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A Study of Usability Principles and Interface Design for Mobile e-Books

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A Study of Usability Principles and Interface Design for Mobile e-Books

This study examined usability principles and interface designs in order to understand the relationship between the intentions of mobile e-book interface designs and users' perceptions. First, this study summarized four usability principles and sixteen interface attributes, in order to conduct usability testing and questionnaire survey by referring to Nielsen (1993), Norman (2002), and Yeh (2010), who proposed the usability principles. Second, this study used the interviews to explore the perceptions and behaviours of user operations through senior users of multi-touch prototype devices. The results of this study are, as follows: 1) users' behaviour of operating an interactive interface is related to user prior experience; 2) users' rating of the visibility principle is related to users' subjective perception but not related to user prior experience; however, users' ratings of the ease, efficiency, and enjoyment principles are related to user prior experience; 3) the interview survey reveals that the key attributes affecting users' behaviour of operating an interface include aesthetics, achievement, and friendliness.

Practitioner Summary: This study conducts experiments to explore the effects of users' prior multi-touch experience on users' behaviour of operating a mobile e-book interface and users' rating of usability principles. Both qualitative and quantitative date analyses were performed. By applying protocol analysis, key attributes affecting users' behaviour of operation were determined.

Keywords: mobile e-books; usability principles; interface design; multi-touch devices

1. Introduction

Digital content and cloud computing industries are two of Taiwan's key industries. Technology growth and achievements have driven the digital content industry's flourishing development, altered Taiwanese readers' reading habits, and created simple and intuitive e-books, which are perfect for modern readers and a very important form of reading(Chen *et al.* 2008, Tajika *et al.* 2008, Kang *et al.* 2009). In 2010, Apple Inc. launched the first-generation iPad, which caught the attention of the digital publishing market worldwide. From the success of iPad to Amazon's new colourful tablet computer "Kindle Fire", tablet computers are entrusted with the mission of leading the computer industry's future(Lo 2012).

Previous reading patterns were limited to one-way reading of traditional printed books, and whether contemporary changes, such as e-books' digital, portable, interactive services, wide range of functions, and complex menus, affect users' reading behaviour has become a popular research topic. Thus, how to make mobile e-book interface designs easy to comprehend and navigate has become an important subject. The new iPad application software (app), "Newsstand", allows readers to subscribe to digital books and magazines for direct reading. This study intends to discuss usability principles and interface designs in order to explore whether the intentions of mobile e-book interface designs coincide with users' perceptions.

The purposes of this study are listed, as follows: (1) assess mobile e-books' interactive interface designs and organize important characteristics of user behaviour

pertaining to operating an interactive interface; (2) explore usability principles and organize suggestions for mobile e-book interface design attributes; (3) exam the relationship between users' prior multi-touch device experience and users' operation of a mobile e-book interface; determine the interactive elements and key factors that affect users' operation of a mobile e-book interface.

2. Literature review

This study tested the reading services of mobile e-books, and discussed the usability principles and interactive interface attributes affecting user prior experience as the basis of the research design.

2.1 Reading service of mobile e-Books

Changes in people's digital lifestyle, as well as the gradual popularization of tablet computers over the past few years, have prompted the rapid development of apps and ushered in the common practice of digital reading. In addition, publishers have been offered a number of digital publishing solutions from production to publishing, such as Adobe Digital Publishing Suite (DPS), AppCross, Apple iBooks Author, and the Rogue S digital publishing system.

Many publishers combine articles with multimedia elements, which include web links, pictures, menus, videos, and audio, in order to create interactive e-books. The Nielsen Norman Group conducted usability testing of websites and apps specific to the iPad. The report proposed the term "mental models", which refers to the "many different aspects of users' knowledge regarding the systems they use." For example, users can move between pages containing article synopses by swiping the page, or read an entire article by dragging the surface(Budiu and Nielsen 2010). Software that supports human behaviour can better help users achieve their goals(Tidwell 2006). Therefore, mobile e-books must support user behaviours and provide friendly interactive interface behaviours. This paper investigated several book-making apps(Young 2010, Lu 2011, Huang 2012, Liao 2012) available in the Apple store, and summarized five interface behaviours, as illustrated in Figure 1, including: (a) exploration: users may click an app icon to open a mobile e-book and explore the content of an article; (b) navigation: the function of searching for particular texts in an e-book page allows readers to rapidly skim through the page or go to the particular content of an article; (c) video: users may click and play a video clip inserted into an e-book page. Alternatively, a video clip might automatically play when readers reach a particular e-book page; (d) menu: users may use a single icon or an array of icons to switch between articles with different themes or in different categories; (e) scroll: regardless of screen size, users may use scroll to read more content of an article.

(a) (b) (c) (d) (e)

Figure 1. Interface behaviours: (a) exploration: ELLE App; (b) navigation: GQ App; (c) video: Wired App; (d) menu: GQ App; (e) scroll: VOGUE App.

2.2 Usability principles

Usability refers to ensuring that interactive products are easy to learn, effective to use, and enjoyable from the use's perspective(Rogers *et al.* 2011). Usability has long been a key issue of interface design. Nielsen (1993) proposed that usability has multiple components, and is traditionally associated with five usability attributes: (1) learnability: user can easily learn and rapidly use; (2) efficiency: user has learned the system, and a high level of productivity is possible; (3) memorability: user is able to return to the system after some period of not having used it, without having to relearn everything; (4) errors: users make few errors when using the system; (5) satisfaction: users are subjectively satisfied during use(Nielsen 1993).

Norman (2002) suggested four design principles that can render complexity more manageable: (1) visibility: user can know the state of the device and alternatives for action; (2) a good conceptual model: designer provides a good conceptual model for the user, with consistency in the presentation of operations; (3) good mappings: it is possible to determine the relationships between actions and results, between the controls and their effects, and between the system state and what is visible; (4) feedback: user receives full and continuous feedback regarding the results of actions(Norman 2002).

Yeh (2010) proposed 3e indicators of meaningful criteria for evaluation of the interactive design: (1) effective: it is able to successfully assist users in completing tasks and achieving goals; (2) easy: it can help users reduce four particular elements: memory work, physical work, visual work, and unnecessary work; (3) enjoyable: it can bring users pleasure in physio-pleasure, socio-pleasure, psycho-pleasure, and ideo-pleasure levels(Yeh 2010). As illustrated in Figure 2, this paper summarizes four usability

principles for mobile e-books by referring to the usability attributes of Nielsen (1993), the good design principles of Norman (2002), and the 3e indicators of Yeh (2010):

(1) Visibility: The system provides users with information that is conducive to communication and interaction, as well as clear instructions.
(2) Ease: The system is easy to learn, and users can quickly familiarize themselves with the system's functions and operations, thus, time spent on learning is minimal.
(3) Efficiency: Once users have learned how to use the system, it is easy to use the functions of the system at full capacity.
(4) Enjoyment: Users feel satisfied upon completing a task when using the system.

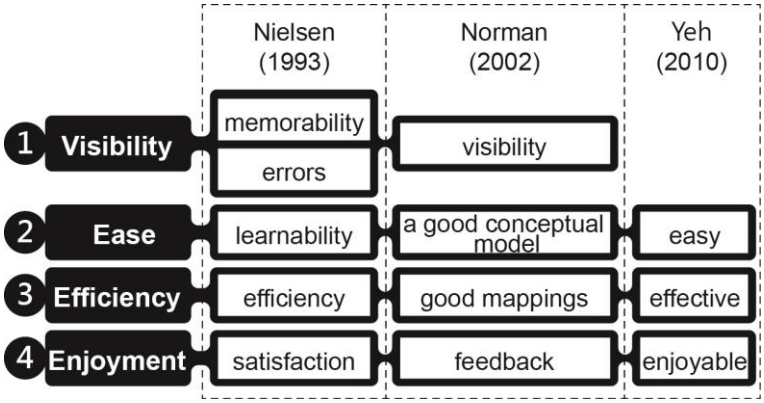

Figure 2. Usability principles.

2.3 Interactive interface attributes

This study analyzed the interactive interface attributes of mobile e-books by referring to the above four usability principles, and many studies have been performed on interface design and usability of e-books(Budiu and Nielsen 2010, Budiu and Nielsen 2011, Cheng 2012). In addition, integration by Wang and Huang (2012) demonstrated the impact factors of user operation and the resulting interaction patterns for mobile e-books(Huang and Wang 2012). The first principle is visibility. Visibility denotes that an interface provides users with clear guidance. When an article indicates that users can use this article to execute tasks, the article is "capable of performing" the tasks(Tidwell 2006). The designs of e-book interfaces must be simple, clear, and tell users their functions at first glance. Additionally, properly added tips and guidance are conducive to enhancing users' feelings and rating of an interface(Cheng 2012). From the above, this study summarized four interface attributes of visibility: simple presentation, obvious prompts, visible buttons, and readable colour scheme.

The second principle is ease of use, meaning that users must put forth only minimal efforts in discerning and thinking(Yeh 2010). Users prefer to quickly learn how to navigate a new interface(Preece *et al.* 2002). Thus, usability and readability are two important elements of interface designs. An interface designed with the function of restoration makes it easier for users to use a new system. From the above, this study summarized four interface attributes of ease: easy to use, easy to read, easy to understand, and easy to return.

The third principle is efficiency, meaning that an interface should be designed to successfully assist users to accomplish tasks, solve problems, or achieve goals.

Moreover, simple procedures are essential for minimizing the time required for users to achieve a goal upon entering the system(Yeh 2010). From the above, this study summarized four interface attributes of efficiency: smooth operation, cognitive match, consistent processes, and memorable operation.

The fourth principle is enjoyment, meaning the pleasure a user experiences while using an interface to accomplish a task, including beautiful illustrations and visual designs, as well as diversified and interesting content, which all increase users' enjoyment level, thus, designs of interactive products should consider fun, aesthetics, and enjoyment(Yeh 2010). From the above, this study summarized four interface attributes of enjoyment: graphic design, overall visualization, rich content, and interesting operation. As mentioned above, this study concluded four usability principles and sixteen interface attributes as the question items for usability testing and questionnaire survey, as shown in Figure 3.

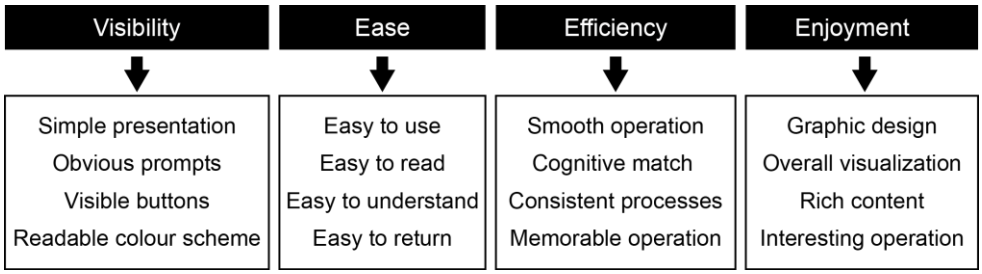

Figure 3. The sixteen interface attributes.

3. Methodology

This study was designed to explore the usability principles and interface designs of mobile e-Books. First, this research applied usability testing and a questionnaire survey in order to understand users' behaviours. Second, it applied individual interviews with senior users to determine the important design principles affecting user operation through multi-touch prototype devices.

3.1 Research model and research hypothesis

Interactive design considers the behaviour of products and services(Saffer 2006). Designers depend upon good design principles to design an actual working interface(Tidwell 2006). As mentioned in the literature review, this study discussed the influence of interactive elements and key attributes of user operation. Experiments of this study are divided into three parts, as follows:

(1) Interface behaviour: sequential interface behaviour expresses an input/output behaviour in an unambiguous manner(André *et al.* 2000). Mobile e-books should provide an interactive interface that allows users to use their intuition to accomplish tasks and achieve goals. In this study, usability testing was employed in order to understand users' behaviours and perceptions by examining users, products, and tasks.
(2) Design principles: design principles are derived from a mix of theory-based knowledge, experience, and common sense(Preece *et al.* 2002). Design principles can guide users, evaluate a system or an interface, and provide a user-

friendly interface mode. This paper investigates users' experience and evaluates usability principles through a questionnaire survey in order to determine interactive elements.

(3) User prior experience: User prior experience is prior knowledge acquired before interaction with a new product(Britton *et al.* 2013). Users had prior experience with similar devices to carry out tasks quickly. As user prior experience may affect users' impression of a product, as well as their behaviour when using the product, and applying prior experience to multi-touch devices may help to identify the interactive elements and key factors of mobile e-books that affect user behaviour. User prior experience with a product or service has influence on the changes of users' perceptions, behaviours, and evaluations(Cummings and Venkatesan 1976, Shirley and Peter 1995, Constantiou 2009, Kim *et al.* 2009). The research model is as shown in Figure 4.

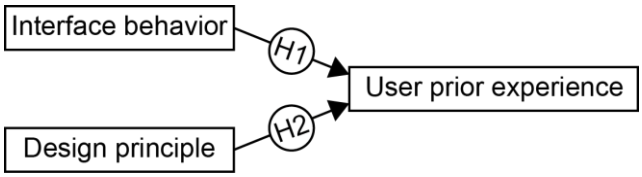

Figure 4. Research model.

Experienced users can rapidly work on a wide range of tasks(Preece *et al.* 2002, Shneiderman and Plaisant 2004). More experience with a product will facilitate better performance in jobs requiring advanced product skills(Allison and R. Kelly Rainer 1992). Several studies have noted that prior experience has a positive relationship with users' perceptions, behaviors, and ratings. Therefore, the research hypotheses are, as follows:

- H1: Users' perception and behaviour of using a mobile e-book interface is related to user prior experience.
- H2: Users' ratings of a mobile e-book's design principles are related to user prior experience.

3.2 Experimental design and procedure

From the above literature review and research hypothesis, this study applied usability testing, questionnaires, and interview surveys to explore the usability principles and interface design of mobile e-books. First, this study investigates the interface behaviours of user operations through usability testing. Second, this study evaluates design principles of the mobile e-book interface through questionnaire survey. Third, this study discusses the relationship between user prior experience and the interactive interface design through interview survey. The experimental procedures are, as follows:

3.2.1 Usability testing

Usability testing is the measurement of performance by typical users during typical tasks(Preece *et al.* 2002). As mentioned in section 2.1, this paper designed a series of tasks in order to understand the typical usability issues that people encounter when using a mobile e-book on an iPad. Table 1 shows the five main tasks: explore GQ, use a

navigation tool, watch a video, swipe menus, and drag scrolling. The researchers captured all the operation screens using the Display Recorder of the iPad app. Each test participant was tested individually and invited to express their thoughts and feelings during the experiment.

Table 1. Tasks and typical works.

Task	Typical works
Task 1: Explore GQ	(a) Tap to start the GQ magazine app. (b) Explore GQ for 1-3 minutes.
Task 2: Use a navigation tool	(a) Tap the screen once to display the top and bottom navigation bars. (b) Brower other stores in the issue by tapping the screen. (c) Release the slider bar to read a new article.
Task 3: Watch a video	(a) Find any available "video" that can be watched. (b) Play and view. (c) Tap the "done" button.
Task 4: Swipe menus	(a) Find any available "menu" that can be selected. (b) Tap the thumbnails to see different information.
Task 5: Drag scrolling	(a) Find any available "scroll" that can be dragged. (b) Drag and drop words to activate scroll function. (c) Tasks complete.

3.2.2 Questionnaire survey

When all the tasks were completed, the participant was given a questionnaire consisting of items derived from the sixteen interface attributes. This part of the experimental process investigated the level of satisfaction and agreement with usability testing for GQ magazine. A 7-point Likert scale was applied, ranging from 1 ("very dissatisfied" or "very disagree") to 7 ("very satisfied" or "very agree").

3.2.3 Interview survey

Individual in-depth interviews, which are face-to-face interactions between a researcher and users, help to gather information of users' opinions regarding the usability of a chosen mobile e-book interface. This research method is able to gather feedback and responses, as well as respond to complex issues. In this study, the enthusiastic involvement of participants also gave the researcher opportunities to make further inquiries(Chang 2004). For issues that required further evidence, as indicated by usability testing and questionnaire survey results, individual in-depth interviews were conducted. Among the usability testing and questionnaire survey participants, three participants who were heavy users of multi-touch devices were invited to participate in further individual in-depth interviews involving the above four usability principles (visibility, ease, efficiency, and enjoyment). Open-ended interview questions were designed in advance in order to determine whether the interviewed heavy users of multi-touch devices had particular thoughts regarding the usability of the chosen mobile e-book interface. During the interviews, timely instructions were provided to lead interviewees to talk about whether the four usability principles are related to heavy use of multi-touch devices, and offer suggestions on the usability of the e-book interface. The list of open end questions is, as follows:

(1) Could you tell which elements of GQ magazine on an iPad are interactive icons and which elements are categorized as general information presentations? What are the criteria for your judgments?
(2) Could you instantly learn how to read and use GQ magazine on an iPad?
(3) Do you think that GQ magazine on an iPad can effectively satisfy your demands?
(4) Are you satisfied with the usability of GQ magazine on an iPad?

3.3 Participations and materials

A total of 30 people participated in the usability testing and questionnaire survey, and 3 people participated in the interview survey. Participants are third year commercial design students at the National Taichung University of Science and Technology and staff of the Chunghwa Wideband Best Network Corporation in Taiwan. They voluntarily participated in the experiment and are interested in mobile e-books.

In more recent years, many digital publishers create mobile e-books from WIRED using Adobe DPS. WIRED is an English magazine, and users are accustomed to reading Chinese magazines in Taiwan. GQ, the popular e-magazine for iPad, was featured in Newsstand's local magazine from the App store. Since GQ's interactive type, development software, and content framework are the similar to WIRED, GQ was chosen as this study's research sample. Considering that the international Chinese edition of GQ magazine is representative of high-quality lifestyle in readers' minds, the researchers chose GQ e-magazine as this study's research sample in order to observe users' behaviours while reading.

4. Results and discussion

First, this study invited 30 participants to test GQ magazine, and asked the participants to complete a short questionnaire after completing the tasks. Second, this study invited 3 senior users to evaluate mobile e-books through interviews, and the results are, as follows:

4.1 Basic information of participants

A total of 30 people participated in usability testing and the questionnaire survey: 11 males and 19 females; 25 participants (84%) had held multi-touch devices. Table 2 shows the basic information of the participants.

Table 2. Basic information of participants.

Item	Median/Total
Gender	Males: 11; Females: 19
Age	<20:1; 21-30: 18; 31-40: 9; >41: 1
Education level	Associate: 9; Bachelor: 14; Master: 7
Multi-touch user	Yes: 25; No: 5
Years of multi-touch users	<3 years: 2; 3-6 years: 2; 6-12 years: 4; >12 years: 17
Multi-touch usage times per day	<1 hour: 7; 1-3 hours: 7; 3-5 hours: 5; 5-7 hours: 3; >7 hours: 3

4.2 Analysis of interface behaviour

The participants of this study were thirty users (25 multi-touch users; 5 non-users) who independently evaluated GQ on the iPad. The results of usability testing are as shown in Table 3. Summarizing participants' feelings regarding each task and typical work, this study generated the following results:

- Task 1: explore GQ: As most users had prior experience with apps, starting GQ magazine on an iPad was an easy task for the majority of users.
- Task 2: use a navigation tool: GQ magazine on an iPad was designed with the function of instantly searching for particular texts within a page that users intend to read. However, some users had no idea how to start the page search function and required assistance from the researcher to accomplish the task.
- Task 3: watch a video: General users were accustomed to viewing videos on media player software. However, GQ magazine on an iPad contains both images and videos, meaning some users had difficulty instantly discerning images from videos. In addition, the play icon of a video was unnoticeably placed at the bottom left corner of the video, thus, users had to look carefully to determine whether or not it was a video.
- Task 4: swipe menus: As a menu is a common webpage design, most users considered the task very easy. On the other hand, users considered switching menus as nothing more than a mode of reading, and did not regard it as interactive. This was mainly due to users' higher expectations of a menu, such as a webpage-like multifunctional menu or speedy hyperlinks. Nevertheless, as it was restricted by the mobile e-book's touchscreen interface, in which a multifunctional menu is impossible, simple hand movements were primarily used to access the interactive menu.
- Task 5: drag scrolling: Regardless of screen size, by scrolling, users can move a book page around in order that different parts of the page appear on the screen, and users can read more content of an article. However, readers generally thought that the colourless (black and white) scrolling icon, which was placed at the bottom right corner of the article block, was inconspicuous and could possibly be overlooked. Furthermore, only a very tiny linear icon was placed at the bottom right corner to show the scrolling function. Users tended to use the scrolling function the way they use a scroll bar on a webpage, and had the preconception that all they had to do was place their fingers on the scrolling icon, thus, it was easy for users to conclude that the operation was not smooth and the system was unresponsive. Therefore, most participants required assistance from the researcher in order to complete such typical work.

Table 3. The results of usability testing.

Task	Typical works	Group	Participant's feelings and sensitive
Task 1: Explore GQ	(a)	B	Upon entering the system, changing pages was not very smooth (S17)
	(b)	A	Reading was not smooth enough (S16);
		B	Page scrolling was not smooth and a number of pages popped up at one time (S17)
Task 2: Use a navigation tool	(a)	A	The round white icon that popped up onto the screen was annoying (S10); it was easily confused with the next page function (S18)
	(b)	A&B	Did not know how to start the navigation tool (S10, S14, S17)
	(c)	A	Did not know how to use it (S14); too many pages popped up together

			(S16)
Task 3: Watch a video	(a)	A	It was difficult to differentiate the video mode from the image mode (S7, S21, S24); you had to look carefully to find it (S18); the player icon was at the upper left corner (S26)
	(b)	A	It takes a long time to find it (S29); it is not conspicuous (S30)
	(c)	A	Users would habitually find the stop button (S8); the stop button was not easy to find (S26)
Task 4: Swipe menus	(a)	A	The design of the menu was very easy to understand (S4);
		A&B	It was hard to find (S9, S16, S19, S25)
	(b)	A	The interactive menus could provide more information (S11); did not consider it interactive (S16, S18).
		B	Making selections promptly was only possible after learning the method and the buttons (S17)
Task 5: Drag scrolling	(a)	A	Icons might be mistaken for another type of page design (S4); it was difficult to locate the scrolling bar's functions before reading the article (S21)
		A&B	The scrolling icon was inconspicuous and difficult to find (S9, S11, S14, S15, S16, S19, S24, S25, S28, S30);
	(b)	A	Did not know how to scroll down (S4); the speed was not fast enough (S10); users would click the icon first and scroll down when the icon was not responding by clicking it (S18); it was difficult to use without any cues (S16, S19, S20)
	(c)	A	Unclear (S14); no cues showed on the screen (S19); unable to operate without instructions from other people (S29)

From the above, multi-touch users, as opposed to non-users, can more practically apply e-book reading and interface operations at first use. This was mainly due to experienced users being familiar with the operation of multi-touch devices. However, both multi-touch users and non-users had no idea how to start special functions, including the navigate tool, menus, and scroll. In addition, most participants required assistance from the researcher in order to complete such typical work. It is obvious that ease of use is the most important element in an interactive design.

4.3 Analysis of design principle

This paper conducted quantitative data analysis using SPSS to analyse users' rating for the design principles of mobile e-books, and discussed the differences in questionnaire results between multi-touch users and non-users.

4.3.1 Reliability and Validity

Reliability is the overall consistency of a measure(Scott 1955), while validity is the extent to which a test measures what it claims to measure(Cronbach 1951). To ensure the validity and reliability of this questionnaire regarding the scale of usability, Cronbach's α coefficient was adopted in order to assess the internal consistency of the Likert scale. In addition, factor analysis was adopted to assess the questionnaire's construct validity.

Cronbach's α coefficient was used to investigate the four facets (visibility, ease, efficiency, and enjoyment) and sixteen interface attributes of the questionnaire's internal consistency. A Cronbach's alpha value of 0.8 and above indicates a higher questionnaire consistency(Cronbach 1951, Tu and Chia 2012). As revealed by the results of reliability analysis, the Cronbach's alpha value of this questionnaire's

visibility facet was 0.898; ease facet was 0.939; efficiency facet was 0.941; enjoyment facet was 0.925, which are above 0.8, indicating this questionnaire's superb reliability.

Factor analysis was used to investigate the construct validity of the questionnaire. The Kaiser-Meyer-Olkin index (KMO) of sampling adequacy and Bartlett's test for sphericity were adopted in order to assess the questionnaire's construct validity, and whether the data were qualified for factor analysis. Generally speaking, a KMO statistical value of 0.9 or above indicates the optimal effect, a KMO statistic value of 0.7 or above is acceptable, and a KMO statistic value lower than 0.5 indicates inaptness for factor analysis(Tu and Chia 2012). As indicated by the results of this study, this questionnaire's KMO statistic value was 0.861, the sphericity approximation chi-square distribution was 602.177, the degree of freedom was 120, and the significance level was 0.000 (p<0.01), all of which reached the level of significance, and therefore, were adequate for factor analysis.

4.3.2 Factor analysis

The feature extraction method of principal component analysis (PCA) was adopted to examine the questionnaire' factor loadings, and extract two common factors. The cumulative percentage of total variance extracted was 79.745%, as shown in Table 4. The first common factor is the operating model, which is composed of obvious prompts, visible buttons, memorable operation, easy to use, cognitive match, easy to return, smooth operation, consistent processes, interesting operation, easy to understand, and simple presentation. The second common factor is the visual model, which is composed of overall visualization, rich content, readable colour scheme, graphic design, and easy to read.

Table 4. A conceptual summary of factor analysis.

No	Factor	Item	Factor loadings	Initial Eigenvalue		
				Total	% of Variance	Cumulative%
1	Operating model	Obvious prompts	0.874	11.756	44.484	44.484
		Visible buttons	0.846			
		Memorable operation	0.814			
		Easy to use	0.773			
		Cognitive match	0.762			
		Easy to return	0.727			
		Smooth operation	0.719			
		Consistent processes	0.703			
		Interesting operation	0.696			
		Easy to understand	0.679			
		Simple presentation	0.622			
2	Visual model	Overall visualization	0.903	1.003	35.261	79.745
		Rich content	0.865			
		Readable colour scheme	0.745			
		Graphic design	0.704			
		Easy to read	0.66			

4.3.3 Users' rating for design principles

The *t*-test is used to compare the means between two samples in the cases(Chang 2004, Tu and Chia 2012, Wang *et al.* 2014). In this experiment, the researcher compared the level of satisfaction and agreement of multi-touch users (Group A) and non-users (Group B) using independent samples *t*-testing. Table 5 shows the ratings of Group A

and Group B of mobile e-books' sixteen interface attributes. The results showed that Group A users and Group B users only showed significantly different ratings (t=-2.648, p=.021) on the "readable colour scheme" attribute. Certainly, Group A users generally believed that the "readable colour scheme" attribute of the GQ magazine on an iPad was between "neither agree nor disagree" to "slightly agree". Group B users generally believed that the GQ magazine on an iPad was designed with a "readable colour scheme".

In term of the mean score, Group A users generally gave a higher rating (M=5.52) to the "simple presentation" and "readable colour scheme" attributes under the visibility principle, yet a lower rating (M=3.96) to the "smooth operation" attribute under the efficiency principle. In comparison, Group B users generally gave a higher rating (M=6.40) to the "readable colour scheme" attribute under the visibility principle, and a lower rating (M=4.0) to the "smooth operation" attribute under the efficiency principle. However, the usability testing and questionnaire survey results were unable to generate a clear understanding of the differences between multi-touch device users. In order to understand whether multi-touch device users had special thoughts regarding the usability of the interface of mobile e-books, three heavy users of multi-touch devices, who had participated in the stage one experiment, were invited to participate in the stage two experiment of interview surveys.

Table 5. The results of evaluation: multi-touch users (A group) and non-users (B group).

Principle	Interface attributes	Minimum		Maximum		Mean		Std. Deviation		t	Sig.
		A	B	A	B	A	B	A	B		
Visibility	Simple presentation	2	4	7	7	***5.52***	5.80	1.194	1.095	-.484	.632
	Obvious prompts	1	3	7	7	4.44	5.20	1.474	1.789	-1.019	.317
	Visible buttons	1	4	7	6	4.40	5.20	1.500	1.095	-1.127	.269
	Readable colour scheme	4	6	7	7	***5.52****	***6.40****	1.122	.548	-2.648	**.021**[a]
Ease	Easy to use	1	4	7	7	4.72	5.00	1.745	1.225	-.340	.736
	Easy to read	2	4	7	7	5.04	5.40	1.594	1.140	-.478	.636
	Easy to understand	2	4	7	7	4.84	5.00	1.599	1.414	-.208	.837
	Easy to return	1	4	7	7	4.40	5.20	1.756	1.304	-.961	.345
Efficiency	*Smooth operation*	1	2	7	7	***3.96****	***4.00****	1.947	2.000	-.042	.967
	Cognitive match	1	3	7	7	4.40	4.80	1.708	1.483	-.487	.630
	Consistent processes	1	2	7	7	4.64	4.80	1.655	1.924	-.193	.849
	Memorable operation	1	2	7	7	4.40	4.80	1.826	1.924	-.444	.661
Enjoyment	Graphic design	2	4	7	7	4.84	5.60	1.405	1.140	-1.132	.267
	Overall visualization	3	5	7	7	5.44	5.80	1.356	837	-.567	.575
	Rich content	3	4	7	7	5.20	5.80	1.190	1.304	-1.015	.319
	Interesting operation	1	4	7	7	4.36	5.40	1.604	1.140	-1.373	.181

[a] Note: p<0.05; *Note: Maximum Mean; **Note: Minimum Mean

4.4 Analysis of user prior experience

The researcher observed that multi-touch device users spent less time browsing and enjoyed smoother operation during the usability testing of stage one experiments: usability testing and questionnaire survey, thus, this study further selected three heavy users of multi-touch devices from the stage one experiment for subsequent interviews. The three selected interview respondents were two males and one female, aged 34, 26,

and 24 years, respectively, that personally owned multi-touch devices for three years, one year, and two years, respectively, and spent six hours, two hours, and two hours, respectively, using multi-touch devices each day. These three interview respondents were asked whether their prior experience with multi-touch devices were in their mind during the process of performing typical works.

First, the 19 elements, which are valuable and highly related to visibility, ease, efficiency, and enjoyment principles, were systematized and extracted from the data gathered from interviews. The 19 elements are as shown in Table 6. Four elements that were extracted from the visibility principle include icon, graphic, typesetting, and marks. Three elements that were extracted from the ease principle include operative experience, reading experience, and intuition. Four elements that were extracted from the efficiency principle include learning, framework, familiarity, and habit. Eight elements that were extracted from the enjoyable principle include low errors, content, interaction, vision, achievement, colourful, video, and friendliness.

Table 6. Concepts and elements extracted from the in-depth interviews.

Principle	Concept	Element
Visibility	• *Icon* in users' impression	• **Icon***
	• *Button design*	• **Button***
	• *Special layout*	• Typesetting
	• Conspicuous *marks*	• Marks
Ease	• *Prior experience of using* a multi-touch device	• Operative experience
	• *Prior experience of reading* other e-books	• Reading experience
	• *Easy-to-understand* design, which is similar to the designs of other apps	• Intuition
Efficiency	• An effectively lowered error rate after *learning*	• Learning
	• A similar *framework* to that of general e-books and provides users with desired information	• Framework • Familiarity
	• Users able to spot wanted information *after learning the system*	• Habits
	• Users becoming *familiar with the operating mode* of an e-book after learning the system	
Enjoyment	• Enhanced user satisfaction with a *lower error rate*	• Low errors
	• Heightened *visual enjoyment* brought by diverse content and interaction	• **Vision*** • **Content***
	• Users' sense of *achievement* upon the completion of an action	• **Interaction***
	• A pleasing combination of diverse content and *bright colours*	• Achievement
	• A pleasing combination of *videos* and interactive features	• **Colourful***
	• The *pleasing quality* of usability	• **Video***
		• Friendliness

Furthermore, the extracted elements were consolidated into 14 elements, as based on their common attributes. The two elements: icons and buttons, as seen from the visibility principle, were merged to form the "graphic design". The five elements: content, interaction, vision, colourful, and video from the enjoyment principle were merged to form "aesthetics". Finally, this study inferred that three key elements, as shown in Figure 5, may affect users' behaviour of operating a mobile e-book interface.

(1) Aesthetics: Proper graphic designs, page layouts, icons, and structures may enrich the content of an e-book, as well as bring users pleasant visual enjoyment when reading.

(2) Achievement: Prior experience using multi-touch devices and reading make it easier for users to learn a new interface, minimize the chances of making mistakes, and bring users a sense of achievement.
(3) Friendliness: An interface with operating system features that are similar to users' prior experience can minimize users' chances of making mistakes, which renders learning and operation easier for users.

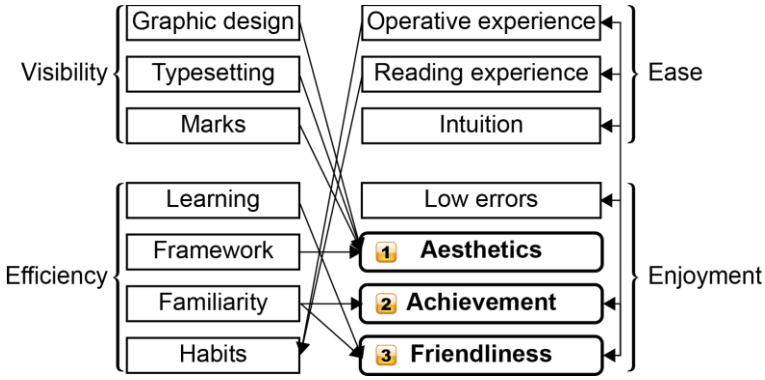

Figure 5. Key attributes of user operation.

4.5 Discussion of research questions

H1: Users' perception and behaviour of using a mobile e-book interface are related to user prior experience.

By summarizing the results of usability testing analysis, and further investigating the correlation between user prior experience and users' behaviour when using a mobile e-book's interactive interface, this study learned about users' needs when using a mobile e-book's interactive interface. Our findings and explanations are provided, as follows:

(1) Task 1: explore GQ: users with prior experience using apps could understand how to explore an e-book. Therefore, GQ magazine on an iPad should be accompanied with a user guide for new users.
(2) Task 2: use a navigation tool: users without previous experience with Newsstand were unable to respond instantly. Therefore, GQ magazine on an iPad should have icons on its pages to show users where to find search tools, in order that users can use the search tools and hyperlinks to locate specific topics or content they wish to read expeditiously.
(3) Task 3: watch a video: given users' existing habits of video watching, mobile e-books should be designed with separate video and image modes. In addition, a commonly-applied play icon should be placed at a conspicuous location, which is obvious at a glance for users.
(4) Task 4: swipe menus: given users' existing habit of switching between menus, mobile e-books should be designed with consistent navigation menus, such as number-based or icon-based navigation menus, which can be easily sighted without users spending too much time searching for the right button.
(5) Task 5: drag scrolling: given users' existing habit of drag scrolling, a conspicuous and easy-to-understand scrolling icon should be designed and displayed along with the graphic interface, and with the desirable property of

affordance in order that scroll can be instantly and effortlessly located and operated.

H2: Users' ratings of mobile e-books' design principles are related to user prior experience.

By summarizing the results of the questionnaire and interview analysis, and further discussing the relationship between user prior experience and interactive interface design, this study evaluates four usability principles and sixteen interface functions. Our findings and explanations are provided, as follows:

(1) Visibility: Visibility means that most interactive elements could be instantly detected and discerned. Guidelines for general users' judgments include prior experience and commonly-used icons, such as a triangular play icon and a magnifying glass icon. Thus, users' rating of the visibility principle is related to users' subjective perception.
(2) Ease: Ease of use is determined by prior experience using multi-touch devices and reading e-books. An e-book's diverse interactive functions, which are related to users' prior experience, contribute to its superior ease of use.
(3) Efficiency: Prior experience assists users to promptly acquire desired information. After users learn a new operating mode, users would be faster in detecting where to obtain their desired information. Moreover, it is easier to discover different content and information once users become accustomed to the new operating mode. Thus, user's rating of the efficiency principle is related to user prior experience.
(4) Enjoyment: Upon the completion of an action, most users would feel a sense of achievement. Prior experience also minimizes the chances of making mistakes, and a lower error rate boost users' satisfaction. Moreover, diverse content, interaction, bright colours, and an easy-to-operate interface not only delight users, but also heighten users' enjoyment and experience. Thus, users' rating of the enjoyment principle is related to user prior experience.

Based on the results, this study proposes the following suggestions regarding interface designs for mobile e-books: (1) provide a user guide and tutorial videos to teach users the basic functions of an e-book; (2) provide user cues regarding how to start search tools; (3) provide clear-cut distinction between an image mode, a video mode, and commonly-used video player functions, and place such functions at conspicuous locations for users; (4) display an array of navigation menus in a particular area, distinguish this area from other areas for general static presentation, and design consistent navigation menus; (5) provide conspicuous scrolling icons, design uncomplicated and easy-to-understand action icons, and design a graphic interface with the property of affordance.

5. Conclusions

This research conducted three experimental procedures, which involved usability testing, questionnaires, and interview surveys according to four usability principles (visibility, ease, efficiency, and enjoyment), and sixteen interface attributes. The findings are, as follows:

(1) The results of usability testing and interview survey analysis revealed that users' behaviour of using a mobile e-book' interactive interface is related to users' experience, as users begin exploration of a mobile e-book according to prior experience. Moreover, as the interactive functions provided by an interface become deeply-rooted in users' memory, the users have become accustomed to such universal methods of operating an interface.
(2) The results of questionnaires and interview survey analysis revealed that users' rating of the visibility principle is related to users' subjective perception, but not related to user prior experience. Users' ratings of principles, including ease, efficiency, and enjoyment, are related to user prior experience.
(3) This paper concluded that the important elements affecting users' interface operation are aesthetics, achievement, and friendliness.

In terms of results and findings, users can enjoy fun, aesthetic, and pleasurable interactive products through the interface of an affordable device. Interface languages applied to the user interface of mobile e-books are key factors for communication between users and products. Perhaps future researchers could examine the interaction between a graphical user interface and user behaviours by applying the affordance approach.

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