordance of navigation or touch modes. This issue could be studied in the future, especially in the case that the mapping of gestures and functions is important. Furthermore, prior experiences of users may influence the degree of familiarity with the newly-designed user interface. As more and more public systems employ the touch screen, universal design of the user interface is one of the interesting topics in the future.

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